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GEOSPATIAL TECHNOLOGY, A SATELLITE -BASED CHANGE DETECTION AGENT: IMPERATIVE FOR ANALYSIS AND MANAGEMENT OF VEGETATION RESOURCES IN DEVELOPING ECONOMY

***Edwin-Wosu, N. L., Mojuetan, T., Ndukwu, B. C. and Micheal, C. A.**
Department of Plant Science and Biotechnology, University of Port Harcourt, Port Harcourt, Nigeria

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ABSTRACT

The application of geospatial technology, apart from being used in diverse specialty of human endeavours, has made immense contribution towards monitoring and evaluating the vulnerability and changing pattern of diverse vegetation ecosystems. Thus, it is being rated among the most accurate means of detecting the trend of canopy cover conditions of a locality over a period of time. In the light of this, the present review focused on geospatial tool as a satellite-based change detection agent for the analysis of vegetation in sustainable resource management. Following the various conventional approaches to a critical review, the application of geospatial tool in the *in-situ* and *ex-situ* analytical phases has indicated its usefulness in evaluation of vegetation ecosystem. It has also proven useful in vegetation resource location and management, harvest planning, fire management, map development, strategic planning, modelling and statistical analysis. Its benefit for detecting changes gives more perspectives than the prehistoric ground measurement. It is faster, easier, energy and time-saving and accurately improving organisational integration. Though of great importance in change detection, geospatial tool is associated with four major issues which include institutional, social, economic and infrastructural challenges. However, researchers should be encouraged to explore this application in order to detect future trend (forecasting) and make researches more globally acceptable.

Key words: Geospatial, satellite, vegetation, imageries and ecosystem.

INTRODUCTION

Vegetation is an assemblage of plant species or plant community (Burrows, 1990). Vegetation is formed by plant species growing as a result of a long developmental process which is consistent with the ecosystems they inhabit. Thus, it can be understood as the effects of various environmental factors on species cohabitation in space and time (FGDC, 2005). Globally, there are diverse vegetation typeswith distanced variability that give rise to different vegetation zones of a country in *Sensu-stricto* and in a continent in *Sensu-lato*. This is made possible as a result of continuous interaction of climatic conditions such as temperature, humidity, rainfall patterns (moisture) (Oyenuga, 1967) and soil types (Iloeje, 2001; Adefioye, 2013; Fashae *et al.,* 2017). It is broader in concept than the term 'flora' which means species composition.

The importance of vegetation in ecosystem services based on Ramsar Convention ranges from provisioning, habitat support, cultural and regulatory services (Olalekan and Gordon, 2011). Change detection programmes of geospatial tool at the local, regional and continental scale have been applied to vegetation zones for their analyses of variation in phytosociology as well as vegetation dimension. The increasing depletion of vegetation cover and change in girth dimension in various countries revolves on two major factors which are either anthropogenic or natural. Anthropogenic activities (hydrocarbon exploration / exploitation, domestic

*Author for correspondence

vegetal cover (Fashae *et al.,* 2017). It is, however, important to note that these factors do not work in isolation but in synergy with other agents of environmental vicissitude.

Change detection is a process of identifying, monitoring and managing differences in the state of natural resources in any vegetation complex at different times (Singh, 1989). It involves studying and understanding pattern and process of forest cover change, causes and human response to such change (IGBP / IHDP, 1999).

The rationale for this review was based on the fact that prior to the 21st Century geospatial application, vegetation change detection analysis was made possible using field measurements, ground troting, historical maps and aerial photographs (Smith *et al.*, 2010). These processes were associated with low interpretation, time consumption and crude, thus making it difficult for a timely broad area coverage (FORMECU, 1996). Presently, changes are detected using new, improved and emerging technological tools that are aimed at promoting and expatiating on the value chain and significance of satellite-based geospatial technologies (Global Positioning System [GPS], Remote Sensing and Geographical Information System [GIS]), their need in vegetation analysis and management especially in developing countries like Nigeria (Ademiluyi *et al*., 2008). These satellite- based geospatial technologies have vast applicability and are automated; they have proven to be faster, less stressful, non-cumbersome and time-effective compared to the sole usage of historic maps and ground measurements. However, the cost of image acquisition and image resolution and unavailability of some imageries are a major challenge to the use of this method. Globally, it is effective in monitoring the changing patterns of vegetation and ecological systems as well as statistical analysis (Oyinloye and Kufoniyi, 2011), detecting position and changes in certain earth features over a period of time, conservation practices, harvest planning, fire management and map production (Sonti, 2015) amongst
others. However, there is paucity of its diverse application in developing countries like Nigeria due to several challenges (Njike and Daniel, 2013); yet, there is hope for its successful and effective application within the shores of the country.

