CHAPTER ONE

INTRODUCTION

1.1 An Overview of the Study

Nigeria has a vast land area covering 923,768 square kilometres. This land area contains a wide range of natural resources, and in particular, vegetation. The vegetation cover of Nigeria reflects past and present climatic variations (Areola, 1982) and is made up of secondary re-growths which over the years have been influenced by both natural and human activities (Badejo, 1998; Cline-Cole, 1998; Salami, 1999). From earlier studies (Soussan and Millington, 1982) it was shown that the general vegetation cover of Nigeria, particularly forest areas, had an annual deforestation rate of 5% per annum of its closed forests. This is one of the highest in the world. However, rapid population growth and demands for economic development on a relatively natural, and in some areas, undisturbed vegetation which is not properly managed can also lead to permanent conversion of most vegetated areas to other forms of landuse such as agriculture and housing in Nigeria.

The report on the implementation of Agenda 21 (UNCED, 1997) of the United Nations Commission Conference on Environment and Development (UNCED, 1992), which is a long-term global action plan for sustainable development, indicated that there is still a persistent decline in the general vegetation cover across Nigeria due to population pressure, overgrazing and continuous exploitation of marginal lands for various purposes. It therefore suggests that periodic assessment and management of vegetation cover for ecological sustainability would be highly desirable.

As a country with a population of over 88 million and a growth rate of 3 % per annum according to the 1990 census, where the majority of this population are peasant farmers, population pressure is most likely to have an impact on the general vegetation cover.

Koop and Tole (2001) assert that 'An important factor that influences a country's environment development trajectory is the extent to which economic expansion alleviates poverty pressures on the environment and promotes environmental awareness'. In the context of the degrading vegetal cover across Nigeria, poverty pressures on the environment are on the increase and the promotion of environmental awareness is not well established at present.

Mapping the distribution of landcover across large areas like Nigeria is said to be a prerequisite for informed natural resources management (Rogers *et al,* 1997). Vegetation is one such important natural resource which requires timely and effective monitoring for ecological sustainability. The coverage of topographic maps in Nigeria is very heterogeneous and mostly outdated (Balogun, 1985; Nsofor, 1998). If most of these topographical maps are produced regularly they can be used on a provisional basis to assess planimetrically where vegetation cover, particularly forest areas across the country, has changed.

Satellite data can be very useful in assessing any changes in vegetation cover across Nigeria because of its repetitive coverage. However, as a country with a GNP as low as US$280 and accumulated debts of over US$28 billion (World Bank, 1999) there are limits to what Nigeria can afford. Data acquired by the Advanced Very High Resolution Radiometer (AVHRR) on board the National Oceanic Atmospheric Administration's

(NOAA) Meteorological satellites can be obtained free (in contrast to other satellite data such as Systeme pour l'Observation de la Terre (SPOT), Landsat Multispectral Scanner (MSS) or Thematic Mapper (TM)) and it has high temporal resolution.

It is in the light of the Agenda 21 report regarding the persistent decline in vegetation cover across Nigeria (UNCED, 1997), the need for periodic monitoring and taking into account its economic status the feasibility of utilising the NOAA/NASA Pathfinder Land (PAL) dataset from AVHRR forms the basis of this investigation to assess changes in vegetation and land cover across the whole of Nigeria.

1.2 The Aim of the Study

This investigation is on the use of coarse spatial but high temporal resolutions AVHRR-NDVI data to assess temporal changes in vegetation cover across Nigeria with the following objectives :

The Main Research Objectives

The objectives were to :

1. Assess temporal changes in vegetation cover in absolute and relative terms across Nigeria from multi-temporal NDVI data.
2. Develop a spatial model of precipitation for Nigeria based on coarse resolution rainfall estimates and other environmental variables.
3. Use the modelled rainfall data and the NDVI data-set to identify and explain areas of change in vegetation and land-cover across Nigeria.

Because there is no systematic monitoring of vegetation cover across the whole of Nigeria this would provide provisional information for the potential use of the multi temporal NDVI PAL dataset periodically. Where necessary, further assessment can be undertaken based on the results obtained by using a small number of high spatial resolution satellite imageries covering specific areas.

