**PRINCE ABUBAKAR AUDU UNIVERSITY, ANYIGBA, KOGI STATE, NIGERIA**

# 18TH INAUGURAL LECTURE

## *GEOGRAPHERS IN THE FOREST: ISSUES, CONCERNS AND TASKS*

**BY**

**PROFESSOR ADESOLA OGIDIOLU**

**B.Sc. (Ibadan); M.Sc. (Ilorin); Ph.D. (Ibadan)**

**PROFESSOR OF GEOGRAPHY**

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**NATIONAL ANTHEM**

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|---|---|
| Stanza I | Nigeria, we hail thee,<br>Our own dear native land,<br>Though tribe and tongue may differ,<br>In brotherhood we stand<br>Nigerians all, are proud to serve<br>Our sovereign Motherland. |
| Stanza II | Our flag shall be a symbol<br>That truth and justice reign,<br>In peace or battle honoured,<br>And this we count as gain,<br>To hand on to our children<br>A banner without stain. |
| Stanza III | O God of all creation,<br>Grant this our one request:<br>Help us to build a nation<br>Where no man is oppressed,<br>And so with peace and plenty<br>Nigeria may be blessed. |

**PRINCE ABUBAKAR AUDU UNIVERSITY, ANYIGBA ANTHEM**

Prince Abubakar Audu State University, you stand in strength and pride
Showing the way for all who yearn
Standing firm in wisdom and truth
In Unity we grow
Committed to imparting knowledge, skills and learning
To all who long for excellence
Prince Abubakar Audu University, the pride of the world
We honour your virtues.

**TABLE 1: PRECEDING INAUGURAL LECTURES OF PRINCE ABUBAKAR AUDU UNIVERSITY, ANYIGBA**

| S/N | INAUGURAL LECTURERS | TITLE | DATE |
|---|---|---|---|
| 1 | Professor Sunday S. Arogba | Phenolics: A Class of Nature's Chemical Weapons of Self-Preservation | 26th August, 2008 |
| 2 | Professor Zacchaeus O. Apata | Unburdening the Colonial Burden: Lessons from History | 17th August, 2010 |
| 3 | Professor Steve Metibiba JP | Matrimony Between Two Healthcare System: An Unholy Wedlock? | 27th June, 2014 |
| 4 | Professor Stephen I. Ocheni | Accounting for Public Funds: The Leviathan of Government Bureaucracy | 28th June, 2018 |
| 5 | Professor Eniolorunda A. Tai Oluwagbemi | Scientific Elegance and Political Naivety of Food and Wood Sufficiency in Nigeria: The Take of an Agroforester | 28th June, 2018 |
| 6 | Professor Charles I. Oyewole | Coroner's Inquest: An Autopsy of the Man with the Hoe | 15th August, 2019 |
| 7 | Professor Odin Eboh Monday | Insanity and Life Pain Two Ancestral Curses: The Role of Village Herbalist | 24th August, 2019 |

| | | | |
|---|---|---|---|
| 8 | Professor Jimoh Habibat Isah | The Geography of Erosion in Nigeria: An Explanation | 30th August, 2019 |
| 9 | Professor Marietu Ohunene Tenuche | Neoliberalism: Forecasting Nigeria's Ungodly Romance with the East | 29th September, 2020 |
| 10 | Professor James Omale | Remedy or Poison? Double- Edge Sword Paradox of Alternative Medicine: The Concern of Toxicologist | 11th March, 2021 |
| 11 | Professor Stephen Jimoh Ibitoye | If Agricultural Revolution is the Answer, What is the Question? | 20th September, 2022 |
| 12 | Professor Eneojo Simon Attah | Intercropping: That there may be Enough Food | 19th February, 2025 |
| 13 | Professor Cornelius Ojo Orishagbemi | Food Research Innovations as Panacea for Post-Harvest Losses, Food Security and Safety: Renown Contributions of a Certified Scientist | 7th August, 2025 |
| 14 | Professor Daniel Friday Atidoga | The Annihillator's Sexual Intent: The Crime of Crimes and Demise of Tomorrow | 13th September, 2025 |

| | | | |
|---|---|---|---|
| 15 | Professor Faith Aladi Sale | Agroforestry: The Magic Bullet for Agricultural Land Degradation and Food Insecurity | 18th November, 2025 |
| 16 | Professor Patrick L. I. Ukase | Does History Really Matter? Knowledge and the Historian in a Society in Transition | 25th November, 2025 |
| 17 | Professor J.J Orugun | Decompressing The Complexities Of Contemporary Nigerian Employment Dynamics | 2nd December, 2025 |

The Vice Chancellor and the Chairman of this occasion
Honourable members of the University Governing Council
Deputy Vice Chancellor (Administration)
Deputy Vice Chancellor (Academics)
The Registrar
Other Principal Officers of the University
Provost College of Health Sciences
Dean, School of Postgraduate Studies.
Dean, Faculty of Social Sciences, Other faculties and Student Affairs
Heads of Department
Professor and Distinguished Members of Senate
My Lords Temporal and Spiritual
My Academic Colleagues
The Congregation and other Staff of the University
Special Guest, Friends, and Well wishers
Gentlemen of the press
Great PAAU students
Distinguish Ladies and Gentlemen.

## PREAMBLE

The Vice–Chancellor Sir, it is a great privilege and honour for me to stand before this great audience to deliver my inaugural lecture which is the first in the area of Biogeography and the second in the Department of Geography and Environmental Studies, Prince Abubakar Audu University Anyigba which consists of three cognate areas of physical Geography, Human Geography and Environmental Management. This inaugural lecture is the fourth in the Faculty of Social Science, Prince Abubakar Audu University, Anyigba.

I give glory to God Almighty who has given us this day for the actualization of a long and over–due dream of presenting my inaugural lecture. I thank God for His abundant grace and for life. I am thankful and grateful for His mercies, all glory, honour and adoration to His Holy Name.

Inaugural lectures as instituted under the University system have been used to serve many ends. Some of the lectures address contemporary issues which are important to the progress of societies. Some others focus on the research activities of the lecturers while many others have topical titles that are often used to address the academic community on important issues of mutual concerns. The desire to expose the relevance of Geography as an academic discipline and as a problem-solving profession prompted me to present this inaugural lecture. Geography has been in the forefront of solving different types of societal problems be it economical, social, political, cultural or environmental. Therefore, one of the purpose of this inaugural lecture is to chronicle the relevance of geography as a discipline, and biogeography as a sub-discipline or specilized area in the wide spectrum of Geography. I am aware that giving an inaugural lecture is not time bound, it is an academic obligation which must be fulfilled in the course of one's career as a professor in the University. Though this inaugural lecture is coming a bit late, it has enabled the inaugural lecturer to bring his experience to bear on the lecture.

Mr. Vice Chancellor, I have decided to focus this lecture on some of my significant contributions and development in the field of Biogeography and more specifically in the area of Forest Biogeography. My journey in the world of Geography was not accidental but one that was propelled by interest generated at very early stages of my academic pursuit. I developed interest in Geography through inspiration and encouragement from two of my early Geography teachers Messrs Aiyeku at ECWA Secondary School Igbaja, and Maliki at School of Basic Studies Kwara State College of Technology, Ilorin. The duo gave me good foundation that I have successfully built on today.

After this initial contact, I began the real academic journey in the Department of Geography, University of Ibadan, before I later expanded my geographical training at the Universities of Ilorin, and Ibadan during my higher degrees.

I got attracted to Biogeography as a research area in geography when I was been supervised by Dr. Oluwole Ameyam at the University of Ilorin and later by the then Dr. A.O. Aweto at the University of Ibadan. I later discovered that even biogeography is a wide area of geography with many possible specializations, such as Soils, Land evaluation or Land Resource Analysis, Land use, Biogeochemistry, Geo-botanical studies, Ecosystem studies, Forest–Ecology and Management, Biodiversity Conservation, Natural Resources Management.

My research activities cover many of these specialist areas of biogeography but my major focus is in the area of forest, ecology and management. I have done extensive and intensive studies in this area, thus I have thought it wise to come up with a synthesis of my knowledge and research activities in this area to the benefit of mankind. I therefore chose to address this august audience on a lecture titled "Geographer in the Forest: Issues, Concerns and Tasks. Therefore, in the next few minutes I intend to look at the major issues of interest to geographers, working on forest, the major things that constitute their primary concerns and their responsibilities especially in ensuring a healthy and sustainable forest ecosystem.

## 1.2 INTRODUCTION

### 1.2.1 What is geography and who is a geographer?

Geography as a discipline has many definitions, which reflect the varying spectacles or perspectives of geographers which also gave them different views of the world.

Geography is the study of places and the relationship between people and their environment. Geography is the description of the earth. It is a science of synthesis which seeks to understand a given area in terms of the total integration of the various phenomena which characterized it. Geography is a field science devoted to the study of land features, inhabitants, and phenomena of the earth. It is an all-encompassing discipline which seeks an understanding of the earth and its human and natural complexities (Ofomata, 2008).

Geography is often defined in terms of two branches (dualism in geography) namely:

1). Physical geography which is concerned with the study of processes and patterns in the Natural environment (atmosphere, hydrosphere, geosphere and biosphere).

2). Human geography which is concerned with the study of people and their communities, culture, economies, and interactions with the environment. This aspect of geography focuses on the built environment. It is also known as anthropogeography.

Today, a third branch of geography has emerged, which is termed environmental geography which focuses on interaction between humans and the environment. It is also known as integrated geography. This branch of geography developed as a result of increasing specialization in the two major branches. Each of the two dichotomous branches of geography have been further broken down to ensure the definition of geography at the finest or microscale level.

The physical branch of geography is divided into the following sub-branches:

a). Biogeography, which deals with the geographic pattern of species distribution and the processes that produced these patterns. It is a branch of geography which came up as a result of the work of Alfred Russell Wallace. However, previously there was descriptive and historic plant and animal geography.

Biogeography is also divided into several sub fields such as:

i). Island biogeography
ii). Paleobiogeography
iii). Phytogeography (plant–geography)
iv). Zoogeography

v). Biogeochemistry
vi). Geobotanical studies
vii). Forest biogeography
viii) Soil studies
ix). Land Evaluation and Land Resources Analysis
x) Ecosystem studies
xi) Biodiversity conservation
xii) Biosystematics

b). Climatology which studies climate scientifically. It is concerned with the nature of micro and macro climates (local and global climates) and natural and human activities. It also has sub-divisions.

c). Meterology: This is the scientific study of the atmosphere with focus on weather processes/phenomena.

d). Soil geography: This is the study of distribution of soils across the globe. It is the scientific and field study of pattern of soil distribution and its typologies.

e). Pedology: the study of soil in their natural environment with major focus on pedogenesis, soil morphology soil survey and soil classification.

f). Paleogeography: This is the study of preserved materials in stratigraphic research. It is closely linked with geology because it involves the use of paleomagnetism or study of fossil (biostratigraphy).

g). Coastal geography: It is the study of dynamic relationship between ocean and the land. This is popularly studied as coastal geology or coastal geomorphology looking at coastal landforms, changes in sea levels and accompanied coastal processes.

h). Geomorphology: The study of landforms and processes by which they are shaped. This branch of geography also have sub–disciplines such as fluvial geomorphology, geomorphology in environmental management, drainage basin geomorphology, glacial geomorphology.

i). Hydrology which studies the amount and quality of water moving or accumulating on the land surface or underground, thus it studies water in rivers, lakes, and aquifers.

j). Glaciology: This studies glacial and ice sheet or cryosphere. This branch of geography also has a number of sub disciplines such as snow hydrology and glacial geology.

k). Landscape Ecology: This branch was founded by a German geographer called Carl Troll. It is concerned with the changes and dynamics of flow of energy and materials and the impact of human activities.

Other branches of physical geography include Quaternary science, Geodesy, hydrography, Oceanography etc.

The branches of human geography are; cultural geography, settlement geography, Development Geography, Economic Geography, Health (medical) Geography, Historical Geography, Political Geography, or Geo-politics, Population Geography, Religious Geography (faith geography) Social Geography, Transport Geography, Industrial Geography, Tourism Geography, Urban Geography, Rural or Agricultural Geography.

Going by the multiplicity of branches of geography, like many other subjects, it is a discipline with many callings. Mr. Vice–Chancellor Sir, my calling is in Biogeography, an aspect of applied physical Geography.

Before I talk about my calling and indeed my tasks, and concerns, it is pertinent to say here that whichever areas of Geography one find himself or herself, geographers major concern is that of full understanding of the vast systems on the earth surface comprising man and their environment. Of the three great parameters that is of concern to scientists (space time and composition of matter), geographers are concerned with two (space and time) hence geographers look at man–environment system from the point of view of space and time (Broek, 1965), (Spatio-temporal perspectives Ofomata, 2010).