The present review was aimed at evaluating the trend of geospatial tool application in change detection and analysis of vegetation for sustainable management priorities, with the objectives of understanding the concept of satellite and geospatial technology, geospatial tool application in the detection of changes in vegetation particularly in Nigeria and some other parts of the world, the significance of geospatial technology in vegetation management and ascertain the challenges associated with the potentials of geospatial tools.

SATELLITES AND GEOSPATIAL TECHNOLOGY: A CONCEPTUAL OVERVIEW

The emergence of information and technology age plays a large and important role in gathering, compiling and synthesizing data using satellites and geospatial tools (GPS, Remote sensing and GIS) (O’neil *et al.,* 2003).

Satellites

A satellite is an electronic device (Fig. 1) that moves around the earth or another planet after being launched into space. It is used for communication by radio, television etc and for providing information. It is in two categories (artificial and natural satellites). The artificial satellites are semi-independent computer- controlled systems intentionally sent into space to orbit round the planets while the natural satellites include planetary galaxies such as the sun and moon (Hornby, 2010). It’s the satellite that helps in gathering change detection information for analyses and interpretation.

Since the launch of the first artificial satellite in 1957 by the Soviet Union, several others (over 6, 600 satellites) from over 40 countries have been launched. These include Astronomical satellites, Biosatellites, Communication satellites, Earth observation satellites, Navigational satellites, Spaceships, Weather satellites, Agricultural satellites, among others, for various purposes. These satellites are what make geospatial technology functionally applicable.

Fig. 1: A launched satellite in space
Source: www.flatearthperspectives.wordpress.com (2018)

Geospatial Technology

Spatial describes the relationship of objects within space. It entails collective data and the associated technology that has a geo-locational component. The word 'Geospatial' relates to information that identifies where particular features are on the earth's surface (Gislounge, 2017). Geospatial technology refers to all forms of technology used to acquire, manipulate, enhance and store geographic information and inquiry (Gislounge, 2017). It also entails a range of modern tools for data analysis of the earth, human societies and geographic mapping *(*Palaniswami *et al.*, 2011).

Such data can be converted or displayed across a landscape as charts, drawings or as maps. These technologies provide a means to handle complexities, such as incorporating scale and hierarchy concepts into ecosystem-based management approaches thus leaving a footprint in decision-making process (O'Neill, 1996). Virtually all geospatial technologies or tools are satellite-based and automated. These include GIS, Telemetry, Aerial photography, Remote sensing, Satellite positioning systems such as the Global Positioning System (GPS) (Ademiluyi *et al.*, 2008).

The increasing availability of geospatial technologies and geospatial data at various spatial, spectral and temporal resolutions have been of immense help in monitoring the changing pattern of vegetation and also offers the potential to monitor biophysical characteristics of ecological systems (Oyinloye and Kufoniyi, 2011; Adefioye, 2013). For millennia, humankind has endeavoured to map the Earth's surface and identify spatial relationships. But the precision with which we can locate geographic features has increased exponentially with satellite positioning systems.

Satellite-Based Geospatial Tools: Pre- and post- application

Satellite imageries and topographical maps of an area together with geographical coordinates of selected ground control points have been used for registration and image-matching, classification and processing (Ayuyo and Sweta, 2014). There are two phases in the application of geospatial tools in the change detection of any vegetation zone, viz: the *in-situ* and *ex-situ* analytical phases.

***In-situ* analysis**

The *in-situ* analysis is based on ground troting field work which uses satellite-based hardware such as the GPS. The GPS takes the coordinates of a sampling area. In the course of field work, such an area could be divided into sampling plots and sub-sampling units using transects and with the measurement of area taken . The GPS takes the X (longitude) and Y (latitude) coordinates and altitude above sea level of each sampling plot in order to ascertain the location (Z) of the sampling plot. This can be used for the post-field work analysis by other geospatial tools. It can also be used to record the coordinates of dominant plant species to ease the geospatial software application.

The global positioning system technology is a satellite and ground-based radio navigation and location system (Fig. 2) that enables the user to determine a very accurate location on the earth surface with precision accuracy of 10 to 20 metres (Sonti, 2015) and more level accuracies in centimetres. GPS helps land, sea and airborne users locate where they are on earth 24 hours a day by triangulation of earth-orbiting satellites. Typically, three satellites are needed to obtain a triangulation; the GPS receives signal from at least 2 satellites which give the latitude and longitude and the third satellite gives the altitude. A minimum of 24 satellites orbit the earth at least twice a day for the GPS to function normally.

Fig. 2: A GPS receiver
Source: www.vectornav.com (2018)

(i) *Ex-situ* analysis

The *ex-situ* analysis is a post-field work software geospatial tool involving remote sensing and GIS. The following methods can be used for vegetation detection and analysis and off-site detection of spatial patterns in the space.

