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The use of Geographic Information System (GIS) technology in the survey of forest for national development

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ABSTRACT: This paper presents the use of geographic information system (GIS) technology in the survey of forest for the purpose of accessing the resources in the forest for national development and suggesting proper ways of managing the resources that are limited to man and other living organisms. The forest ecosystem and land has an important and strategic role in the development of a nation. Increase in population from year to year causes an increase in the need for resources and land use, while the form and extent of land are relatively fixed. The traditional survey methods used in counting tree stands and other resources is prone to generalization and is not specific to phenomenon most of the time

KEY WORDS: GIS, National development, forest, resources

I. INTRODUCTION

The lives of living organisms are highly dependent on the environment they find themselves, the way an environment is treated by an individual leads to the survival of the individual and this has become increasingly complex and challenging due to natural resource exploitation and development. The forest ecosystem is a heterogeneous environment with great complexity consisting of mainly trees that buffer an earth and support a myriad of life forms. In addition to timber, forests provide such resources as grazing land for animals, wildlife habitat, water resources and recreation areas, it is also an important ecosystem that is valuable in providing food, shelter, fuel and medicinal ingredients to mention but a few. The rain forest ecosystem is located in the tropics where Nigeria belongs to. In Nigeria the forest is divided into three forms which are swamp forest, mangrove forest and rain forest, these forest provides about 40% of the net primary production of terrestrial energy due to high solar radiation, an all year growing season, heavy rain fall, constant moisture budget surplus, rapid decay of leaf layer and recycling of nutrients. The tropical rain forest is a house to diversity of species more capable of adapting to and surviving in changing environmental conditions. Forests are important renewable natural resources and have a significant role in preserving an environment suitable for human life. The productivity of this important ecosystem is based on rapid and unbroken recycling of nutrients. The main issues concerning forest management are depletion due to natural causes and human activities and monitoring of health and growth for effective commercial exploitation and conservation. With the increasing population's need for land use, it can lead to land issues related to increased demand for land use. Xie, Wang, and Huang, (2013) gave such issues to include:

1. Decreased in the land for agricultural activities, which are transformed into settlements, industrial or other non-agricultural land uses.
2. The emergence of new areas that are utilized for settlements that is unfit for habitation and not by the spatial plan of the region, for example on the river edge, in areas of steep slopes prone to landslides.
3. The appearance of productive agricultural land that was previously productive as a result of the sporadic growth of settlements on agricultural land, thus disrupting the irrigation and lack of incentives for farmers.
4. Decreased in the environmental quality due to the use of land that is less attention to the balance of nature and can lead to various natural disasters, such as flood, landslide, and lack of clean water.
5. The increasing amount of waste caused by various land uses that can cause pollution and disrupt various aspects of human life and other living things

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Development is a critical factor and a desirable phenomenon in the sustenance and growth of any nation, an encompassing process involving the steady and systematic change in the cultural, economic and political spheres of society in a way that increases production, empowers the people and their communities, protects the environment, strengthens institutions, grows quality of life and promotes good governance (Lawal and Oluwatoyin, 2011; Woleola, 2015). National development includes controlling human impacts on the environment, it requires efforts made to eliminate poverty and reduce the number of hungry people. In Nigeria overpopulation and the depletion of natural resources, food security, overexploitation of ecosystems for direct use and non-use utility are among the human-environmental issues which have created ecological injustice, different forms of innovations are therefore needed for technological development which is the base for national development. One of such innovation is the use of Geographical Information System (GIS) Technology in the management of forest ecosystem.

Forestry involves the management of a broad range of natural resources within a forested area. Forest resource management in today's ever changing world is becoming more complex and demanding to forest managers. Traditionally forest managers use survey techniques to measure the extent of the forest and site samples to records stands of tree and this is prone to generalization and not specific to a phenomenon most of the time. In an attempt to bridge traditional method the use of GIS was introduced as a potential means of dealing with this complexity.