Having defined geography and identified its various sub disciplines, we can now answer the question of "who is a geographer"? A geographer is that person who studies the earth, who seek an understanding of the earth and its human and natural complexities. A geographer is one that is concerned with spatial form, i.e. patterns of distribution and interaction of and between the earth attributes. A geographer is an academic who has the spatio–temporal view of the world around him. He/she is identified by his/her spatial tradition. Note that, geographers are not only identified by their spatial tradition but also by their methodology which is unique only to geographers. A combination of the spatial tradition and methodology make geographers spatial analyst (analysing patterns of geographic phenomenon) which other disciplines are less concerned with and less likely to discover

As I have pointed out, the inaugural lecturer has his calling in Biogeography. Biogeography is a field of study which has been severally defined. It is the study of the geographic variation in nature, from genes to entire communities and ecosystem (Tivy, 1979). It is the study of the pattern of species composition and diversity across geographical locations (Robinson, 1979). It is the branch of geography that deals with the geographical distribution of plants and animal (Cox, 1980). It is the study of distribution of organism and genetic diversity across the entire surface of the earth, the study of the geographical distribution of living things.

Until recently, biogeography is often studied in the context of ecology, as a sub-discipline of biological systematics. However to geographers, biogeography is concerned with geographical ecology at the species, communities and ecosystem levels.

Biogeography focuses on topics such as distribution of organism, ecological or environmental factors, biogeochemical cycles, populations, and human–ecosystem interactions. It can be divided into many areas of specialization such as, regional biogeography, historical biogeography (paliogeography) ecological biogeography, conservation biogeography. Others include phytogeography, (today known as vegetation studies, vegetation science or vegetation ecology), zoogeography (Animal geography) land use studies, soils studies, natural resource analysis biogeochemistry, geobotanical studies and environmental management.

In addition to mentioning the various areas of biogeography, as a branch of geography it among others:

a). shed light on the natural habitats around the world.

b). enables an understanding of why species are in their present location.

c). enables an understanding of how to develop and protect the world natural habitats.

d). provides a compelling proof for evolutionary theories

e). provides useful necessary information about biotic condition for environmental management.

One can draw from the above discussion that biogeography has different subjects of interests so also is their approaches to biogeographical studies. Over the years, four major approaches stand out, namely: historical approach, ecological approach, integrative approach and analytical approach. The subject matter and the approaches account for the difference in the training and specialization of biogeographers.

As a biogeographer, my interests are in the areas of vegetation ecology/studies, human impact, land use studies, and environmental management. I made bold to say that I have done several works in these areas, but the core of my research work is in forest ecology, where I have carried out several empirical studies on different issues of forest ecology and management. It is the synthesis of issues covered that I have put together and given the title “A geographer in the forest issues, concerns and task” to be able to expositorily allude to the fact that geographers have a lot to do in the forest and with the forest, in order to contribute to sustainable living on the planet earth. In the various sections that follow I examined the different issues and concerns of a geographer in the forest, but before then I wish to briefly talk about my area of special interest which is forest biogeography.

## 1.3 FOREST BIOGEOGRAPHY

Forest biogeography is a specialized area of biogeography and it is concerned with the geographic pattern that characterize a forest. Forest biogeography is the study of all aspects of ecology of wooded areas including rainforest, deciduous and evergreen forest. It is the scientific study of the interrelated patterns, which processes flora, fauna and ecosystem in forests.

Going by these definitions, forest biogeography is concerned with a number of issues that are germane to the functioning and sustainability of forest ecosystems.

Some of these issues and concern are, but not limited to the following:

1). Forest Resources
2). Forest site/soil productivity
3). Forest productivity
4). Forest nutrient cycling
5). Forest regeneration, degradation and loss
6). Deforestation and vegetation change
7). Forest and climate change
8). Forest ecotourism
9). Forest and Biodiversity, conservation

Alongside these major issues are also the major concern of biogeographers. These concern include but not limited to

1). Forest management, conservation and sustainability.
2). Forest and alternative energy
3). Forest and poverty alleviation
4). Forest and global warming
5). Biodiversity conservation.

## 1.4 BIOGEOGRAPHIC ISSUES IN FOREST ECOSYSTEM

### 1.4.1 FOREST RESOURCES

Forests provide an array of benefits to man kind above and beyond their pivotal roles as habitat and environmental regulators in natural ecosystems. These benefits are called resources.

Phil-Eze (2017) identified four categories of importance or significance of forest namely:

a). Commercial value: Forest is a source of many commercial products such as fuel wood, timber, pulpwood etc. Studies have shown that about 1.5 billion people depend on fuel wood as an energy source worldwide. Forests supply timber for plywood, boards, doors, windows, furnitures and agricultural implements. Timber is also a raw material for paper, rayon and films.

b). Life and Economy
Forests provide food, medicine and other products needed by people living in the forest region especially, the rural dwellers.

c). Ecological Uses
Apart from commercial and economic values, forests have many ecological significance which include amongst others

i). habitat for wild animals, plants and millions of species (microorganisms)
ii). reduce global warming caused by Green House, Gases (GHG) by serving as carbon sink during the process of carbon sequestration.
iii). produce oxygen ($O_2$) from photosynthesis
iv). pollution purifier by absorbing toxic gases
v). soil conservation by preventing soil erosion and protecting soil from the vagaries of harsh weather.
vi). soil stability
vii). regulate hydrological cycle
viii). Watershed protection

d). Aesthetic value: The aesthetic value of forests include the beauty and tranquility of the forest which has consequence for tourism and recreation. In discussing forest resources, we can also classify them as either (i) direct resources or (ii) indirect resources. There are the direct and indirect benefits of forests (Akinbode, 2010). The direct resource values of forest include:

1). Fuel wood: source of energy for cooking and for keeping warm.

2). Timber: wood for making furniture.

3). Bamboos

4). Foods (fruits, leaves, root and tuber of plants, meat of forest animals

5). Shelter: for insects, birds, reptiles, mammals and micro organisms

6). Paper: Pulpwood

7). Rayon: Yarn and artificial silk fibres

8). Non timber forest products (NTFPs) e.g. tannins, gums, spices, drug, insecticides waxes, horney etc.

The indirect benefits of forest are:

1). Conservation of soil by preventing erosion, by binding the soil with network of roots of different plants.

2). Soil improvement: through increase in soil fertility due to humus formation by decay of forest litter.

3). Reduction of atmospheric pollution by using carbon dioxide ($CO_2$) for photosynthesis and by this purifies the environment.

4). Control of climate through transpiration by plants thereby affecting rainfall and temperature of the atmosphere.

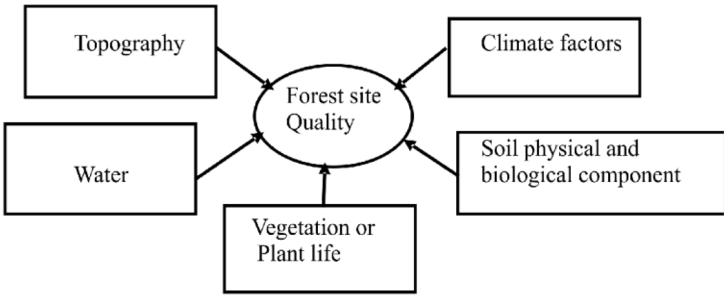
5). Control of water flow by preventing run–off, reducing flash flood and enhancing perennial supply of water to stream.

Being an important issue, forest resources are analysed and studied by geographers with respect to its spatial distribution, quality and its relationships with human living.

Forest resources are important for the survival of forest dwellers. They are also the major sources of conflicts among forest zone communities. Knowledge provided by geographers on forest resources is helpful in its management and sustainable uses.

## 1.4.2 FOREST SITE/SOILS PRODUCTIVITY

A major issue of concern to biogeographer in forest is the forest site especially interms of forest site quality. Forest site is a complex concept. It is the composite expression of a wide variety of physical and chemical attributes, inorganic and organic attributes of a forest area including its soils, topography, climate and water resources. Therefore site characteristic include attributes such as soil depth, soil texture, soil moisture/water holding capacity, soil fertility, slope, aspect, elevation, rainfall, length of growing season etc. Forest site can be classified according to their similarities in climate, topography, soils and vegetation (Ogidiolu, 1997, Chup, 2014). As geographers, we are interested in issues of forest site especially forest site quality. Forest site composite is depicted as shown below.




**Source:** Ogidiolu (1997)

Forest climate as a component of forest site is an ecologically powerful factor as it determines or controls pattern of growth of trees in the forest. Plants depend on climate fundamentally as a condition necessary for their growth and productivity. Infact variation in climatic condition plays a major role in determining whether a particular plant can or cannot exist. The climate factors of greatest importance in this respect include light (solar radiation) moisture (rainfall or precipitation) temperature, humidity and wind.

Solar radiation is of great importance in plant growth and its importance lies in the dependence of life on photosynthesis which in turn dependent on light. Solar radiation is the major source of energy for all life processes and where other requirements are satisfied, the amount of solar radiation green plants can utilize set the limit to plant growth and productivity (Ogidiolu, 1999). Of much importance to plant growth and productivity is the light intensity, which is a function of the physical characteristics of a site (Ayoade, 1983).

It has been well established that at higher light intensity, rate of dry matter production increases. The resultant effects of solar radiation on plant depend on the colour, shape and the arrangement of leaves. These factors regulate the amount of light actually reaching the chlorophyll (Spurr and Barnes, 1980). Solar radiation also influences tree morphology. It is generally acknowledged that plants growing under shade develop structure and appearance different from the same plant growing under full sunlight.

Temperature is another climate site factor that is of great significance to plant. Physiological processes such as enzymic activities that catalyse biochemical reactions (photosynthesis and respiration), solubility of carbon dioxide and oxygen in cells, are influenced by air temperature. In many instances, soil temperature is more important to plant growth than air temperature. Unfavourable soil temperature condition (too high or too low) during the growing season may retard the growth or even ruin the plant completely. (Akintola, 1983).

Water is another critical climatic site factor. The principal source of water in forest environment is rainfall. It recharges the soil moisture and this affect plant growth. Transpiration is a primary process in water relations of plants because it provides the energy gradient causing the movement of water into and through plants.

Soil is another important component of forest site. Soil site factor in forest is a major issues in biogeography. Forest soil provide the physical support for the growth of plants and for storing elements for recycling back to trees. Forest soils are formed under natural forest from geological parent materials in various topographic positions interacting with climate and organisms. (Brady and Well 2002).

Forest soil is important for many reasons including:

i). healthy plant growth.

ii). relatively large amount of carbon is stored in forest soil organic matter. About 650 billion tons of carbon is stored in forest soil globally (Proctor, 2019). This has great significance or consequences for climate changes.

Soil organic carbon is also a key parameter of soil quality. It has direct link to ecosystem productivity. It is a critical pool in the carbon cycle and through its influence on many biological and chemical process, it plays a pivotal role in nutrient release and availability. Soil carbon plays critical role in aggregation and hence the porosity of the soil. Soil organic carbon also has impact on the atmospheric level of carbon dioxide, nutrient cycling and ecosystem functions and on soil microbes.

iii. Soil as habitat of many micro and macro-organisms

A number of issues are of interest to geographers about forest soils. These include but not limited as:

a). soil–plant relationship
b). nutrient status or condition
c). nutrient supplies or cycling
d). water supplies or moisture condition
e). fertilizer application and soil mineral nutrition.

As geographer, the issues of soil–plant relationship is important. According to Courtney and Trudgill (1984), the main soil factors which influence plant growth are:

i). texture and structure
ii). depth available for rooting (rooting depth)
iii). nutrient supply
iv). water condition
v). soil acidity.

Note that plant growth can be enhanced or retarded or the presence of a particular species excluded from a given habitat because of

i). some nutrients are lacking
ii). the nutrient become available for use by plants too slowly.
iii). the nutrient are available in incorrect proportions and are therefore not adequately balanced in the soil (Brady and Well, 2010).

I submit here therefore, that for site selection for afforestation, profitable timber production and silvicultural, practices forest soils should be analysed for crucial information on soil condition (a major duty of geography (soil survey and characterization.)

In discussing forest soils in relation to tree growth, the concept of forest soil quality or productivity is important. While the two words are used interchangeably, soil quality is a combination of physical and biological factors characterizing a soil. The properties that determine soil quality are generally inherent in the soil, but they can be influenced by management. Soil productivity on the other hand is a quantitative estimate of the potential of a given soil to produce plant biomass. It is the capability of soil to produce plant biomass or net primary production (NPP) irrespective of how much of this potential is realized by the plant or vegetation.

### 1.4.3 SOIL PRODUCTIVITY ASSESSMENT

In forest regions of the world, the productivity of the soil is assessed to ensure proper use and management. Soil productivity is function of both natural and management related factors.

Soil quality assessment is usually done using either or a combination of two methods:

i). geocentric method (based on soil characteristics)

ii). Phytocentric method (based on plant or tree parameters which are correlated with soil properties)

According to Ogama, Ekaette, Johnson, and Osho (2017) forest soil quality can also be estimated using either direct or indirect method. The direct method involve measuring height or age of trees while the indirect methods include:

- i). mensuration method
- ii). plant indicators
- iii). physiographic site classification
- iv). symeclogical coordinates
- v). soil survey.

Geocentric method is more populatar. Using this approach, Ameyan and Ogidiolu (1999) assess soil productivity under protected forest ecosystem in a part of Savanna belt of Kwara State. Using the method of factor analysis, four major indices of soil quality were identified and developed namely,

- i). textual index
- ii). Organic matter index
- iii). Moisture index
- iv). porosity index

These indices altogether accounted for about 92% of the total variation in forest soil productivity in this environment. In similar studies, Aweto (1981, 1988) have obtained organic matter and total nitrogen as major indices of forest soil productivity in the forest zone of South Western Nigeria.