(ii) Remote Sensing (RS)

Remote sensing technologies are used to gather information about the surface of the earth from a distant platform, usually with a satellite or airborne sensor without touching the object (Sonti, 2015). Recently, many remotely-sensed images have been acquired by a range of airborne and space-borne or remote sensors (Xie *et al.,* 2008). Most of the remotely sensed data for mapping and spatial analysis was based on reflected electromagnetic radiation processed into a digital image that can be overlaid with other spatial data (Chuvieco and Congalton, 1989). These images range from multispectral to hyperspectral sensors (Table 1) and with spatial resolutions from submeter to kilometres captured at varying portions of the electromagnetic wavelengths from visible to microwave parts of the spectrum. A variety of remote sensors have made available imageries (Figs. 3, 4 and 5) with a range of temporal frequency, spatial and spectral resolutions from some objects, area or phenomenon. The temporal frequencies of sensors range from 30 min. to weeks or months. This means that there is hardly any application found in built-up and natural environment devoid of image that can be applied to its study (Xie *et al.,* 2008). It measures both the visible and invisible features of a location or site and also converts the point measurements of continuous spatial information (Sonti, 2015). The remotely-sensed data is also an important means of mapping, monitoring and updating information/data of vegetation maps (Nwosu and Ugwuoti, 2013).

Table 1: Types of remote sensors used for change detection in vegetation assessment.

Satellite and Aircraft (Remote) Sensor	Spatial Resolution	Biophysical Variables for Vegetation
Landsat 7 (ETM+)	15 m Panchromatic (Pan) bands; 30 m in the sex VIS, NIR, IR and shortwave (SWIR) infrared bands; and 60 m in the thermal infrared bands	Designed to monitor seasonal and small-scale processes on a global scale such as cycles of vegetation and agriculture
Landsat 8 (OLI)	15 m pan bands; 30 m in the sex VIS, NIR, SWIR1, SWIR2; and 30 m in the cirrus bands ASTER 15 m in the VIS and NIR range, 30 m in the shortwave infrared band	Land cover classification and change detection
NOAA (AVHRR)	1.1 km spatial resolution	Large-area land cover and vegetation mapping
SPOT	5 and 2.5 m in single-band and 10 m in multiband	Land cover and agricultural
Geo-Eye / IKONOS	Panchromatic at 1 m resolution and multispectral at 4 m resolution and colour images at 1 m	Pigments Canopy structure Biomass derived from vegetation indices
Digital Globe's / Quick Bird	Panchromatic with 61 cm resolution and multispectral images with 2.44 m resolution and colour images with 70 cm	Leaf index Vegetation stress Absorbed photosynthetically active radiation
RADAR (SAR)	3 m resolution	Evaporations
LIDAR	0.5–2 m resolution and vertical accuracy of less than 15 cm	

Source: Al-Kindi *et al.* (2017).

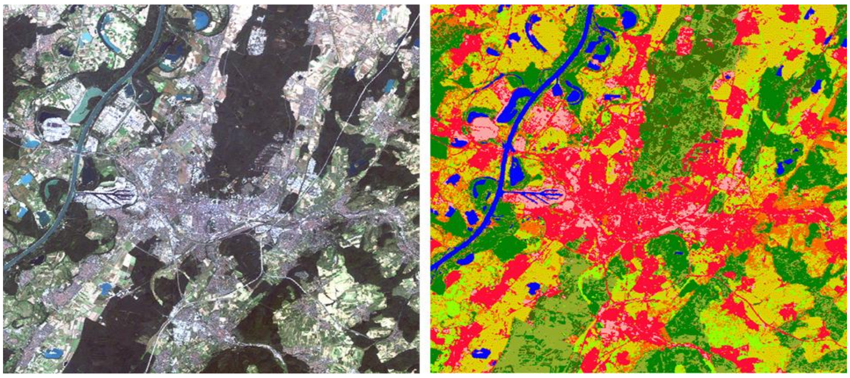

Fig. 3: A classified satellite image from the Karlsruhe region showing landuse obtained from LANDSAT.
Source: www.soes-project.eu/modules.com (2018)

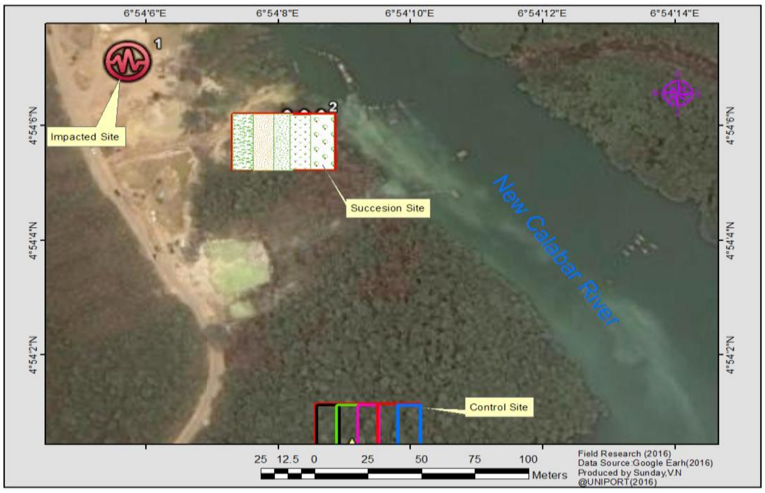

Fig. 4 A classified satellite image from Sampled Transects site along New Calabar River, Isiodu location in Nigeria showing dredged land use obtained from LANDSAT (Edwin-Wosu *et al*., 2017)