One of the key steps toward national development economically and forest ecosystem is resource development and has the potentials for national development, especially among developing nations that seeks to transform from import-dependent to self-reliance economies. Although it seems that the forest ecosystem is economically invaluable, there are ecological problems arising from habitat fragmentation and biodiversity loss due to developments of different scales. (Chang *et al*., 2012; Yigitcanlar and Lee, 2014; Yigitcanlar and Dizdaroglu, 2015, Onwuka *et al*., 2017; Musa *et al*., 2017). This include climate change and changing precipitation regimes which have been projected to cause other natural hazards such as desertification, drought, exposure to diseases, compromise food and water security, amongst many (World Bank, 2010; IPCC, 2014; Ifatimehin et al., 2016). There is therefore urgent need for effective and resilient development planning by relevant authorities to combat this situation.

Upadhyay, (2009) stated that "Geographical Information Systems is an information technology that has been used in public policy making for environmental and forest planning and decision making over the past two decades". GIS and related technologies provide foresters with powerful tools for record keeping, analysis and decision making. A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface (Anon, 2015). It can also be seen as a system of the integration of spatially referenced data for decision making in a problem solving environment.

A.WHY USE GIS IN FOREST MANAGEMENT

Upadhyay (2009) pointed out that GIS is a good tool for forest management because it answers the following question that helps in forest management activities.

- Location: What is at?: This shows location of forest resources in the earth in many ways such as a place name, post or zip code, or geographic references such as latitude and longitude.
- Condition: Where is it?: Explains non forested land of certain size distance from road or river.
- Trends: What has changed since?: It helps to find out what has changed within study forest or land use an area over time
- Patterns: What spatial patterns exist?: Determine whether landslide in forest area
- Modelling: What if?: Determine what happens, if a road network is added in a forest.

GIS enables us to see different kinds of data on one map, such as streets, buildings, and vegetation. This enables people to more easily see, analyze, and understand patterns and relationships. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships. GIS technology is a crucial part of spatial data infrastructure, which the White House defines as "the technology, policies, standards, human resources, and related activities necessary to acquire, process, distribute, use, maintain, and preserve spatial data." GIS has proven to play a vital role in the following

• Resource Management
• Harvest planning
• Fire Management
• Map production
• GIS for strategic planning and modelling

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GIS can be established to provide crucial information about resources and can make planning and management of resources easier, for example, recording and updating resource inventories, harvest estimation and planning, ecosystem management, and landscape and habitat planning (Upadhyay, 2009). The use of remote sensing and Geographic Information System (GIS) tools generally have been found handy in spatial sciences as they provide a more objective, synoptic and continuous coverage of large areas, suitable for locating or for citing facilities and utilities, even in very rugged and sensitive terrains, and understanding relationships that exists (Ujoh, Eneche and Obiegbu, 2018). This essay intends to show the significant value of forests and the potential of GIS to aid in their management.

B. GIS IN FOREST MANAGEMENT

Various studies clearly demonstrated the potential of integrating remote sensing, GIS and field information for landscape assessment (Thompson and Whitehead, 1992). GIS application in forest management in Africa has been used in various countries such as Kenya and Cameroun. Sonti (2015) reported that Kenya has a wide range of forests, from coastal forest, through central high mountain forests to the thick wet rainforests of the West which are an important source of livelihood, environmental services, and economic growth in Kenya and the forests of Cameroon are a resource of local, regional, and global significance. Their productive ecosystems provide services and sustenance either directly or indirectly to millions of people. Interactions between these forests and the atmosphere help stabilize climate patterns both within the Congo Basin and worldwide. In order to designate part of the local forest area as a potential community forest, the community must proceed through a sort of land use mapping and planning process. Wulder (2007) explained that following the advances in high resolution Remote Sensing Digital Data and Aerial Photography, mapping of the trends of cover changes have become relevant source of information for understanding land cover pattern changes.

The application of GIS in forest management as given by Global Forest Watch, (2019) can be seen in the following areas: Forest Inventory, Forest Fires, Deforestation, Reforestation, Forest Heights, Vertical Point Profile Cut Lines, Illegal Logging, Forest Carbon Reserves, Agent-Based Simulation, Global Forest Watch, Drones, Wild fire Rescue, Vegetation Potential, Leaf Area Index, Amazon Rain Forest, Remnant Rain Forest, 4D GIS, Age of Trees, Forest Disease and Wild fire Simulation

The use of GIS for forest management planning involves making predictions about what the future forest will look like relative to alternative management activities (Sonti, 2015). This ability is important to almost all aspects of management forecasting, particularly long term wood and wildlife supply. According to Kane (1997) GIS stores both the geographic and numerical structure of the forest stands and links that spatial database to the planning models. Within the limits of the inventory and model, the manager can then map what the forest will look like in the future.