Many of the studies on forest soil productivity carried out by geographers especially in Nigeria have been done within the framework of soil–vegetation relationship. (Aweto 1978, Ukpong 1989, Ezenwa 1988, Ogidiolu 1997).

In this relation, Ogidiolu (1997, 1999, 2000), examined the relationship between soil nutrient status (soil productivity) and the growth and productivity of cultivated indigenous tropical forest tree species (Terminalia ivorensis and Triplochiton scleroxylon in Sakpoba forest, Edo State. Using seven vegetative parameters and twenty–six soil variables, the patterns of interrelationship were examined with different statistical method which include multiple regression analysis, reduced ranked multiple regression, principal component, analysis, and canonical correlation analysis. The results obtained corroborate each other. The results of canonical correlation analysis showed that productivity of Terminal ivorensis is related to soil site characteristics in seven ways (as shown by the seven canonical variates extracted).

**Table 1: Canonical variates and variance extracted in 20years Terminalia ivorensis plots**

| Canonica l Variate | Productivity Parameters | Site Parameters | Variance Explained |
|---|---|---|---|
| I | Total height/bole height | Available phosphorus | 0.0803 |
| II | Taper/crown diameter | Clay/base saturation | 0.1159 |
| III | *Crown diameter/total height* | *Soil pH* | 0.0567 |
| IV | Bole height/total height | Soil slope/soil temperature at 5cm | 0.1829 |
| V | Based area/Boil volume | Waterholding capacity/ground elevation | 0.4518 |
| VI | Total height | Sand/soil temperature at 10cm | 0.0433 |
| VII | Taper/crown diameter | Organic matter | 0.0691 |

The first pair of canonical variates indicate a positive association between total height and available phosphorus while the second canonical variate indicates positive relationship between clay content of the soil and the crown diameter of the tree. This second relationship as noted by Aweto (1978) should be unidirectional since plant does not significantly alter the proportion of clay or other inorganic fractions in the soil. The values of the variance extracted and the coefficient of redundancy is given in Table 2.

Table 2: Canonical variance extracted and redundancy for productivity and characteristics for 20years terminalia ivorensis plots

| Canomical variate | Squared canomical correlation | Productivity parameters | | Site character istics | |
|---|---|---|---|---|---|
| | | VE | R | VE | R |
| I | 1.000 | 0.0803 | 0.0803 | 0.0196 | 0.0196 |
| II | 1.000 | 0.1159 | 0.1159 | 0.1609 | 0.1609 |
| III | 1.000 | 0.0567 | 0.0567 | 0.0385 | 0.0385 |
| IV | 1.000 | 0.1829 | 0.1829 | 0.0846 | 0.0846 |
| V | 1.000 | 0.4518 | 0.4518 | 0.0237 | 0.0237 |
| VI | 1.000 | 0.0433 | 0.0433 | 0.0531 | 0.0531 |
| VII | 1.000 | 0.0691 | 0.0691 | 0.0283 | 0.0283 |
| Total variance | | 1.000 | | 0.3086 | |
| Total redundancy | | | 1.000 | | 0.3086 |

VE = Variance extracted, R = Redundancy

The equality of the variance extracted by each variate and their corresponding redundancies implies that there is maximum (100%) overlap between the two sets of variables packed in each canonical variate (soil and productivity variables). Similar results were obtained for Triplochiton scleroxylon. (For detailed results, see Ogidiolu 1997, 1999, 2000) Observations from these studies have shown that a number of soil site factors are related to productivity of the species studied. The site factors however differ with respect to species and age. (Bada 1991, Ogidiolu 2001, Oguntala 2002).

Using the multiple regression (stepwise regression model), Ogidiolu (1997) further explored the interrelationship of soil–site factors and forest tree growth and productivity. The technique is not only capable of handling the problem of interactions among independent variables (multicollinearity) but it also enables us to know the contribution or importance of each independent variable (or linear composite of variables) to the explanation of variation in a particular dependent variable of interest. It also allows the prediction of value of the dependent variable (Johnston, 1988, Udofia 2011).

Regression analysis was used to develop regression (predictive) models for the productivity parameter in Terminalia ivorensis plantation see table 3 to 9.

Table 3: Summary of regression results between Diameter at breaks height (Girth) and site characteristics in 20–years Terminalia ivorensis plots

| Variables | b Coefficient | Standard error of b | Multiple R | Level of explanation (%) | Increase in Level of explanation (%) | F–values for equation | T–values for variables |
|---|---|---|---|---|---|---|---|
| Silt | 4.90 | 0.14 | 0.57 | 32.8 | 32.8 | 1105.14 | 8.79 |
| Available P | 52.14 | 1.90 | 0.70 | 16.7 | 49.5 | 748.33 | 5.62 |
| Slope | 15.24 | 1.29 | 0.79 | 14.3 | 63.8 | 139.39 | 6.35 |
| Waterholding capacity | 2.58 | 0.26 | 0.85 | 8.5 | 72.3 | 96.44 | 5.37 |
| Total – N | 14.83 | 1.56 | 0.89 | 8.1 | 80.4 | 89.54 | 7.51 |
| Base Saturation | 3.88 | 0.28 | 0.93 | 5.6 | 86.0 | 189.56 | 17.37 |
| Soil temp 10cm | –9.69 | 0.57 | 0.95 | 5.4 | 91.4 | 280.93 | 2.67 |
| Exch. Ca+ | 96.64 | 5.79 | 0.98 | 4.8 | 96.2 | 278.33 | 6.23 |
| Soil temp 30cm | –4.90 | 0.62 | 0.98 | 1.2 | 97.4 | 62.22 | 5.55 |
| Min temp | –1.76 | 0.45 | 0.99 | 1.2 | 98.6 | 14.75 | 10.5 |
| Soil temp 100cm | 1.70 | 0.48 | 0.99 | 0.5 | 99.1 | 12.74 | 8.65 |
| Elevation | 2.65 | 1.12 | 0.99 | 0.5 | 99.6 | 5.68 | 5.67 |

Intercept = –547.650 All variables are significant at 0.05 level

Table 4: Summary of regression results between total height and site characteristics in 20–years Terminalia ivorensis plots

| Variables | B Coefficient | Standard error of b | Multiple R | Level of explanation (%) | Increase in Level of explanation (%) | F–values for equation | T–values for variables |
|---|---|---|---|---|---|---|---|
| pH | –13.2 | 3.14 | 0.54 | 30.1 | 30.1 | 17.67 | 7.74 |
| silt | 0.28 | 0.12 | 0.71 | 20.6 | 50.7 | 5.72 | 7.09 |
| Exch. Acidity | –24.3 | 6.88 | 0.78 | 10.0 | 60.7 | 6.04 | 4.09 |
| Total Porosity | 0.44 | 0.18 | 0.84 | 11.1 | 71.8 | 5.87 | 5.86 |

Intercept = 184.350, All variables are significant at 0.05 level

Table 5: Summary of regression results between Based Area and site characteristics in 20–years Terminalia ivorensis plots

| Variables | b Coefficient | Standard error of b | Multiple R | Level of explanation (%) | Increase in Level of explanation (%) | F–values for equation | T–values for variables |
|---|---|---|---|---|---|---|---|
| Silt | 0.84 | 0.000 | 0.57 | 32.6 | 32.6 | 340.1 | 8.68 |
| Available P | 7.72 | 0.004 | 0.109 | 15.9 | 48.5 | 367.6 | 5.26 |
| Slope | 2.44 | 0.001 | 0.79 | 14.3 | 62.8 | 365.1 | 6.12 |
| Slope temp 100cm | 1.72 | 0.000 | 0.82 | 9.3 | 72.1 | 16.3 | 12.44 |
| Total – N | 10.48 | 0.000 | 0.87 | 19.1 | 81.2 | 349.3 | 5.67 |
| Exch. Ca++ | 2.53 | 0.001 | 0.91 | 7.3 | 88.5 | 451.7 | 6.16 |
| Base Saturation | 15.2 | 0.001 | 0.94 | 5.5 | 94.0 | 880.8 | 5.82 |
| Soil temp 30cm | –0.68 | 0.000 | 0.97 | 2.1 | 96.1 | 415.6 | 12.3 |
| pH | –0.93 | 0.001 | 0.98 | 2.0 | 98.1 | 840.6 | 10.8 |
| Waterholding | 2.70 | 0.000 | 0.99 | 1.4 | 99.5 | 300.0 | 11.7 |
| capacity | 0.06 | 0.004 | 0.99 | 0.2 | 99.7 | 443.6 | 10.3 |
| Lead | –3.92 | 0.000 | 0.99 | 0.2 | 99.9 | 566.0 | 5.37 |
| Bulk density | 0.02 | 0.003 | 0.99 | 0.1 | 100.0 | 230.4 | 11.9 |
| Nickel | 0.44 | 0.000 | 1.00 | 0.0 | 100.0 | 422,3 | 22.6 |
| Iron | | | | | | | |

Intercept =–31.988 All variables are significant at 0.05 level

Table 6: Summary of regression results between Bole Height and Site Characteristics in 20–years Terminalia ivorensis plots

| Variables | b Coefficient | Standard error of b | Multiple R | Level of explanation (%) | Increase in Level of explanation (%) | F–values for equation | T–values for variables |
|---|---|---|---|---|---|---|---|
| Slope | 6.99 | 1.32 | 0.61 | 36.8 | 36.8 | 27.96 | 10.46 |
| Slope temp 30cm | 1.92 | 0.52 | 0.77 | 22.8 | 59.6 | 13.80 | 9.58 |
| Sand | –0.46 | 0.16 | 0.82 | 8.6 | 68.2 | 8.51 | 4.34 |
| Organic matter | 2.42 | 0.94 | 0.87 | 6.9 | 75.1 | 6.03 | 4.13 |
| Exch. K | –2.41 | 11.4 | 0.90 | 6.0 | 81.1 | 4.43 | 4.48 |

**Intercept =12.804 All variables are significant at 0.05 level**

Table 7: Summary of regression results between Bole Volume and Site Characteristics in 20–years Terminalia ivorensis plots

| Variables | b Coefficient | Standard error of b | Multiple R | Level of explanation (%) | Increase in Level of explanation (%) | F–values for equation | T–values for variables |
|---|---|---|---|---|---|---|---|
| Available P | 4.89 | 0.69 | 0.53 | 27.8 | 27.8 | 61.4 | 7.83 |
| Waterholding capacity | 0.111 | 0.04 | 0.64 | 13.3 | 41.1 | 7.92 | 2.81 |
| Silt | 0.28 | 0.07 | 0.71 | 10.0 | 51.1 | 21.91 | 4.68 |
| Slope | –1.18 | 0.29 | 0.78 | 9.8 | 60.9 | 20.07 | 4.78 |
| Zinc | –7.34 | 2.49 | 0.82 | 6.5 | 67.4 | 10.57 | 3.25 |
| Soil temp 20cm | 1.23 | 0.32 | 0.88 | 9.5 | 76.9 | 17.75 | 4.21 |
| Soil temp 10cm | –1.70 | 0.47 | 0.93 | 9.1 | 86.0 | 15.70 | 3.96 |
| Clay | 0.04 | 0.02 | 0.95 | 4.1 | 90.1 | 5.59 | 2.36 |

Intercept = 1.246 All variables are significant at 0.05 level

Table 8: Summary of regression results between Taper and Site Characteristics in 20–years Terminalia ivorensis plots

| Variables | b Coefficient | Standard error of b | Multiple R | Level of explanation (%) | Increase in Level of explanation (%) | F–values for equation | T–values for variables |
|---|---|---|---|---|---|---|---|
| Waterholding capacity | 0.04 | 0.01 | 0.43 | 18.7 | 18.7 | 6.50 | 2.55 |
| Electrical conductivity | –0.06 | 0.01 | 0.59 | 15.7 | 34.4 | 4.50 | 2.12 |
| Exch. Ca++ | 1.46 | 0.66 | 0.79 | 14.4 | 48.8 | 5.06 | 2.25 |
| Elevation | –0.02 | 0.006 | 0.75 | 0.5 | 59.3 | 5.00 | 2.23 |

Intercept =2.1482 All variables are significant at 0.05 level

Table 9: Summary of regression results between Crown Diameter and Site Characteristics in 20–years Terminalia ivorensis plots

| Variables | b Coefficient | Standard error of b | Multiple R | Level of explanation (%) | Increase in Level of explanation (%) |
|---|---|---|---|---|---|
| Available P | 0.55 | 0.05 | 0.48 | 23.9 | 23.9 |
| Total–N | 13.64 | 1.76 | 0.63 | 16.6 | 40.5 |
| Soil temp 20cm | 1.82 | 1.02 | 0.70 | 9.4 | 49.9 |
| Exch. Ca++ | 7.47 | 0.31 | 0.82 | 17.1 | 67.0 |
| Slope | –2.12 | 2.07 | 0.88 | 11.0 | 78.0 |
| Bulk density | 7.28 | 0.59 | 0.92 | 7.9 | 85.9 |
| Copper | –66.87 | 9.12 | 0.94 | 3.4 | 89.3 |

Intercept =–58.7385 All variables are significant at 0.05 level

$$DBH = 247.6 + 490_{ST} + 52.1_{AP} + 15.2_{SL} + 2.53_{WHC} + 14.8_{N} + 3.88_{BS} - 9.69S_{T100} + 96.6_{CA}$$

$$TH = 184.3 - 13.2_{P}^{H} + 0.28_{ST} - 24.3_{EA} + 0.144_{TP}$$

$$BA = - 31.9 + 0.84_{ST} + 2.44_{TP} + 0.4_{Ni} + 15.2_{CA} + 1.72S_{T100}$$

$$BH = - 12.8 + 6.99_{SL} + 1.92_{ST30} - 0.46_{SD} + 2.42_{K}$$

$$BV = 7.98 + 7.50_{WHC} - 102.7_{SD} + 32.6_{ST100} + 158.0_{M}$$

$$TA = 2.15 + 0.04_{WHC} + 0.01)_{OM} - 0.06_{EC} + 1.46_{CA} - 0.13_{PH}$$

$$CD = - 58.7 + 13.6_{AP} + 1.82 + 1.72_{OM} + 7.47_{CA}.$$

Where

DBH = Diameter at Breast Height
TH = Total height
BH = Bole height
BV = Bole Volume
TA = Taper
CD = Crown Diameter

The multiple regression analysis performed on each of the productivity parameter was used to develop the important value index "(Ogidiolu, 2003). The index is simply the percentage contribution of each of the significant soil–site factor to the prediction of growth and productivity of the forest species. From this analysis (Table 4) five soil–site factors were identified as crucial factor for the growth and productivity of *Terminalia ivorensis* namely: available phosphorus, water holding capacity, soil $p^H$, percent silt and percent slope).