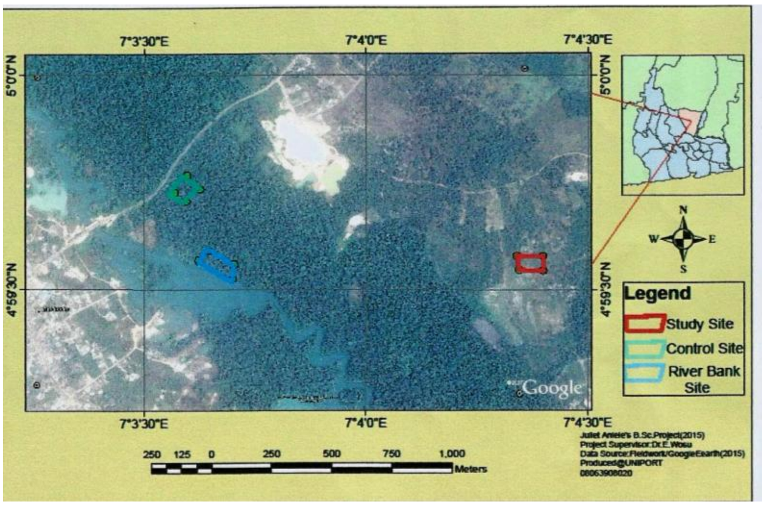

Fig. 5: Chokocho satellite image view of the established succession, controlled succession and colonized succession (River bank) study sites obtained from LANDSAT (Edwin-Wosu and Anaele, 2018).

Based on the fact that different sensors have different spatial, temporal, spectral and radiometric characteristics, images come with different degrees of spatial characteristics. Some sensors acquire images at very high resolutions while others acquire images at very low resolutions. Also, the regularity with which they revisit a particular spot differs. While some have very short revisit time of few hours, others return only after weeks or months. Different objects / materials by their nature on the earth's surface absorb, transmit and reflect the different wavelengths of light from the sun in varying degrees (Bertels *et al*., 2005). Therefore, the choice of imagery to be used is of fundamental and critical importance in determining the level of success that can be achieved in change detection analysis (Xie *et al*., 2008). Consequently, the selection of appropriate imagery is very important for mapping vegetation cover. This makes every vegetation zone on the earth's surface have a 'unique' spectral identity for its own identification. The choice of imagery to be used in a mapping project for the analysis of change detection is predicated on several factors including the mapping objective, cost of images, climatic conditions and technical issues in image interpretation and data generation (Xie *et al.*, 2008).

(iii) *Geographic Information System* **(GIS)**

Recent advancements in capabilities and increased availability of GIS in performance of spatial analysis, image processing, statistics and modelling within the same system are key factors in developing approaches capable of dealing with the complexities of vegetation and analyses (Tueller, 1999). The geographic information system is a general-purpose technology involving the use of computer system in handling location and attributes of geographically referenced data in digital form (Chang, 2010). It has been described as any computer-assisted information system for the acquisition, integration, storage, editing, analysis and display of geographic data and information for decision-Making (Wikipedia, 2017). It is one of the most evolving aspects of geospatial technology which has metamorphosed through several stages involving desktop application in the 1980s, enterprise GIS in the 1990s and then the distributed GIS of the 21st Century evolution currently in transition from mobile GIS via web GIS to cloud GIS (Yusuf, 2012). Furthermore, the GIS entails hardware (computers and workstations) and software (computer programmes), with more computing power (speed and memory) in combination with large computing storage (disk space) (O'neil *et al*., 2003). The power of a GIS is its ability to synthesize information about spatial phenomena in vegetations by integrating geo-referenced data to show the original data and derived information in new ways and perspectives (Arnoff, 1989).

The GIS uses any information that has to do with location expressed in many ways such as latitude and longitude, address or even zip code (Google, 2017). The GIS compares, contrasts and analyzes information and relationships between features and their associated data (Anon., 2015). It also enables the storage, management and analysis of spatially distributed vegetation data such as crop yields that might be associated with fields or experimental plots, represented on a map by polygons (Sonti, 2015). GIS maps are very interactive by comprehending the geospatial distribution of plant species for intelligent decision-making (Sonti, 2015).