Forest managers require a wide variety of maps to assist with their daily activities. Plantation maps are most commonly used for location purposes and may contain additional useful information such as roads, rivers, compartment boundaries, planted species, and compartment size. Other features such as topographic features (contours), infrastructure, water points, fire breaks, neighbours and conservation areas may be also included in the map (Khalesian *et.al.*, 2009; Ujoh, Eneche and Obiegbu, 2018).

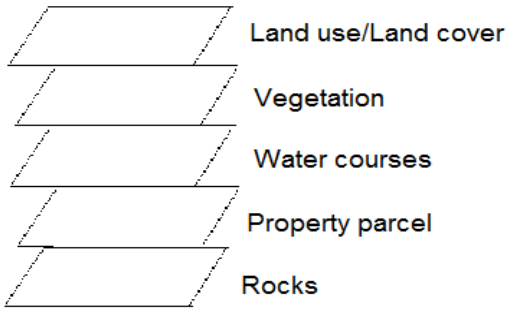

Fig1: Examples of layers in GIS for forest management

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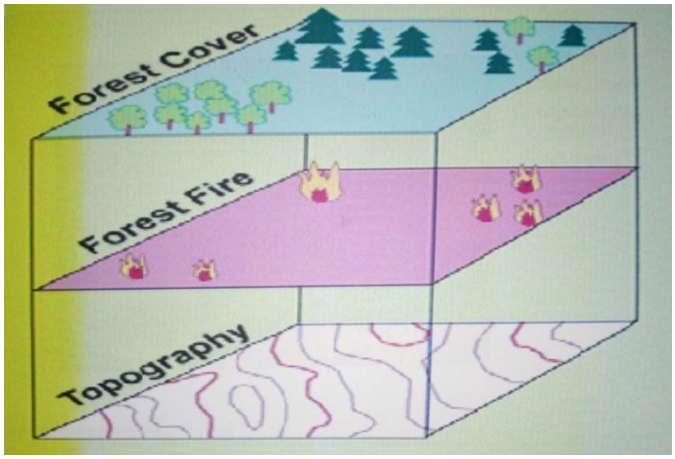
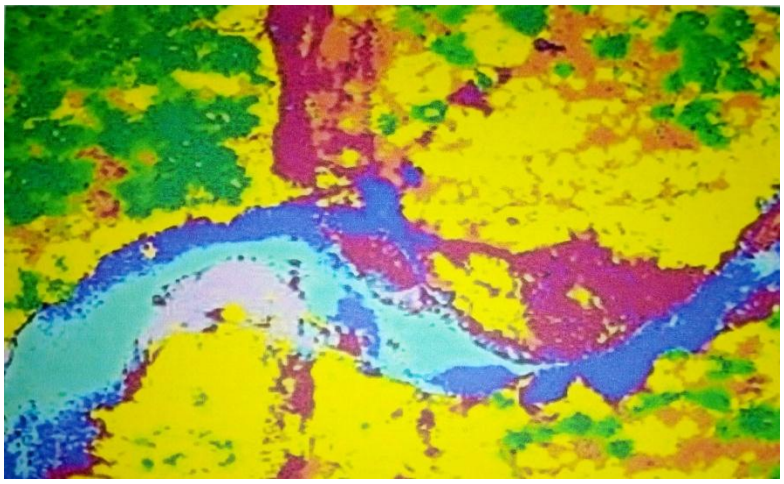


Fig 2: Overlay of features



Key

Dark green: conifers

Green: lower branches

Light purple: gravel

Yellow: deciduous

Orange: dry ground

Red: wet ground

Light blue: water

Dark blue: deep or clear water

Fig 3: Classification of vegetation ecosystem using GIS technology

Source: Macmillian Bloedel and ITRES Research Limited

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C.TREE DENSITY (stems/ha)

Stand area (hectares) 9.0
Total number of trees 520
Tree density (stem/ha) 58
Crown closure (%) 12.46
Average tree crown area (sq m) 21.47