Table 10: Index of site Characteristics Contribution (%) to the Growth & Productivity of 20–years Terminal iaivorensis

| | 20–years Terminaliaivorensis | | | | | | | Pred. Index |
|---|---|---|---|---|---|---|---|---|
| | DBH | TH | BA | BH | BV | TA | CD | |
| Sand | | | | 8.6 | 8.8 | | | 2.49 |
| Silt | 32.8 | 20.6 | 32.6 | | | | | 12.3 |
| Clay | | | | | | | | |
| pH | | 30.1 | 0.5 | | | | | 4.37 |
| Organic matter | | | | | | | | |
| Electrical conductivity | | | | | | 15.7 | | 2.242 |
| Exch. Na+ | | | | | | | | |
| Exch. K+ | | | | 6.0 | 7.3 | | | 1.90 |
| Exch. Ca++ | 4.8 | | 5.1 | | | 7.0 | 11.0 | 3.98 |
| Exch. Mg+ | | | | | | | | |
| Exch. Acidity | | 10.0 | | | | | | 1.432 |
| CEC | | | | | | | | 3.54 |
| Total–N | 8.1 | | 7.3 | | | | 9.4 | 3.54 |
| Available P | 16.7 | | 15.9 | | | | 16.6 | 7.03 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Base saturation | .6 | | 5.5 | | | | | 1.58 |
| Copper | | | | | | | 2.0 | 0.28 |
| Zinc | | | | | | | | |
| Manganese | | | | | | | | |
| Iron | | | | | | | | |
| Lead | | | 0.2 | | | | | 0.03 |
| Nicked | | | | | | | | |
| Molybdenum | | | | | | | | |
| Waterholding capacity | 8.5 | | 0.5 | | 12.3 | 18.7 | | 5.71 |
| Bulk density | | | | | | | 2.4 | 0.34 |
| Total porosity | | 11.1 | | | | | | 1.58 |
| Slope | 14.3 | | 14.3 | 30.8 | 11.4 | | 7.9 | 12.1 |
| Elevation | | | | | | 10.5 | | 1.50 |
| Soil temp. (5cm) | 0.5 | | | | | | | 0.07 |
| Soil temp. (10cm) | | | | | | | | |
| Soil temp. (20cm) | | | | | | | 17.1 | 2.44 |
| Soil temp (30cm) | 1.2 | | 2.5 | 22.8 | | | | 3.78 |
| Soil temp. (100cm) | 5.4 | | 5.1 | | 16.6 | | | 3.87 |

In this study, the identified soil–factors explained 66.6% of the total variation in the growth, yield or productivity of the species. What the above study has shown is very important in the sustainable management of our forest and in the fight against food insecurity and poverty especially in developing countries with high dependence on agricultural and forest resources. The study showed that if a forester has information on soil–site factors, he can be guided in his afforestation programme and can forecast the growth and yield of cultivated tropical tree species especially indigenous species which are rarely cultivated in plantations. In other words, such information provided by geographers is a sine–qua–non for forest–site selection or site suitability classification, afforestation, profitable timber production and silvicultural treatments (Johnson and Curtis, 2001).

## 1.5 FOREST NUTRIENT CYCLING

Nutrient cycling, otherwise called biogeochemical cycling is the process whereby chemical elements or nutrients (sometimes referred to as biogenic salts) move continually between biotic and abiotic components of the ecosystem involving use and re-use. It involves plants, animals, fungi and bacteria living above and below ground.

Basic to the principle of conservation of mass, that matter can neither be created nor destroyed, nutrients taken by plants cannot be lost but only change in their form (recycle). Nutrient cycling is a very important process in the consideration of biological productivity. It is important because it establishes the link between living and non–living components.

The importance of mineral element in forest production can only be fully appreciated through an understanding of forest nutrient cycles. Nutrient cycling in forest involves a complex set of direct and indirect relationships in which the soil (abotic component) influences the vegetation (biotic component) and the vegetation in turn influence the soil (Proctor, 1997).

There are five basic components of soil–vegetation nutrient system in forests. These are:

i). nutrient inputs from weathering of minerals.
ii). nutrient inputs from the atmosphere
iii). nutrient losses by leaching
iv). nutrient cycling by plants and animals.
v). the store in the soil of nutrients which are readily available to plants (forest trees).

In forests, nutrients enter the ecosystem through such sources as rain deposition, by dust and aerosols, fixation by micro–organism (in the case of nitrogen) and weathering of rocks. These nutrients are absorbed by plants which synthesize them into complex organic compounds containing large amount of chemical energy. This energy can be recovered for use by the plants by breaking down the complex organic compounds into their simple inorganic elements (decomposition) and in the process releasing the bonded energy.

During the break-down of organic compounds, nutrients are made available for re–absorption and re–circulation by plants. In forest ecosystems, nutrient flow follows the more or less cyclical pattern in which nutrient absorbed from the soil are eventually returned to the soil. This happens through a process known as biogeochemical cycling. Note that the detail of the cycles for the different element e.g. nitrogen, carbon, phosphorus may differ. However in general, there are two (2) major pools in a forest nutrient cycle (Proctor, 1997) namely,

a). above ground pools which include nutrients stored in the plant tissues and atmosphere

b). below ground pools which are mainly the nutrients in the soil. In a more detailed analysis, Trugill (1999) revealed that nutrient elements are stored in three compartments within the forest ecosystem namely:

i). in the soil

ii). in the living organism

iii). in the surface litter.

Between the various pools, nutrients are cycled via three main pathways, namely:

1). the uplake or growth pathway. Here simple inorganic elements of N.P.K and other essential nutrients are taken up from the soil and converted to complex organic compound within the living biomass. The relative amount of nutrient taken up by trees play a role in determining the relative growth and competitive ability of forest trees (Nwoboshi and Esekie, 1990).

2). Fallout pathways: These are plant and animal materials which constitute litter store.

3). Decay pathway: This is formed by decomposition of litter and eventual release of inorganic nutrients back to the soil. Proctor (1999) identified two types of nutrient cycles in forest ecosystem on the basis of the rate of mineral turnover. These are:

i). the relatively rapid nutrient cycling in litter fall, through fall and stem flow.

ii). the slow nutrient cycling involving the incorporation of nutrients in large woody parts (immobilization) which follows the regeneration phase of the forest.

During nutrient cycling processes in forest ecosystem, nutrient losses occur, but these are very difficult to estimate. The most easily lost elements/nutrients are nitrogen and phosphorus which are lost through denitrification and volatilization. Permanent losses occur through erosion, fire, drainage water and total harvesting. (Ogidiolu, 2002)

For sustainability of forest ecosystem, nutrient loss via leaching and harvesting must be balanced by addition through rain water, and atmospheric fixation. Any action which alters or upsets the nutrient balance in favour of greater removal will impair or retard forest growth and productivity.

Nutrient cycling processes in natural and plantation forests differ in some respects while nutrient cycling in plantations are aggrading system, those of mature natural forest are in a steady–state, hence the number and types of pathways of nutrient cycling for natural and plantation forest are different.

In plantation forests, like most other agro–ecosystems, nutrient inputs are from more diverse sources including fertilizer application, use of insecticides/herbicides and other management practices. In addition, nutrient cycling in plantation forest suffer greater losses through short rotation harvesting, burning and other agricultural practices. Nutrient cycles in plantation are therefore more open. Tivy (1997) aptly put it that nutrient cycling in plantation forest is typical of agro–ecosystem which grow quite well only with heavy subsidy of nutrient.

Nutrient cycles in natural forest are closed or nearly closed system and under such system only small nutrient loss is possible mainly through drainage which is corrected by releases from parent rocks.

The soil compartments of the forest nutrient cycles are usually deficient, as most of the nutrients are locked up in the forest biomass. One practical contribution of biogeography is in the quantitative analysis of the different aspects of the forest nutrient cycles. A good knowledge of the quantities of nutrient stored or available in each compartment and the residency time can provide useful information for the improvement of silvicultural or agro–forestry management practices. Knowledge of the biogeochemistry of forests especially in forest soil compartment is important as it will enable researcher to assess the impact of:

i). logging
ii). Climate change
iii). Watershed level forest management.

## 1.6 VEGETATION CHANGE

Another major issues of interest to geographers is vegetation change. Geographers are interested in the study of vegetation because of the importance of vegetation in the earth system. Vegetation change refers to the alteration in the structure and composition of assemblage of species (Mueller-Dombois, 1974 Ogidiolu, etal 2007). It could be temporal or spatial. It could also be phenological or cyclic changes (i.e. changes according to the growth cycle), seasonal change (as in deciduous forest), successional changes and vegetation change over transition e.g. from forest to savanna which involves changes in tree height, tree density, species composition etc.

Before going into details of vegetation change, let us quickly look at importance of vegetation and why geographers study vegetation. Vegetation is an important environmental resource. It is one of the most readily observable elements of the natural environment. In many areas, the nature of the vegetation makes a striking impression on even the casual observer. Given the strong environmental orientation of Geography, geographers cannot gloss over the vegetation of an area. It is an expression of the nature of physical environment. The natural vegetation of an area expresses the sum total of the environmental conditions even the substrate and terrain conditions. Vegetation is also an integral part of land resources and serve several purposes such as provision of food and medicinal materials, conservation of soil, watershed protection, etc. Vegetation survey give a quicker approach to resource inventory of an area, a subject of prime importance to geographers. Vegetation of an area give some indication of the type of landuse which an area is best suited, therefore it gives information on landuse/landcover which are needed for impact studies.

Vegetation change alters the radiative and non–radiative properties of the surface (especially the energy balance which can lead to global warming. Vegetation change has been reported to cause an average increase of $0.23 \pm 0.03^{0C}$ in local surface temperature. It alters the strength of $CO_2$ sink. Vegetation change especially through the conversion of forest into agricultural (farm) land typically brings about increase in albedo and a concomitant increase in evapotranspiration

Physical and ecological (biophysical) effects of vegetation change is a contemporary research area in vegetation studies and forest ecology. A number of studies have noted such impact as the alteration of plant–soil–microbial feedback with long term effect on ecosystem structure and functions.

Vegetation change as a result of greening or browning may affect wildlife habitat and food availability which in turn affect community hunting practices, access to new energy or fuel source and availability of job e.g. firefighting. Vegetation change causes wildlife to migrate e.g. migratory caribore. Apart from the biophysical effects, vegetation change has a number of socio–economic implications, both positive and negative (Omogbai, 2013) Examples of positive impact associated with increase in vegetation cover include energy production when woody species increases, increase in wildlife stock for the hunting communities. Increase in woody species may hinder visibility of hunters as well as increasing the risk of fire occurrence during the dry season. In a recent study Chup (2014) emphasis the importance of knowledge of vegetation change in allowing ranchers to design better integrated management programme for range lands.

Apart from the importance and impact of vegetation change, geographers are interested in the analysis of drivers of vegetation change as the knowledge of vegetation change is crucial in the sustenance of biodiversity and ecosystem services and for the evaluation of effects of ecological engineering constructions. Drivers of change are the factors affecting or causing vegetation change. These include:

i). climate factors e.g. rainfall, temperature, wind etc.

ii). biophysical factor e.g. slope, soil, insect infestation.

iii). socio–economic factor e.g. food and wood production, poverty etc.

iv). anthropogenic factors e.g. overgrazing, land fragmentation, farming, urbanization etc.

These causes can be broadly classified as either natural or anthropogenic factors or causes (Kershaw 1994, Vander Marcel 2004).