The GIS aids in the production of vegetation maps, which is a visual representative image of data and models that predict the trend of a particular vegetation. It has been found useful in the determination of the quantitative and qualitative phyto-sociological analysis of vegetation. For every change detection, the GIS application has various soft wares for different purposes; algorithms, models and technique as well as various classification approaches in order to classify images obtained from the remote sensor. A technique applied by most GIS users is the use of NDVI (Normalized Difference Vegetation Index) with high features of interest for image enhancement or transformation of obtained imageries for the required number of periods or length of change. Others include ERDAS Imagery, Environment for Visualizing Images (ENVI), ER Mapper, IDRISI, ArcGIS from ESRI and QGIS (Ayuyo and Sweta, 2014; Ghandi *et al*., 2015). The choice of software is based on the potency to aid the analyst to extract information from imagery as much as possible and classify the area covered by the imagery as accurately as desired (Xie *et al.*, 2008),

An important decision in designing a spatial database for vegetation study is the selection of the underlying geo-reference system and spatial resolution. Although the choice of scale may be strongly influenced by existing data, the selection is important for establishing a common system for data integration, addressing data-quality issues and specifying detection limits (Tueller, 1999). An understanding of precision and accuracy of data within a GIS is also important. Though a GIS can mechanically reformat and transform data from different sources into a common system, yet it is the responsibility of the GIS user to determine the consequences of integrating data that have been collected at different scales, represented by different topological structures, digitized with varying degrees of precision, or containing other sources of errors. Thus, the integration of Remote Sensing and GIS can aid in detecting as well as analyzing changes, trends, magnitudes and the emanating environmental impacts in vegetation zones / area over several decades (Adefioye, 2013; Ayuyo and Sweta, 2014; Fashae *et al.*, 2017).

GEOSPATIAL TECHNOLOGY: AN ANALYTICAL DETECTION TOOL FOR CHANGES IN VEGETATION

The concern for change detection or determination entails the integration of different geospatial technologies in vegetation studies. The most common component of geospatial application involves two or more of the geospatial tools. The idea of integration started with the use of remote sensing data as ancillary data in GIS for satellite image classification. In recent times such integration has included computer-aided design (CAD), GPS, survey data, internet, RFID, geosensor and telecommunication (Yusuf, 2012). Remote sensing and GIS technology offer a good source of geospatial information for ecological and vegetation resource management (Hansen *et al.,* 2013; Lillesand *et al.,* 2015). Though GPS, Remote sensing (RS) and GIS are similar in terms of map production which helps to detect changes within vegetation, yet they are used at different stages in the production of a map (Google, 2017). Several studies have shown that field measurements and remote sensing data are used to detect and describe vegetation properties and analyze changes in their boundaries (Weiss and Walsh, 2009; Zhang *et al*., 2009).

Prior to the application of geospatial tools in change detection of any vegetation, there are pertinent questions ('where', 'how', 'what' and 'why'?) such as: (i) Where is the vegetation located? (ii) How is the present condition of the vegetation? (iii) What are the changes to be detected or what is the trend of change? and (iv) Why the need for change detection? that might need resolution.

Geospatial tools especially the GIS is a tool that can be used because it answers the question of location, condition as well as trends which are necessary in change detection analysis (Upadhyay, 2009). The feasibility of geospatial application in carrying out change detection involves the integration of geospatial tools with field measurements as well as ground trotting. Several studies have utilized geospatial tool application in the detection of changes within various vegetation types ranging from rainforest, mangrove, arid ecosystems as well as the ecotone in the light of vegetation, floral composition, cover and structure in both terrestrial and aquatic ecosystems (Adefioye, 2013; Ayuyo and Sweta, 2014; Ivanova and Soukhovolsky, 2016; Fashae *et al.*, 2017; Weilgolaski *et al*., 2017). This entails some important steps involving the location of vegetation of interest for reconnaissance survey, *in-situ* ground trothing field work by GPS, and *ex-situ* post-field work by remote sensing and GIS.

Prior to geospatial tool application, traditional field observation, assessment and survey methods involving manual sampling have been used though with difficulty, delay,
time-consumption and cost implication in data acquisition and analyses (FORMECU 1996). Since large-scale, long-term, cost-effective monitoring and mapping tools are required, these were addressed by means of geospatial technology (Keunser *et al.,* 2011). These tools are becoming increasingly important in the field of Plant Sciences and other fields of agro-allied ventures. Spatial and non-spatial information have been used in various aspects of forest phytodiversity and conservation measures (Weilgolaski *et al.*, 2017).