The effect of fire on forest resources is another important management concern. Management activities include fire prevention, wildlife control, prescribed burning, and post fire recovery actions. The loss of timber, damage to life and property, loss of recreation value of the forest and the destruction of wildlife habitat are also consequences of forest fires. Extinguishing fires faster by understand how they grow in discrete steps bringing together wind, weather and fuel for the fire is better done by GIS. The modelling capabilities of GIS have been quite effective in this context. Forest fire managers have used GIS for fuel mapping, weather condition mapping, and fire danger rating. Forest fires have an important influence on the vegetation cover, animals, plants, soil, stream flow, air quality, microclimate, and even general climate (Sonti, 2015).

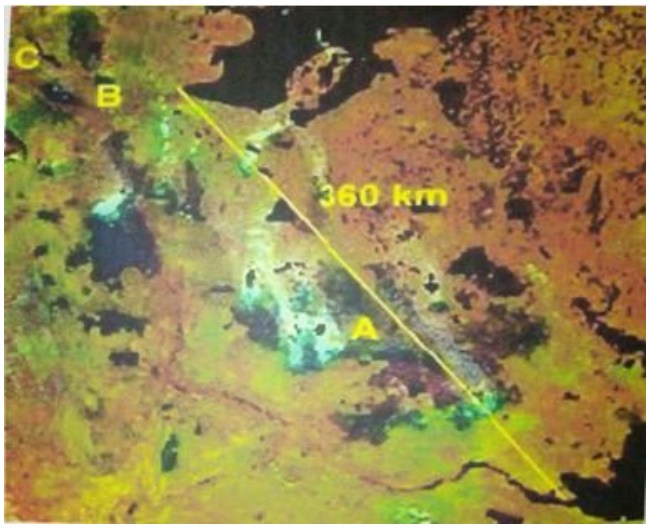

Fig 4: Burned and burning forest

The key to managing approved burning activities was the ability to anticipate fire behaviour after ignition. Chuvieco and Congalton (1989) explained that fire behaviour models have been developed from fuel models to predict the fire intensity based on factors such as slope, elevation, site exposure, wind speed, relative humidity, cloud cover, temperature, and live and dead fuel moisture. These models are not spatial, however, and are typically used to predict fire behaviour for a fairly large area.

Harvest planning activities which include the identification of felling directions, extraction routes, depots and sensitive zones such as wetlands requires good forest management practice. Maps constitute a basic planning tool for these activities. Other tactical harvest planning functions utilize maps 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 other resources (Sardadi *et.al*.,2008).

Resource management: Wulder and Franklin (2007) mentioned that collecting forest inventory data and monitoring changes are critical to forest management activities. Yet, a GIS can build on these activities by incorporating models to guide, for example, timber harvesting, silviculture and fire management activities, or predict fuel wood and other resource supplies. Other priorities, such as providing for wildlife habitat, ensuring recreation opportunities and minimizing visual impacts of harvesting, are also growing in importance. Some applications deal with single management issues, such as timber production, while others illustrate how a mix of management concerns can be integrated through the use of GIS, such as timber production combined with habitat protection.

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Key

Dark green: Tall trees (thick forest)
Green: Short trees
Yellow: Grass land
Light yellow: Bare ground
Red: Rocks
Fig 5: Classification of land cover

II. CONCLUSION

The study brings to lime light the role of GIS in developing smart and objective policies which are capable of promoting sustainable ecological prosperity in the face of degrading ecosystem services and climate change, especially for countries striving to rapidly improve economic and living conditions, throughout the world, forests are subject to many demands. As a result, many forest management problems have the nature of multi-objective planning procedures. With increasing environmental pressure and social involvement forest management has become increasingly complex, the role of GIS in forest management becomes important as this allows empirical data capture and query in the field. Areas with high ecological connectivity are revealed, such that if a program is to be embarked upon, the government can plan and deploy resources for necessary implementation. In a sense, forestry applications embody the full scope of GIS technology. Thus its study provides an excellent overview of the state of the technology and its potential as a management tool for natural resource concerns.

Based on the findings of this study it is suggested that the government should develop phased programmes to objectively identify, effectively link and invest in green infrastructural development across ecologically vibrant areas in the nation Nigeria.

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