## 1.7 DEFORESTATION AND FOREST LOSS

Deforestation is another issue not only of interest to geographers, but to most environmental researchers. Its prominence as an environmental issue has climaxed with the coming of twenty–first century. Today it is not a local issue but a global one. As geographers, interest in deforestation is because it is a major factor of vegetation change and has significant environmental and socio–economic implications.

Mr. Vice Chancellor Sir, this issue affects everyone (knowingly or unknowingly), educated or illiterate, rich or poor, Muslim or Christian. In this lecture, I focus on important aspect of the issue since it is an hydra-headed matter. I shall briefly consider this issue by looking at its definition, forms, causes, effects, status of forest and the mitigation strategies. Several scholars more importantly geographers have spent a lot of their research efforts and time on this issue. Some of the recent works include Amacher, etal (2009), Gadiga and Dan (2015), Mganga, Nyariki Musimba, and Amuwata (2018), Nabbi (2015), Ocholi (2018), Odihi (2018), Ogidiolu, (2019).

Deforestation has been defined as the removal of tree cover from the forest or the long–term reduction of the tree canopy cover below the minimum of 10 percent threshold (FAO, 2010). It is the conversion of a forest area to another landuse, mainly by clearing the existing vegetation cover (Middleton, 2008)

Deforestation is the removal of a forest or stands of trees from land surface which is often converted to a non–forest use. It is the decrease in forest area across the world that are lost for other uses such as cropland, urbanization or mining activities (Naibi, 2018).

There are two forms of deforestation

i) Natural deforestation: this is caused by natural forces such as landslides, eruption etc.
ii) Human induced deforestation (associated with activities of man such as cropping, urbanization, construction, mining etc.

Deforestation issue exhibits spatial and temporal dimensions. Thus, it is more extreme in tropical areas (e.g. in Amazon forest) than temperate areas. Evidence from studies and reports show that between 2020 and 2022, about 2.6 million square kilometer of forests around the world were cut down. More than 3.6 million hectares of virgin tropical forest was lost in 2018 alone

(Ogidiolu and Eneche, 2020). Infact in Amazon forest, an area of the size of a football pitch is cleared every minute.

Nigeria situation is pathetic, although accurate data on rate of forest loss is lacking but from different estimate, Nigeria forest cover declined by an average of 410,000 hectare per annum, between 1990 and 2000. This figure has since increased to between 800 and 950 thousand hectares per annum in the 2010–2020 decade. Some reports have shown lower figures while other have been highly exaggerated (Naibi, 2018).

Table 11 shows ten (10) countries with the largest annual net loss of forest area. From the table, Nigeria is amount the top five countries in the world with highest deforestation rate since 1990. This is not surprising given the amount of fuel wood harvest (the traditional cooking energy) especially in rural communities of the countries. The fuel wood harvest has again increased within the last few years with removal of subsidies on petroleum fuel and gas which has caused increased in energy prices and even occasional scarcity.

Deforestation in Nigeria has put Nigeria forest ecosystem in a very fragile status and except in the few forest reserves, natural forest vegetation is scarce. Presently the few forest reserves are under pressure coming from lumbering and cultivation (Ogidiolu and Eneche, 2020) and some has been depleted. One of the most widely researched aspects of deforestation is the causes or driving forces. According to United Nation Framework Convention on Climate Change (UNFCCC) the major and overwhelming cause of deforestation is agriculture. Both subsistence and commercial agriculture account for about 48% and 32%, respectively of deforestation worldwide. Land are cleared for food crop production, or tree crop farming which result in loss of colossal expanse of forest land. Conversion of forest lands to agricultural production is a major driver of deforestation in the tropical forest (Perez–Verdin, Kim Hospodarsky and Tecle, 2009).

Table 11: Ten Countries with the Largest Annual Net Loss of Forest Area, 1990–2010.

| Country | Annual change 1990–2000 | | Country | Annual change 1990–2000 | |
|---|---|---|---|---|---|
| | 1000 ha/yr | % | | 1000 ha/yr | % |
| Brazil | –2 890 | –0.51 | Brazil | –2 642 | –0.49 |
| Indonesia | –1 914 | –1.75 | Australia | –562 | –0.37 |
| Sudan | –589 | –0.8 | Indonesia | –498 | –0.51 |
| Myanmar | –435 | –1.17 | Nigeria | –410 | –3.67 |
| Nigeria | –410 | –2.68 | Tanzania | –403 | –1.13 |
| Tanzania | –403 | –1.02 | Zimbabwe | –327 | –1.88 |
| Mexico | –354 | –0.52 | Congo | –311 | –0.2 |
| Zimbabwe | –327 | –1.58 | Myanmar | –310 | –0.93 |
| Congo | –311 | –0.2 | Bolivia | –290 | –0.49 |
| Argentina | –293 | –0.88 | Venezuela | –288 | –0.6 |
| Total | –7 926 | –0.71 | Total | –6 040 | –0.53 |

**Source**: FAO (2010a p.21).

Other causes of deforestation are:

i). logging (representing about 14% of global deforestation)

ii). Fuelwood collection or removal (about 5% of global incidence of deforestation)

iii). Population increase or growth

iv). poverty (no power to afford alternative energy source)

v). corruption of government institutions

vi). Inequitable distribution of wealth and power

vii). urbanization (through urban and industrial development)

viii). climate change which has resulted in the increase in frequency and power of wildfires especially in boreal forest.

ix). extractive industries (mining activities)

x). economics incentives as a major cause of deforestation is linked to government and trade incentives that make forest conversion more profitable than forest conservation. Many forest services have no market and hence no economic value that is readily apparent to the forest owners/communities.

xi). cattle ranching/infrastructure. Studies from Brazil and other Latin American countries have shown that cattle ranching and infrastructure is a major cause of deforestation. Over 70% of deforested land in Brazil is used for livestock pasture. Removal of forest made way for cattle ranching. Today, this is the leading cause of deforestation in Brazil

xii) hydroelectric dam project. In Amazon forest of South America and precisely in Brazil, dam project had caused flooding of forest e.g. Balbina Dam had flooded approximately 2,400 square kilometer of rainforest. Construction of the dam also encouraged construction of roads which lead to deforestation in the area.

xiii). in many parts of the world particularly in Brazil, soya bean production has been a major contribution to deforestation. Soya bean for livestock feed and soya industry is an important export in Brazil. Animal feeds for meat production is Europe largest contribution to deforestation with soya import representing 47% of Europe deforestation footprint.

The effect of deforestation is also a major issue in forest biogeography. This is an extensively documented aspect of deforestation. Both the environmental and socio–economic effects have been widely discussed even at international fora.

The common and globally expressed impacts of deforestation include:

i). biodiversity loss
ii). savannization / desertification
iii) climate change
iv) food insecurity
v) land degradation into wasteland
vi) pollution
vii) water supply
viii) habitat damage

ix) soil erosion

x) economic life of indigenous people

Globally, deforestation is a major threat to biodiversity as it leads to loss of many plants and animal species through the loss or modification of their natural habitats. Deforestation reduces gene pool, hence there is loss of genetic variation that is needed to adapt to climate change in the future. Forests are important in the exchange of carbon dioxide ($CO_2$) and are second only to ocean as carbon sink Deforestation is responsible for about 10% of current greenhouse gases emission due to removal of forest which would otherwise have absorbed the emission. It reduces or eliminate the carbon sink associated with forest. This is to say that deforestation has adverse effect on biosequestration of atmospheric carbon dioxide.

Deforestation through logging mean fewer trees, thus less photosynthesis. Again emission of $CO_2$ increases as the gas is released from a tree when it is cut down and burnt or left to rot. A tree can absorb as much as 48 pound of carbon per year, so the felling of trees has a major impact on climate change (Odoh and Chigozie, 2012). Climate scientists have found that deforestation can lead to rising temperature. A rise of about $1.4^{O}C$ was recorded as a result of degradation in Amazon. Increased temperature in already hot locations may increase

i) human mortality rate

ii) electricity demand, and may reduce crop yield, and water resources

Findings from American Meterological Society (2018) through their research based on analysis of impact of deforestation on climatic pattern using data and observatory readings show that deforested land heats up faster and reaches a higher temperature leading to localized upward motion that enhance the formation of cloud and ultimately produce more rainfall. Given its global impact on climate, the United Nation Framework Convention on Climate Change at Rio de Janeiro in 1990 made deforestation a key issue.

Deforestation leads to the removal of protection from the soil thereby becoming more prone to desertification (evident by higher surface temperature, and reduce moisture). Deforestation also cause soil erosion which leads to degradation of soil fertility.

Exploitation of forest for mining activities such as coal and gold mining increases the risk of mercury poisoning and contamination of ecosystem. Mercury poisoning can affect food chain and affect wildlife both on land and in water. Still on the pollutional effect, it was reported in 2019 that smoke from wildfire in Brazil rainforest become so thick that it arrived in Sao Paulo and plunged the city into darkness in the middle of the day for an hour reported as "Prayfora Mazonia" in social media.

Deforestation can have impact on fresh water supply. This is because,

i). forest provides induce rainfall

ii). forests also help with water storage. Deforestation on the other hand can lead to shortage of water leading to drought. Examples including the reported cases of Brazilian drought of 2005, 2010, and 2015–2016. Deforestation leads to shortage of water ensuring drought in the affected region.

Note that in many countries including Nigeria, deforestation has almost reached a tipping point" (point after which forest will change to savanna). Apart from the above ecological impact, deforestation has major socio–economic implications, most especially the impact on community livelihood. In many forested regions, communities especially rural areas, are in the frontline of deforestation crises and their lives and livelihood are threatened.

Healthy forest supports the livelihood of 1.6 billion people globally, of which 1 billion of are among the world poorest. Many of the people hunt in the forest, gather raw products for their consumption and small–scale agricultural processing. Consequent upon the loss of this livelihood and the low yield resulting from decline in soil fertility or soil degradation, deforestation is today linked to food insecurity.

Given the implications of deforestations outlined above, geographers in the forest are among the policy makers to recommend solution. Some of this solutions are listed below:

i). private ownership of forest which allows for stakeholder involvement in monitoring deforestation
ii). employment and poverty reduction
iii). improved agricultural practice that will discourage shifting cultivation, overgrazing and land fragmentation.
iv). good government policy, that will prohibit reckless and unguided development. Some government policies in Nigeria have aided destruction of forest over the year e.g. the establishment of National Agricultural Land Development Authority (NALDA) which has destroyed about 28,000ha of the 53,6800ha of land it acquired for its operation. Akinsola and Oladele 2009, Naibi et al 2014).
v). deforestation awareness campaign through local, national and international media particularly on the danger of deforestation. Educating the local communities and tourists about the need to protect forests. Using education to enhance the community behavoural change especially consciousness about stopping deforestation, recycling and reuse of resources and education on other detrimental activities.
vi). fighting illegal logging and limiting logging in old forest.
vii). appropriate laws (enactment and enforcement)
viii). use of alternative energy to fuel wood.
ix) improving standard of living which guarantee access to modern cooking fuels (Naibi and Healay, 2015).

## 1.8 FOREST BIODIVERSITY AND CONSERVATION

#This is another issue that is of utmost concern to a geographer in the forest. Forest biodiversity is about all the life forms found within forested area or region and the ecological roles they perform. It is about the diverse plants and animal in a forest region, so it consists of plant biodiversity (floristic biodiversity) and animal biodiversity (faunitic biodiversity). In forest ecosystem, biodiversity encompasses tress as well as multitude of plants, animal and micro–organisms that inhabit forests and their associated genetic diversity. (Fatubarin, 2011). Forest biodiversity can be considered at different levels namely:

- i). ecosystem diversity
- ii). landscape diversity
- iii). species diversity
- iv). population diversity
- v). genetic diversity

Forest biodiversity is of interest to geographers because of its numerous importance to mankind which are collectively referred to as ecosystem services. Thus forest biodiversity provide services such as:

- i). Biomass production
- ii). Habitat provisioning services
- iii). Pollination
- iv). Seed dispersal
- v). Resistance to wind storms
- vi). Fire regulation and mitigation
- vii). Pest regulation
- viii). Carbon sequestration
- ix). Cultural ecosystem service
- x). climate regulation
- xi). Water supply

Other recognized ecosystem services are:

i). Provision of food in form of meat, egg, oil grains, tubers, vegetable spices, fruits etc.
ii). Provision of shelter in the form of wood, bamboo, etc for building houses
iii). Provision of clothing (cotton from plants and leather from animal skin)
iv). Provision of drugs
v) Provision of energy in the form of wood, fossil fuels etc.
vi). Recreational value
vii). Aesthetic value
viii). Religious and educational value.

From ecological point of view plant biodiversity provide the following services:

i). help in trapping solar energy that gets into any ecosystem and through them becomes available to other organism in the ecosystem.
ii). through photosynthesis, help in reducing the amount of carbon dioxide in the atmosphere
iv). also through photosynthesis helps in replenishing the oxygen in the atmosphere
iv). protecting land and soils from erosion and extreme insolation.

Owing to the significance of forest biodiversity, it is being exploited for different purposes in different countries. The rate of exploitation in developing countries is a major source of concern today, as such many of the forest biodiversity constituents are either endangered, threatened or lost completely. Many species of plants and animal in forest zones of the world have gone into extinctions (Chup, 2007).