SIGNIFICANCE OF GEOSPATIAL TECHNOLOGY IN VEGETATION MANAGEMENT

Geospatial technologies have been adopted for better management of natural resources for a sustainable ecosystem production (Palaniswami, 2011). It has proven to play a vital role in vegetation management and conservation measures particularly with reference to Nigerian experience in diverse application in the following ways:

Vegetation resource location and management

Monitoring changes in forest as well as inventory data collection are among the critical factors in forest management activities (Wulder and Franklin, 2007). Geospatial tools can build on the above trend by incorporating models to guide activities such as timber harvesting, silviculture and fire management activities (Wulder and Franklin, 2007). Over the last century, it has been noted that forest cover of the world has declined at an alarming rate but with the application of geospatial tools, a forest manager can generate information regarding forest cover within the study area, human encroachment into forested land and desert-like encroachment (Figs. 6) (Sonti, 2015). The integrative use of remote sensing and GIS helps to determine the presence and distribution of vegetation within a protected area, check the presence of invasive species within the protected ecosystem and to combat desertification by helping the forest managers to know the land use practices of an area, the vegetation in it and the land-use impact on the environment (Google, 2017).

In managing natural resources, critical information will help in the process of decision- making to ensure that effective polices are put in place to control the manner in which forest resources are utilized. Finally**,** GIS has proven to be of great help in resource management because it helps the forest managers to make proper decisions for a systematic identification and harvesting of only matured timbers while the young ones are allowed to attain full maturity, thereby making way for sustainability (Sonti, 2015).

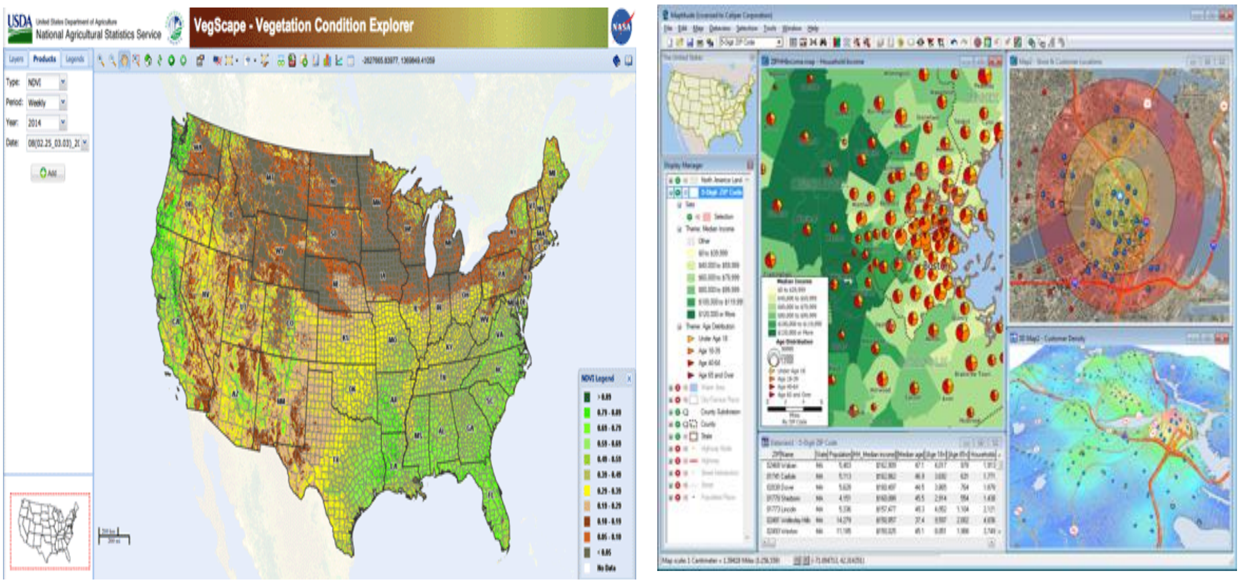

Fig.6: Geographic Information System for vegetation resource location and management
Source: Sonti (2015)

Harvest Planning

A good forest management practice requires a detailed planning of harvesting activities. Harvest planning activities include the identification of felling direction, extraction routes, depots and sensitive zones such as wetlands (Kane, 1997). Maps generated by the use of cartographical tool like GIS constitute a basic planning procedure and tools needed for harvesting activities (Kane, 1997). Some other tactical harvest planning utilizes the map to identify planned felling over a number of years and to consolidate felling areas and extraction routes thereby permitting the efficient use of harvesting equipment and some other resources. It is used to access the existing forest resources and develop harvest schedules and some programmes to project more timber supplies and other operational planning activities. Geospatial tools store and analyze the forest information. It could also help in calculating the harvestable timber in the forest.

Fire Management

The effect of fire on vegetation resources is another important management concern. This calls for accurate and timely information highly crucial for the safety and protection of the vegetation from fire incident (Kane, 1997). Data acquired by satellites enable fire-fighters to be dispatched on time and to the accurate location so that damage from such fire will be at a minimal level. The use of GIS in fire management in a forest region involves activities such as prevention of fire outbreak, wildlife control, prescribed burning and post-fire recovery actions, fuel mapping, weather condition mapping, fire danger rating and also to stop or reduce the rate of forest fires (Chuvieco and Congalton, 1989).

It also allows the forest managers to have a better view and understand the physical features and the relationships that influence fire behaviour (Fig. 7), and the likelihood of fire occurrence which can then be modelled to detect fire outbreaks by using fire models such as canopy cover and stand height, with the help of remote sensor (Ejikeme *et al*., 2013).

Using the GIS-fire models, new insights in fire danger situation can be gained; to give sound, accurate and efficient information to forest fire management personnel responsible to the containment and extinguishing of wild fire (Ejikeme *et al*., 2013). GPS and GIS have been proposed and used as an effective tool in managing fire disasters in parts of Nigeria including areas such as Onitsha metropolis in Anambra State. It helps in tracking areas of fire outbreak and graphically display features on the ground and to perform query on them, respectively. The analytical capabilities of geospatial technologies could also detect the shortest route as well as model housing pattern and location of important features, thereby providing a quick response to fire outbreak (Ejikeme *et al.*, 2013).

Fig. 7: The GIS Analysis of Fire in Vegetative Management
Source: Sonti (2015)

Map development and production

In natural resource management, the GIS and remote sensors are mainly used in the mapping process. Map production is a central function of Geographic Information System which stores data in database and provides a visual interpretation of data represented in a mapped format. The use of geospatial tools (GIS and remote sensor) in checking the geospatial distribution of vegetation via map production helps forest managers in their daily activities. For instance, plantation maps are commonly used for location purposes and may contain some useful information like roads, rivers, water points, compartment boundaries, planted species, topography, fire breaks and infrastructural features (Figs. 8, 9) (Kane, 1997; Edwin-Wosu *et al*., 2017). The first important step in precision agriculture is to generate a map for crop, soil characteristics and the base for spatial variability control of plants (Mandal and Ghosh, 2000).

The visual and digital data collected with the use of remote sensing technology is usually analyzed to generate a pre-field map containing information like soil tone, texture, pattern, association, size and shape (Peter, 2012). In the use of GIS to produce map, ground verification is often carried out using pre-field map / ground trothing and GPS in order to know the location and to verify the information regarding the state of the vegetation, geomorphology, topography, soils and consequently produce the final map (Peter, 2012). Varieties of maps including land cover maps, vegetation maps, soil maps and geology maps have been produced using these technologies.

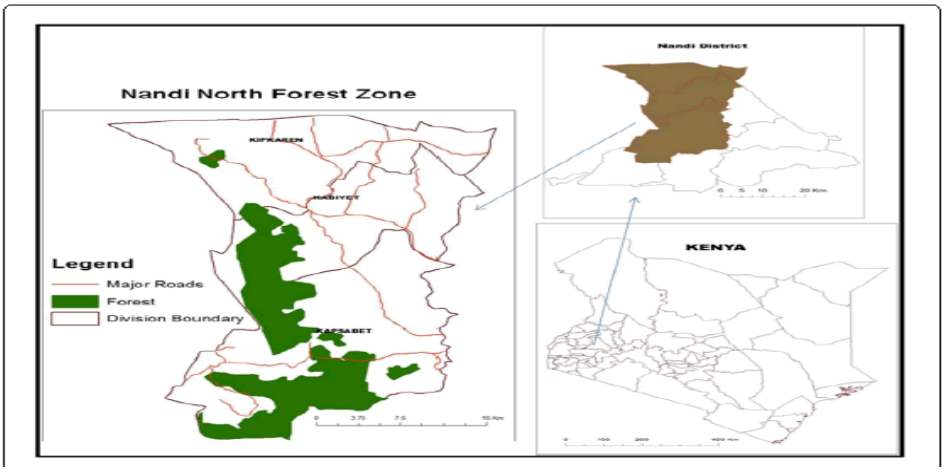

Fig.8: Maps generated with the use of geospatial tools.
Source: Sonti (2015)

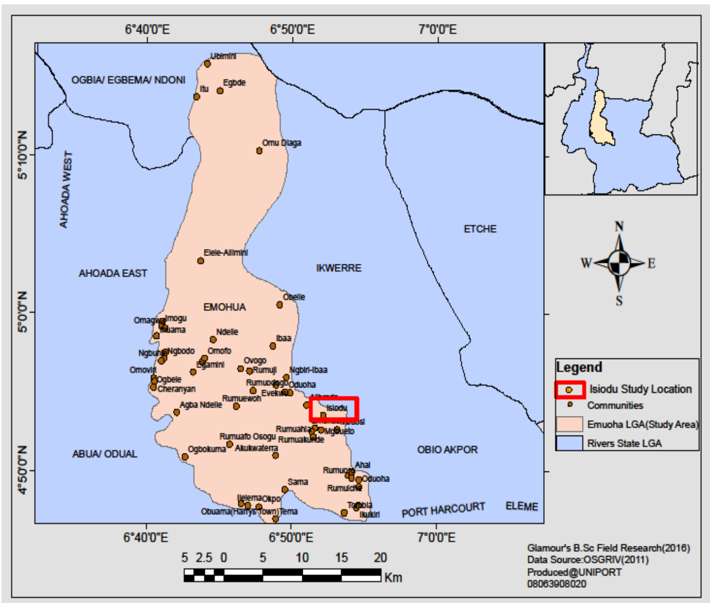

Fig. 9: Map generated with the use of geospatial tools showing Isiodu Community Study Location in Emohua (Edwin-Wosu *et al.*, 2017).