The issue of biodiversity loss is a major subject in contemporary forest ecology. Loss of biodiversity is the gradual decline in the number of individual plant and animal species. Biodiversity loss is caused by four major drivers (Ocholi, 2019)

i). Direct effect of human activities e.g. habitat destruction and fragmentation
2). Invasive species (competition, predation and contamination of genetic diversity).
3). Over exploitation (e.g. in tropical forest ecosystem).
4). Indirect effect of human activities such as climate change.

Other causes of biodiversity loss include:

i). Loss of habitat
ii). Change of habitat quality
iii). Habitat fragmentation
iv). Exploitation of population
v). Changes in biotic environment

Apart from the drivers or causes of biodiversity loss, geographers are interested in the impact of biodiversity loss, which can be either ecological or socio–economic, has effect on water distribution and water quality in the ecosystem. The effects of biodiversity changes or loss is predicted to be greater in arid ecosystem and semi–arid systems because of reasons such as

i). low availability of water in general
ii). low effect of organism in regulating infiltration and subsurface flow
iii). relatively low diversity of functional groups and of species within functional groups.

Biodiversity loss also has effect on evapotranspiration and other climatic parameters, particularly radiation and light intensity in forest–ecosystem. Other ecological impacts of biodiversity loss include destruction of landscape structure, disruption of ecosystem functioning and processes, loss of fertility etc. The socio–economic impact has to do with loss of livelihood and cultural attachment.

Other biodiversity issues such as endemism, monitoring and measurement and human impact are very important and germane to a geographer's assignment in the forest. Endemism is a concept which has to do with restricted distribution of species or taxon to a specific geographical area or region. Some species of plant and animal are restricted to a particular geographical locations, and thus grow and thrive only in this location. Endemism is not widely studied in modern biogeography. Endemism is usually and loosely categorized in four contexts, namely,

i). site or restricted area e.g. arthropod groups on individual summits in the crystaline mountains of Tanzania.
ii). biotope e.g. as with *Quercus durata* to serpentine outcrops.
iii). biogeograpical regions e.g. as with Turkey, Neleagridinae, confined to Neoartic biogeographical region.
iv). political area e.g. with *Bradypus torquarus* endemic to Brazil.

There are other earlier classification of endemism such as those of Engler (1882) who classified according to their evolutionary age into

i). Neoendemics, comprising clusters of closely related species and subspecies that have evolved relatively recently e.g. hundreds of species of cichlid fishes in Lake Malaw.
ii). Palaeoendemics comprising phylogenetically high ranking taxa

Geographers have investigated the pattern of endemism on the earth surface and have come to the conclusion that endemics are not randomly distributed but tend to be clustered. The causes of endemism and its pattern are complex. Little is known about these, however studies have indicated that causes of endemism include among others:

i). historical processes
ii). contemporary ecological factors
iii). inherent biological properties of the taxa.

The study of these correlates or determinants of endemism is important for biodiversity conservation.

Human impact on forest biodiversity is another major issue that have occupied the attention of biogeographers over the years. Humans depend on biological (forest) resources for food, energy, construction materials, medicine, inspiration etc. By its character, forest resource is renewable and therefore with proper management it can be used sustainably. However when the level of human use exceed the capacity for renewal, the diversity and the productivity may be reduced. Thus, the way different societies manage forest determines how much diversity survives. In traditional societies, agriculture, fishing, livestock husbandry and other activities had the quality of sustainability, but modern tools and technologies with their roots in the industrial revolution had changed the relationship between people and resources in at least two fundamental ways: scale and intensity. Many of these technologies have caused profound, unprecedented and uncontrollable consequences for forest biodiversity.

The impact of human activities on forest biodiversity are both direct and indirect. The direct impact/mechanism include: habitat loss and fragmentation, invasion by introduced species, the over exploitation of living resources, pollution, domestication and selection, global climate change, local and industrial agriculture and forestry. All these have led to the biotic impoverishment and had consequently led to biodiversity loss.

It is important to note that man is the major factor determining the biodiversity status of forest ecosystem, the impact of his activities is monumental. The Global Biodiversity strategy identified the indirect mechanisms of human impact on forest biodiversity to include:

i). human social organization
ii). the growth of human population
iii). natural resource consumption pattern
iv). global trade
v). economic systems and policies that fail to value the environment and its resources (forest in particular).
vi). In equity in the ownership, management and flow of benefits from both the use and conservation of biological (forest) resources.

Today, Brazil has the largest remaining area of forest land but it is also under high pressure. This pressure has resulted in many places to conversion of habitat from one habitat type to another or a modification of condition within the habitat.

Also, of the indirect forces or mechanism of human impact on biodiversity, the effect of urbanization (a product of human population growth) is of greater importance. Urbanization rate has been phenomenal in the 21st century. Today about 45–50% of the world's population is urbanized (although not evenly distributed between developed countries (over 70% and developing countries (just under 40%) (Berry 2010, WRI 2014).

The effects of urbanization on biodiversity can be considered from two perspectives:

i). Direct effects which include the loss of habitat, fragmentation of habitat, creation of new human–made habitats such as cemeteries, derelict lands, rubbish tips.

ii). The indirect, effects cover the urban landscape with impervious surfaces (sometimes representing 17–20% of the total urban area Nwoboshi (1982). This has dramatic effect on runoff, a situation which is exacerbated by poor drainage systems.

Because of the economic and ecological value of biodiversity as well as the problems of externalities, managing forest biodiversity is key for healthy living on the planet earth. Thus managing biodiversity is another issue geographers are interested in. The major goal of biodiversity management is to strike an optimal balance between conserving the diversity and advancing human sustainable living. Biodiversity management is the human effort to plan and implement a set of approaches to

i). protect and sustainably use biodiversity and biological resources and ensure adequate sharing of benefits there from.

ii) develop the human, financial, infrastructural and institutional capacity to address biodiversity management objectives.

iii) establish the institutional arrangement/framework necessary to foster the required co–operation and action by private and public sector interests.

Forest biodiversity management involve the preservation of species, their genetic traits and the array of habitats and landscapes through the restoration of ecosystem and the harvesting of plants, animals and microbial resources for human needs, and distribution of benefits.

Many approaches have been put forward for managing forest biodiversity which include:

i) in–situ approach
ii) ex–situ approach
iii) restoration and rehabilitation approach
iv) major landuse approach
v) policy and institutional approach.

The *in–situ* approach include methods and tools that protect species, genetic varieties and habitats in the wild. This approach may involve the establishment of protected area such as nature reserves, wilderness area, national parks, protected landscape and seascapes. The *ex–situ* approach includes methods that remove plants, animals and microbial species and genetic varieties from their environment. This is done for breeding, storage, cloning or rescue especially where habitat can no longer sustain the species because of site alteration or transformation.

Restoration or rehabilitation approach includes methods that draw upon. *In–situ* and *ex–situ* tools to establish species, genetic varieties, communities, population, habitat and ecological processes. Restoration methods usually involve the re–construction of natural or semi–natural ecosystem on degraded land including the re–introduction of native species. Rehabilitation involves the repair of ecosystem processes such as nutrition cycling or hydrologic regimes. The major landuse approach includes strategies and tools in forestry to incorporate protection, sustainable use and equity criteria and guidelines. The policy and institutional approach include methods that limit the use of forest resources through zoning schemes, use of incentives and tax policy to encourage a particular practice, comply with law, to promote stewardships and other practices that favour biodiversity.

## 1.9 FOREST, GLOBAL WARMING AND CLIMATE CHANGE

One important concern of geographers in today contemporary world is the interaction between forest and climate change phenomenon. Forest–climate relationship is a complex one which geographers have over the years tried to analyze in terms of the underlying structure, pattern and processes. Ordinarily, it is known that forest affects climate (by creating a microclimate) but climate also affect forest in several dimensions.

My discussion here will briefly look at the two sides of this relationship:

First, I consider the effect of climate on forest. Ogidiolu (1997, 2000) identified the effect different climatic elements especially temperature and rainfall on carbon dioxide concentration in forest ecosystem. Using different models such as equilibrium model, dynamic vegetation model, several scholars have shown that climate could bring about the modification of frequency and intensity of forest fires, insect, pathogens and disease outbreak (Adejuwon, 1962, Ogidiolu 2020). The loss of timber and other non–timber forest products caused by fire and other weather hazards is unimaginable.

Forest health condition has to do with pests and diseases which could cause defoliation, growth loss, timber damage and forest dieback. Between 2008 and 2012, about 5million ha of forest was adversely affected by insects in United State, 14 million ha in

Canada. Evidence has shown that warmer temperatures have shifted the habitats of some forest insects e.g. Pire beetle, Gypsy moth in response to change in precipitation. In 2017, Pire beetle destroyed more than 650,000 acres of forest in Colorado, spruce beetle damage over 307 million acres in Southern Alaska and Western Canada. (Ogidiolu, 2019).

Extreme events such as strong wind, drought, flood can lead to massive loss of forest (this is region specific). Climate change can modify tree physiology and tree defense mechanisms. It could also affect productivity and distribution of forest especially as a result of change in temperature, rainfall and the amount of carbon dioxide in the air. Climate change can complicate problems already faced by forest from land development and air pollution. Climate change increases the risk of drought, fires and floods in some areas. Drought could damage plant, increase wildfire risk (as dry trees and shrub fuel the fire). Wildfires in 2011 consumed over 8 million acres of forest in USA (an area roughly the size of Maryland) causing 15 deaths, and about 1.9 million-dollar damages.

Apart from the above-mentioned effects of climate and climate change on forestry, they also affect forestry sector generally through,

a) change in supply
b) change in demand
c) timber production

Forest role in climate changes is the other side of the relationship. Forests generally play two–fold roles in climate change:

i). act as a cause of climate (microclimate)
ii) as a solution for greenhouse gas emissions.

Specifically, forests play other important roles in climate change.

1) they currently contribute about 20% of the global carbon emission when cleared, overused or degraded (Oguntala and Okali 2007)

2) produce fuelwood as an alternative to fossil fuels (which generate less amount of greenhouse gases)

3) they have the potential to absorb at least 10% of the global carbon emission (absorb into their biomass, soils and products). i.e. carbon sequestration.

4). React sensitively to a changing climate when managed sustainably i.e. forests help stabilizes the climate.

Restoring forest losses and halting forest degradation has the potential to contribute over one–third of the total climate change mitigation. It could increase carbon sequestration up to 1.7 gigatonnes annually (FAO, 2018).

The role of forest in climate change can be enhanced by combating deforestation and forest degradation, restoring forest landscape and ensuring right–based landuse.

## 1.10 FOREST CONSERVATION

This is another important issue of concern to geographer in the forest. Forest as stated initially is very important, it performs several ecological, economic and social functions. It is acknowledged to be the "lungs" of the environment and the factory of oxygen and other natural resources (Ogidiolu and Eneche 2020), therefore the concern by geographers for its conservation is not a misplacement. Forest conservation is the preservation and protection of forest. It is the controlled use of forest resources in such a way that its capacity to renew itself is not impaired. Conservation of forests ensures the continuity of benefits derived from them which are essential to continuous survival of man.

Forests need to be conserved for a number of reasons. According to IUCN (1980), conservation has three major objectives, which include: (i). maintenance of essential ecological processes and life support system (ii). preservation of genetic diversity (iii). Enhancing sustainable utilization of species and ecosystems.

Apart from these objectives, forests are conserved for reasons such as

a) Ethical value: Man is a trustee of nature, therefore he has a duty to foster the survival of other species. Man has no moral justification to bring about massive destruction and possible extinction of other species. Note that forest is passed on to us as an heritage, we should also pass it on to posterity.

b) Material benefits: Forest has many tangible and intangible benefits, therefore it should be conserved to ensure continuous supply of these benefits. Note that even those whose benefits are not known now have potential benefits: material such as wood, foods etc are gotten from forests.

c) Scientific value: The biodiversity of forest have great scientific value especially to the breeders who depend on the gene pool from wild varieties to improve the domesticated species. Forest plants are good for pharmacological research.

d). Ecological value: Forest helps in maintaining ecological balance. Ecosystem processes will be negatively affected if forest are not conserved and may result in different environmental problems e.g. acid rain, global warning etc.

e) Aesthetic value: Forest create beautiful scenery and provide opportunity for recreation and sport hunting and thereby contributing to overall well–being of the population.

### 1.10.1 Obstacles to Forest Conservations

Forest conservation in many developing countries including Nigeria is not enviable and thus the countries are witnessing rapid loss of forest both in quantum and value. This is perhaps due to several obstacles which need to be addressed for productive conservation efforts and programmes.

i) Conversion of forest land to other uses without consideration for environmental consequences.

ii) Poverty, Human and Socio–Economic Needs: Most landowners are subsistence farmers whose major source of livelihood is farming, so they are strongly attached to the land and hence they would do everything to thwart any conservation effort/programme that deprive them of their land.

iii) Ignorance of the public. People do not know the basic conservation practices, consequences of deforestation and why they should plant trees. In this regard forest conservation effort should include good forestry extension services and education

iv) Inadequate funding and non–participation of wood–based industries.

v) Political factors: This is where political factors are given priority over ecological factors in project development. In many countries, forest conservation is not given political priority and probably not budgeted for.

vi) Inadequate and Non–enforcement of existing laws backing conservation efforts. We recommend the introduction of laws mandating wood–based industries to participate in forest regeneration.

### 1.10.2 Forest Conservation Strategies

Effective forest conservation have been achieved in developed countries of Europe and America and even developing countries of Asia like Malaysia Indonesia, Singapore. This probably is due to the adoption of best strategies, such as:

i) Educational strategies in the form of public enlightenment especially politicians, policy makers on forest conservation tips and guides. Teaching, forest or natural resource conservation to college and university students.

ii) Economic strategies, which involve taking care of the needs of the local population, since forest is their main source of livelihood. It could be in the form of financial assistance especially from wood–based industries/firms, or tax break, or subsidies for forest dwellers or other economic incentives–a major reason behind Costa Rica’s success in forest conservation.

iii) Professional training for staff of forestry department at the three tiers of administration.
iv) Political strategies: by building in ecological consideration into development programmes instead of purely socio–political factors.
v) Legal strategies which involve: promulgating sufficient laws and enforcing the existing ones.

Once these strategies are understood and adopted, they should be complemented with the adoption of good forest conservation techniques such as:

i) afforestration
ii) reforestation
iii) selective logging
iv) control burning
v) agroforestry
vi) establishment of wildlife management areas.

## 1.11 SUSTAINABLE FOREST MANAGEMENT

Of great concern to geographers is the issue of sustainability of the environment and its natural resource. Following the UN declaration of Stockholm in 1990, the issue of sustainable development gains greater emphasis in academic discourse. To geographers, environmental sustainability is like a major paradigm shift because the attention/focus of geographical researches especially since the 1990's have been on sustainable environment.

Environmental resources need to be sustainably managed not the least is forest resource, hence biogeographers are concern with issue of Sustainable Forest Management (SFM). Sustainable Forest Management is a concept aimed at maintaining and enhancing the economic, social and environmental values of forests for the benefit of present and future generations. Ministerial Conference on the protection of forest in Europe (FOREST EUROPE) and subsequently FAO (2019) define SFM as the "stewardship and use of forest and forest lands in a way and at a rate that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future relevant ecological, economic and social functions at local, national and global levels and that does not cause damage to other ecosystems.

Sustainable Forest Management can also be seen as the attainment of balance between society's increasing demand for forest products and benefits and the preservation of forest health and diversity. It involves looking at the ways to use forest today to ensure similar benefits, health and productivity in the future.

It also entails reconciling a number of conflicting factors such as:

a) commercial and non–commercial values.
b) environmental considerations
c) community needs
d) global impact

Sustainable forest management enable forest to provide benefits such as:

i) safeguarding the local livelihood
ii) protecting biodiversity and services provided by forest
iii) reducing rural poverty
iv) mitigating some of the effects of climate change
v) water supply

Sustainable forest management also known as Sustainable Forestry, is the practice of regulating forest resources to meet the needs of society and industry while preserving forest health. Scholars have documented the benefits of SFM in a number of publications in forest ecology and management.

A review of these indicated that such benefits to include:

1) helping to keep the balance between ecological and socio–cultural pillar i.e. ensure outcomes that are socially just, ecologically sound and economically viable.
2) provide an holistic approach to ensure that forest activities does not compromise its benefits now and in the future.
3) forest when managed sustainably contribute to productive function of forest resources
4) contribute also to forest health and utility.

### 1.11.1 Strategies for Sustainable Forest Management

Ogidiolu and Eneche (2020) enumerated some of the ways to achieve sustainability of forest especially in the face of escalating demand for forest products. Some of these involve behavioural and attitudinal re–orientation and education of forest dwellers, and even policy makers.

The strategies involve even simple things like tree planting, (one tree planted for everyone tree removed). Other strategies are listed to include:

1) Selective logging, that is, removing certain trees (preferably matured one) while preserving the balance of the woodland. Although this strategy is more time consuming and more expensive. It is ecologically sound, interms of reducing interruption in ecosystem processes.
2) Delayed harvesting: This involve allowing young trees time to mature, in this way sustainable forest management protect the long–term value of the forest.
3) Afforestation
4) Creation of protected forest (reserves) which serve to provide safe habital for plant and animal species.
5) Perfect coordination between forest department and other departments or agencies since forest conservation is a national problem.
6) Peoples participation (community–based approach) which involve getting the locals and forest owners in a bottom–up approach to SFM.
7) Joint Forest Management (JFM): In this strategy the locals and forest department in formal or informal agreement are involved in the formation of Forest Protection Communities (FPCs). These people will participate in restoring the green cover and protect other areas from being over–exploited. This is another secret of Costa Rica Success in sustainable forest management.
8) Agroforestry. This involve the practice of combining food crop and forest crop either simultaneously or subsequently to ensure the most efficient landuse under a management system according to the social and cultural practices of the people.
9) Adopting the practice of social forestry i.e. forest plantation established in non–forest area for the benefit of the society.

## 1.12 ECOTOURISM

One of the many issues of concern to geographers in the forest is ecotourism and more specifically forest ecotourism. It is of concern to geographers because of its numerous potential benefits and challenges. In recent times, ecotourism has been found to reduce human carbon footprint on the earth. It is about uniting conservation, communities and sustainable travels (Afolabi and Mohammed, 2010).

Ecotourism has been variously defined. For instance, Boo (1990) defines ecotourism as a form of tourism, a product, response to both social and environment needs, discretionary travel, market segment and green strategy applied to influence a destination's attractiveness. It is also seen as travelling to undisturbed or uncontaminated natural areas to study, admire and enjoy the scenery, wild plants and animals and any existing cultural manifestation (both past and present) found in these areas (Eagles, 1993).

Boyd and Butler (1996) submitted that ecotourism is a responsible travel experience that contributes to the conservation of the ecosystem while respecting the integrity of the host communities and ensuring that activities are complementary or at least compatible with the existing resource use present at the ecotourism level.

Ecotourism is also defined as a responsible travel to natural areas that conserve the environment and sustain the well-being of the local people. It is a discretionary travel to natural areas that conserves environmental, social and cultural values, while generating economic benefits to the local community who spend time and money to experience the outdoor, learn more about the particular wildlife or culture of the destination and have a concern for minimizing impact (social, economic and cultural) to the environment (Ferrell and Runyam, 1991).

#The above definitions point to three important attributes of ecotourism

- i) It is nature–based
- ii) It is educative, providing educational programmes.
- iii) It promotes sustainability by supporting conservation efforts

Forest ecotourism simply involve responsible travel to forests where flora, fauna and cultural attractions are the primary attention. It is the travel to and use of forest for recreational purpose that also recognises the conservation and sustainability of the environment and the benefits of the local people.

Forest ecotourism also involves sensible and responsible visits to forest ecosystem with their biotanical and zoological features without compromising biodiversity conservation. Participation in forest ecotourism is associated with the following advantages; ecological, social and economic. (Afolabi and Mohammed, 2010).

These benefits have been specifically broken down into the followings:

i) status recognition
ii) shift of attention of tourists from cities
iii) prevention of ecocide (total destruction of an area due to its eco–friendly, cautionary activity).
iv) retention of naturaliness
v) spatial development
vi) entrepreneurship development
vii) landuse diversification
viii) contribution to regional income
ix) employment generation

**1.12.1 Forest Ecotourism Resources in Nigeria**

An outline of Nigerian vegetation by Keay (1959) revealed that there are different categories of forest ecosystem in Nigeria ranging from the mangrove salt water forests along the coastal areas to high or rain forest and mountain vegetation of the hinterlands. There are also several forest reserves. Forest ecotourism resources of these different forest types are presented briefly in this section.

a) Mangrove Forests: These are found along the coastal area extending between 30–50 kilometer inland. They are either the salt–water or fresh water. They are extensive along the coastal areas of Badagry (Lagos) Ijebu–waterside (Ogun State) Aiyetoro (Ondo State) Burutu, Forcados, Okpari (Delta State) Sengan and Brass (Bayelsa State) Degema, Beguma, Bonny, Opobo (River States) Ikot–Abasi Qua Ibo (Akwa Ibom State), Odukpani Atimibo, Ikang and Calabar (Cross River State).

The ecotourism resources of this forest in these areas include the floristic composition and the culture of the various communities which depend on the Mangrove forest. An ecotourist can compare the wildlife (fauna species) with that of the interlands. Mangrove forests are rich in flora of different geometric shapes and sizes, different aerial root systems that are very fascinating and enhance the scenery of the region. This is a common feature in Yenegoa, Nembe and Okubie in Bayelsa State (Ukpong, 1990).

b) High or Rainforest. This forest type is found extensively in the southern part of Nigeria especially Southwest, and South–east geopolitical regions. A detailed account of the floristic composition of this forest is given by Hokpins (1968). It consist of tall, tropical hardwood species such as *Triplochiton scleroxylon, Terminolia species, Khaya ivorensis, Adansonia digitata*, etc. The canopy consists of three recognised layer (for mature undisturbed forest which are habitats to several forest birds. What a forest ecotourist want to see include the richness of the forest with respect to both flora and fauna species, the varying heights and shape of the trees, the medicinal trees and wildlifes such as *Cercopithecus spp* (Monkey) *Papio anubis* (Baboon) *Hystrix spp* (Porrcuyane) *Cephalophus inger* (Black duiker) etc.

c) In the montane forests and forest reserves there are many tourism resources similar to those earlier mentioned. However montane forests are found on high landscapes such as ridges, mountains, hills and inselbergs which themselves are ecotourism resources. Many of these hills and mountains associated with forest (montane forest) are found in places like Adamawa Hill, Kurawa Hills, Wiga Hills, Biu Plateau, Sheno Hill, Muri Mountain and Jos Plateau in Northern Nigeria, Idanre Hill, Arolu Hill, Oyemekun Hill, Olosunta Hill, Adoawaye Hills in Southern Nigeria.

Forest reserves are found in many states of Nigeria, see table 12.

## Table 12: National Forest Reserves in Nigeria

| National Forest Reserves | Area ($Km^2$) | State(s) | Region |
|---|---|---|---|
| Afi River | 312 ($Km^2$) | Cross River | South–South |
| Akure Ofosu | 394 ($Km^2$) | Ondo | South–West |
| Edumanom | 93.24 ($Km^2$) | Bayelsa | South–South |
| Idanre | 561 ($Km^2$) | Ondo State | South–West |
| Ise | 142 ($Km^2$) | Ekiti | South–West |
| Ngel Nyaki | 46 ($Km^2$) | Taraba | North–East |
| Oba Hills | 52 ($Km^2$) | Osun | South–West |

| | | | |
|---|---|---|---|
| Okeluse | 144 ($Km^2$) | Ondo | South–West |
| Okomu | 1081 ($Km^2$) | Edo | South–South |
| Oluwa | 829 ($Km^2$) | Ondo | South–West |

Source: Adapted from Encyclopedia Britannica (2014).

These reserves are good ecotourism sites, many of which are fascinating because of their floristic and fauna composition, (similar to those of National parks or game reserves). They can be equipped with modern ecotourism infrastructures and recreational facilities such as reserve viewing vehicles, boats, binoculars, cameras, guest houses, securities etc.

Important forest reserves which have been converted to national parks include Okomu National Park, Old Oyo National Park, Yankari National Park, Kaniji Lake national parks, Gashaka–Gumti National park. Forest reserves are created by government for purpose of forest protection. They are good ecotourism sites where visitors are allowed to see nature *in-situ*.

## 1.13 FOREST HEALTH AND VITALITY

The issue of forest health and vitality is a crucial aspect of forest biogeography and it is today gaining greater attention from geographers and foresters. Forest health is important because forest also keep man healthy in many ways, for instance, by storing and filtering the water needed for drinking. Forest products provide economic and energy benefits to individual and communities. Decline in forest health and vitality may have significant economic and ecological consequence for the society including loss of forest benefits and degradation of environmental quality.

The question is what does health and vitality mean for forest? Just like human and human society, health and vitality are essential for survival. In this lecture, forest health is a term used to describe the condition of a forest and how well it is able to meet management objectives It is a qualitative term that refers to the general condition of a forest.

A healthy forest is the forest that is able to maintain its organisation and autonomy over time while remaining resilient to stress (Constanca 1992, Raffa *et al* 2009). A healthy forest is one that is relatively free of insects, exotic weeds and air pollution. A healthy forest is a forest that possesses the ability to sustain the unique species composition and processes that exist within it. A healthy forest should be able to accommodate the present and future needs of the people for a variety of values, products and services.

The health of a forest must be preserved, which will ensure the survival of plant and animal species that make forest their home. Note that a forest may be healthy and contain unhealthy trees, and an unhealthy forest may have healthy trees so forest health is a matter of degree or scale. Today there are a number of threats to forest health, that call for regular monitoring–a major duty and task of a geographer in the forest. Threats or obstacles to forest health can be both biotic and/or abiotic stress agents. These stress agents cause sustained disruption of the normal physiological or structural functioning of a tree which if it persist can harm or kill the tree. Note, the distinction between biotic and abiotic stress agents determine whether the stress can spread and how it can be managed.