GIS for strategic planning and modelling

In vegetation management, strategic planning involves making predictions about what the future vegetation will look like relative to alternative management activities. GIS as a tool for strategic planning helps to determine the current conditions of vegetation within a study area. This ability is crucial to nearly all aspects of management forecasting. GIS stores both the geographic and numerical structures of forest stands and links the spatial database to the planning models. It allows forest manager to effectively add the temporal and spatial dimensions to the management planning process (Kane, 1997). Within the limits of the model and inventory, the forest manager will be able to map out the future trend of the forest in the light of land use, infrastructure, settlement, distribution, physical and environmental characteristics and other relevant spatial features and relationships between them. It also models spatial analysis in order to address questions or gain useful knowledge, thus creating new information from the spatial data (Dave, 2008).

CHALLENGES OF GEOSPATIAL TOOLS IN VEGETATION ANALYSIS

There are peculiar challenges involved in the application of geospatial tools or technologies in vegetation analysis among other areas of its application. Corroborating Njike and Daniel (2013), some challenges of geospatial tools in Nigeria are listed below. However, these have been categorized into four major levels, viz:

Institutional Challenges

i. **Failure or poor understanding by decision / policy makers**: Decision and policy makers do not understand the potential implications as well as benefits of geospatial tools; and have not come up with possibly flexible laws and policies that might favour their usage, inculcate more awareness or proper harnessing by various sectors of human endeavours.

ii. **Rigid administrative networking**: Administrative bottlenecks, corruption and lack of transparency in the discharge of set goals that might influence the workability and sustainability have been noted as limitations to the application of geospatial tools.

iii. **Insufficient funding**: No sustainable or sufficient counterpart funding (and if ever in existence) between the Government Institution and private organizations for the advancement of geospatial technological usage (Hageplex, 2016).

Social Challenges

i. **Lack of qualified personnel**: This is one of the major setbacks to geospatial technology application in developing countries around the world like Nigeria compared to developed countries like Europe and America. Only few persons understand and have the knowledge to use and apply geospatial tools in vegetation analysis. This makes it really expensive to be used as one has to pay heavily for the services of the few qualified personnel within the country.

ii. **Apathy for awareness, research and training**: Lack of zeal on the part of Nigerian researchers and trainers, coupled with insufficient awareness on the availability and potential of geospatial application in all fields of specialty.

Economic Challenges

i. **Finance**: The hard and software of geospatial technology are very expensive and sophisticated. This poses a serious challenge for people to learn, buy and even use them to get result, especially in the modelling aspect and purchase of remote-sensored imageries.

Infrastructural Challenges

i. **Data and network limitations**: The use of geospatial software in the analysis of vegetation requires a very large amount of data and consistent internet work connection. In Nigeria, data and network connections are both expensive and most often with poor signals. This poses a major problem due to break in assessing the remote sensors for imageries, leading to time and energy wastage, poor imagery and loss in resources.

ii. **Power supply**: In developing countries like Nigeria, the epileptic shortage and non-constant power supply poses a major challenge in the geospatial analysis of vegetation changes and its vulnerability. The impromptu power failure or light outage while assessing and using software geospatial tools often leads to wastage of resources, time and energy and generally poor production of maps and imagery.

iii. Poor educational system and inability to pursue technological development of the country coupled with gender disparity and poverty are limitations to geospatial application.

CONCLUSION

The use of geospatial technologies has been of immense help in monitoring and detecting the changing pattern of various vegetation covers. It provides some of the most accurate means of measuring the extent and pattern of changes in cover conditions over a period of time. A major benefit of the use of geospatial tools in detecting changes is that it gives more than one perspective compared to the use of prehistoric maps or ground troting measurements; also, it is faster, easier, saves time and energy and it is more accurate. It has the ability to improve organizational integration. Though of great importance in change detection, utilizing geospatial tools in analysing these changes is quite expensive and technical. Landsat Imageries as well as the acquisition of software are quite expensive.. Also, understanding their mode and operation are quite technical and expensive to be taught. In Nigeria, researchers should be encouraged to make use of geospatial technologies for their research as this will help in detecting future trends (forecasting) and in making their work widely acceptable by the world of researchers.

CONFLICT OF INTEREST

The authors affirm that this paper is devoid of any conflict of interest.

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