Biotic agents are living organisms including plants, animals, and microorganisms, while abiotic agents are non–living mainly in the form of pollution, drought, fire or herbicides, Biotic agents are infectious and transmissible e.g. disease and insects. These have claimed more timber annually, especially in developing countries that lack good silvicultural practices. (Nwoboshi, 2082). In these countries insects and diseases are great risk to forest resources.

Teale and Castlello (2011) specifically listed the threat and obstacles to forest health and vitality as:

i). Fire
ii). Insects and disease

iii) Over–exploitation of wood and non–wood forest product (human threat)

iv) Poor harvesting practices

v) Poor management

vi) Uncontrolled grazing

vii) Agriculture and urban sprawl.

viii) Invasive species

ix) Air pollution

x) Extreme climate events e.g. drought, forest, storms, floods etc.

xi) Socio–economic threat e.g. poverty.

## 1.14 FOREST AND ALTERNATIVE ENERGY

Global energy demand is soaring and the sources are also changing especially as a result of concern for,

i) cost (fossil fuel prices)

ii) reduction of greenhouse gas emission, and

iii) reduction of fossil fuel import dependence.

Therefore, many countries are looking to forest as a viable alternative energy source. The concerns of geographers in this is in two major areas:

i) forest as an alternative source of energy and its effect on environment generally.

ii) the consequences as well as the management of the consequences of relying on forest as an alternative energy source.

In developed economies, forest is an alternative source of energy that has reduced energy consumption from fossil fuel. Forest fuel is a form of bioenergy (type of energy derived from biofuels). Biofuels are fuels derived from matter of biological origin which could be:

i) forest (woodfuel)

ii) agricultural (agrofuel)

iii) municipal (municipalfuel)

According to FAO (2008) each of these types of biofeuls can be divided into solid, liquid and gaseous form, hence we have for instance.

a) Solid woodfuel (wood in rough chips, sawdust and pellets and charcoal)

b) Liquid woodfuel (black liquor), a by–product of woodpulp industry, ethanol and methanol and pyrolytic oil.

c) Gaseous woodfuel–produced from the gasification of solid/liquid biofuels.

While agrofuels are biomas–materials derived from fuel crops, agricultural, agro–industrial and animal products, municipal fuels are mainly waste products in the form of sludge.

Bioenergy is a renewable energy and it is important to know that the net benefit of bioenergy depend on the balance between carbon dioxide ($Co_2$) captured during plant growth and $Co_2$ released in producing, processing, transporting and burning the fuel. With improvement in technology new biofuel that are more energy efficient and generate less greenhouse gases are being produced (second generation biofuels). Nigerian forests are a good source of this second-generation biofuel if sustainably managed. Thus, while we advocate the use of forest or wood biofuel for energy in developing countries such countries must carefully consider or assess the risks and benefits of investing in bioenergy technologies.

Forest residues can generate considerable energy however, efficient methods of harvesting and transportation is an issue, and we must therefore choose the one that can reduce socio–economic and environmental costs. Government of Nigeria can establish forest plantations as a source of wood energy however to be economically viable, such plantations will require efficient harvesting, good logistics and high productivity.

Developed countries now have

i) forest of power (solar energy harvesting trees), this is a success story in Finland where scientist at V.T.T. developed a prototype of a tree that can harvest solar energy from its surrounding (either indoor or outdoor) stores it and turns it into electricity to power small devices like mobile phones, thermometers etc.

ii) Energy forest: a form of forestry in which a fast-growing species of tree or woody shrub is grown specifically to produce biomass or biofuel for heating or power generation. There are two types of these energy forest:

a) short rotation coppices which include tree crops for example eucalyptus grown for 2 to 5 years before harvest

b) short rotation forestry: These are crops of alder ash, birch, eucalyptus, poplar and sycarmore grown for 8 to 20 years before harvest.

The advantages of bioenergy are numerous, such as,

1) promote economic well–being by creating jobs.
2) allow better use of unproductive land (preventing land disputes)
3) increase energy security
4) reduce GHG emissions (while growing they absorb $Co_2$)
5) they are better source of energy interms of quantity of energy released by unit of carbon emitted.

Good as this source of energy is, the major criticism is in the concern for food vs fuel (when land is taken from food crop to energy crops). The threat of this can be reduced as energy forest can be grown on slopes, marginal or degraded land, sometimes with long–term restoration purposes in mind (Aylott, *et al* 2018). Apart from food crises, the consequences on poverty, biodiversity, climate change and water security are other source of concern which should be adequately managed.

## 1.15 FOREST AND POVERTY

The concern of geographers in this instance, is the role of forest in poverty alleviation. Poverty play major role in deforestation. Many of the world rainforest areas are found in the poorest areas of the world. Forests are a part of natural economies providing a wide range of production inputs, environmental goods, foods, fuels, medicine, household equipments, building materials and raw materials for industrial processing. Without providing these benefits, the economy of the forest communities will not be healthy.

Forest and trees are critical in the well–being of many of the world's poor people. Forest is a source of day–to–day subsistence and a safety net in times of need, therefore sustaining forests (and other natural resources) is critical to achieving poverty alleviation and promoting global human well–being.

Developed countries have used forest to achieve poverty alleviation in three major ways which support households:

i) subsistence
ii) safety net
iii) pathway to prosperity

Poverty is the deprivation of well–being related to lack of material income or consumption, low level of education and health. In promoting well–being, forest contribute to income of rural and urban communities. It contributes between 20–25% to income of household living near forest. It offers subsistence through provision of income and consumption. Forests provide forest land for agriculture, timber, agroforestry, non–timber forest products as well as other important life supporting ecosystem services. Forests provide both cash and non–cash income. Non–cash incomes like food, fodder, energy, house building material and medicine are important and are obtained from forest by people living near the forest. Studies have shown that these forests environmental incomes represent about 20–25% of the income for the rural poor (Samii, *et al* 2014).

Forests also provide safety nets (natural insurance) in the form of alternative sources of income and subsistence to cope with shocks in times of scarcity and instability. Using forest to supplement their income and smooth consumption post shocks (floods, fires, pests etc) people living in the forest are able to bounce back to life.

Forest can also be a means of alleviating poverty (as a pathway to prosperity). This is done through promoting more cash saving when people use more of forest resources. Forest-based livelihood is much easier to enter than other options (Dubois, 2003). Note that the role of forest in poverty alleviation is affected by a wide range of social, economic, political and environmental factors.

While we acknowledge the importance of forest and forest resources to people's well–being and the potential of forest–based poverty alleviation, over dependence and over–exploitation of forest should be discouraged.

## 1.16 FOREST AND INSECURITY

This is another area of concern of a Geographer in the forest. Insecurity is a global, regional natural and local problems. In Nigeria forest can provide cover for criminal activities, making it challenging for security forces to track and apprehend perpetrators. Some of the concerns include:

(i). hiding spot (dense forest can be used by bandits, kidnappers or militants).
(ii). limited surveillance. (remote forest area can be hard to monitor).
(iii). resource exploitation. (forest may be exploited for illegal logging, mining or pouching}.

Examples of such forest related insecurity are found in states like Anambra, Imo, Ebonyi (kidnapping/militantancy) Bayelsa, River, Delta (oil thrift, piracy and militancy), Benue, Nassarawa, Niger, Kwara, Kogi. (Banditry, Kidnapping and Farmers herders conflicts). Borno, Yobe, Adamawa (Boko Haram, insurgency) Zamfara, Sokoto, Katsina (banditry, kidnapping and castle rustling). Insecurity affects all facets of life be it, social, economic, political and environmental. It is therefore worthy of attention from geographers who can use their geospatial technologies to study and analyse the spatial patterns of these insecurities' issues and proffer appropriate solutions such as community led mapping to identify hot–spots.

## 1.17 BIOGEOGRAPHER'S TASKS

Mr. Vice–Chancellor sir, the issues and concerns identified and discussed in the foregoing sections bestow some responsibilities or tasks on geographers which are briefly discussed below. The major tasks of the geographer is that of demonstrating the relevance of geography and geographers in the understanding of some ecosystem processes in the forest as well as demonstrating the usefulness of their skills in sustainable forest management. Geographers are by their training, specialists in spatial and environmental issues. They are also knowledgeable in the management of resources, mainly environmental or natural resources, be it land, water, air, soil, vegetation. Geography also offers geographers ample techniques tools and methodologies which set them apart in the social, natural and environmental sciences. Techniques such as those of mapping and survey, geoinformatics, quantitative or analytical and are integral part of their training coupled with other versatile tools like computational techniques enable them to deploy their capacity and potentials in managing issues relating to environment and space.

Forest management is usually believed to be the exclusive preserve of foresters, but from our analysis, we have shown that cognate or allied disciplines like geography have great and central role to play. Geographer's tasks in forestry sector include but not limited to the following.

i). survey and mapping of forest resources
ii). Forest environmental monitoring and evaluation
iii). Forest site/soil capability classification
iv). Data collection using aerial and land-based instrumentations for making pragmatic decisions on forest issues.
v). Analysis of forest dynamics (spatio–temporal) in order to increase, the understanding of processes and be able to predict the outcomes and impact of such processes.
vi). Conduct studies on forest environment–interactions and subsequent modeling of the same.
vii). Conduct impact studies and recommend mitigation measures especially on effects of geographical events on forest e.g storms, floods, drought and socio–economic or human activities.
viii). Forest productivity assessment (mensuration) necessary in the establishment of forest plantation in relation to site or environmental variables).
ix). Sustainable forest advisory services and forest management education and participation
x). Using Geographical Information System (GIS) to identify potential ecotourism sites
xi) Use of geographical tools for environmental surveillance
xii) Impact studies and management of different forest landuses.
xiii) Sustained research on forest dynamics to further understand the emerging frontiers in the science and management of forest.
xiv) Carrying capacity assessment of forest to ensure sustainability.
xiii). Forest management, and planning policy development
xiv). Advocacy on forest conservation by establishing Non–Governmental Organisation (NGOs) with core focus on forest protection and conservation as well as environmental rights

xv). Climate change management

xvi) Agroforestry services

Mr. Vice–Chancellor sir, I have no doubt that if geographers are given the right environment, support and opportunities and by their training, geographers will be well-positioned to contribute greatly in the management and sustenance of our forest and other natural resources.

## 1.18 RECOMMENDATIONS

Mr. Vice chancellor, sir, it is not my intention that the audience here should just listen to the myriad of issues and concerns of a geographer about forest, but what have been analysed are facts and should be addressed appropriately. Around the world, there are examples of policy initiatives and actions that have been introduced to resolve many of the issues mentioned above. To this end, the following recommendations become imperative and are hereby made:

i). keep **more** forest landscape. In view of the several importance of forest resources and the diverse forest ecosystem services, there is the need to expand forest to even marginal lands. This can be through a deliberate effort by the three tiers of government and private sector organizations.

ii). manage **more** sustainably through adopting a number of conservative measures and best silvicultural practices such as, good harvesting techniques, delayed harvesting, etc. This will also involve safeguards against misuses and misapplications.

iii). restore more of those forest landscapes that had been lost or degraded. This may involve more reafforestation and regeneration using more ecologically adaptive and fast-growing species.

iv). combating deforestation and trying to achieve Zero-Net-Deforestation and Forest Degradation (ZNDD)

v). mitigating climate change proactively by complying with various treaties and conventions e.g. the Kyotol protocol, Montreal convention on reduction of carbon emission and the use of environmental friendly energy alternatives.

vi). Enabling right–based landuse

vii). ensuring community participation through the formation of Forest Protection Communities (FPCs) and volunteers. This will proactively prevent destruction of forest through illegal cutting and engender the spirit of co–ownership of the natural resource.

viii). unlocking forest potentials through the development of more environmentally friendly utilization of forest resources and services.

ix). the practice of social forestry, where forest plantations are established in non–forest area for the benefit of the society.

x). forest monitoring and evaluation especially to predict possible forest hazards such as climate hazards e.g. storms, floods etc for proactive management plan and policies. Frequent and periodic monitoring of the susceptibility of forest to pests and diseases have produced wonderful results in Brazil.

xi) Training and retraining of forest workers.

xii) Bioprospecting, otherwise known as biodiversity prospecting is highly recommended. This involved the exploration of wild plants and animals for commercially valuable genetic and biochemical resources.

xiii). Sustained research on forest dynamic to further understand the complexities of forest ecosystem and the emerging frontiers in the science and management of forest.

xiv). Politically, the solution to some of the concerns of geographers about forest ecosystem will involve government making deliberate efforts to remove administrative and operational bottlenecks to good forest management and provide inter sectoral collaboration in forest management and conservation. Government should promote good forest governance, eliminate poverty among the poor forest communities and create alternative livelihoods.

Finally, Mr. Vice–Chancellor, ladies and gentlemen, having given this expository analysis of geographer's concerns and tasks in the forest, it is clear that geographers are among the frontliners in forest science and studies. Geographers are, infact, in the leading position in the study, analysis and management of natural resources including forest.

Therefore, for sustainable and pragmatic management of natural resources especially forest, it is recommended that geographers and hence geography as a discipline be given greater recognition and attention by educational policy makers through making geography a core and mandatory subject in our early educational levels of training particularly primary, junior and senior secondary schools in Nigeria.

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