1.3 Rationale for the Study

This study was undertaken against the background of different types of land cover changes across Nigeria by many studies that used high spatial resolution data such as aerial photographs, SPOT, Landsat imageries and environmental data (Adams, 1985; Adeniyi, 1980; Adeniyi, 1985; Schneider *et al,* 1985; Adejuwon and Adesina, 1988; Adams and Thomas, 1996; Badejo, 1998; Ite and Adams, 1998; Salami, 1999; Boele *et al,* 2001a; Boele *et al,* 2001b), and the report on Nigeria on the implementation of Agenda 21 by the United Nations (UNCED, 1997). This is to see if results from these investigations can further be verified or modified using very coarse spatial resolution data from AVHRR.

Studies which utilised NDVI data from AVHRR (eg Tucker *et al,* 1985; Justice *et al,* 1986; Townshend *et al,* 1987; Prince and Justice, 1991; Tucker *et al,* 1991a; Millington *et al,* 1994;) have shown that NDVI data can provide an effective measure of photosynthetically active biomass. This is because of the degree of absorption by chlorophyll in the visible red wavelengths, which is proportional to leaf chlorophyll density, and by the reflectance of near infrared wavelengths, which is proportional to green leaf density.

The study conducted by Malo and Nicholson (1990) on rainfall and vegetation dynamics in African sahel indicated that there is a strong linear relationship between NDVI and rainfall. Other studies (eg Eastman and Fulk, 1993) have shown that on a continental scale, Principal Component Analysis (PCA) has the potential for analysing time-series NDVI data of 10 minutes resolution from AVHRR, with the possibility of extracting and analysing climatic trends and other influences such as satellite anomalies from complex vegetation responses. Anyamba and Eastman (1996) have shown that there is a relationship between the interannual variability of NDVI and the El-Niňo/ Southern Oscillation (ENSO) over the whole of Africa using a 30 km resolution NDVI data. Young and Wang (2001) have utilised the 8 km AVHRR NDVI data from the PAL dataset using a combination of simple image differencing and PCA techniques to assess vegetation dynamics successfully over the whole of China.

From studies with NDVI data derived from AVHRR (Rogers, 1991; Rogers *et al,* 1996; Hay *et al,* 1997; Linthicum *et al,* 1999), it was shown that such data can be used in epidemiological studies and mapping of vector diseases especially in Africa where the resources available to deal with disease problems are not readily available. From recent studies linked to climate variability, land use and global climatic change (Sutherst, 1998; Linthicum, *et al,* 1999; Patz *et al,* 2000; Anyamba *et al,* 2002), it was also shown that varying climatic conditions related to ENSO events are now becoming risks to both humans and animals.

Furthermore, Millington *et al,* (1994) have examined and shown the potential of imagery acquired by the AVHRR for land cover studies generally, but this has not been utilised fully by countries with low economic standing. Because of the value of NDVI derived from AVHRR it is therefore being utilised in this investigation for the assessment of temporal changes in vegetation across Nigeria. While the data has a high temporal resolution, the spatial resolution is limited to 8 km, and the impact of this needs to be determined.

1.4 The Structure of the Book

The book is divided into eight chapters. Chapter One, the Introduction, has highlighted some of the socio-economic problems which may be responsible for exerting pressures on the vegetation cover across Nigeria and the need for periodic assessment using a very coarse spatial resolution AVHRR-NDVI data.

Chapter Two briefly reviews literature on studies conducted with AVHRR data generally from global to continental and regional scales with further emphasis on the use of AVHRR-NDVI data from the PAL dataset. This also includes other studies conducted on Nigeria using other remotely sensed data and ancillary information.

Chapter Three provides a general overview of Nigeria in terms of its political, social and physical setting which includes its topography, soils, climate, land-use and vegetation.

In Chapter Four the general methodology used in undertaking the study is presented. This includes data access, such as the NDVI PAL dataset, the GTOPO30 Digital Elevation Model (DEM) data and the Gridded Precipitation data from the Global Precipitation and Climatology Centre (GPCC). In addition to these, the procedure for recompositing the NDVI dataset, making a subset of the DEM of the study area from the original acquired GTOPO30-DEM and creation of rainfall models is also presented. This is followed with the description of how the spatial rainfall data was generated from the models. One major problem encountered with the NDVI data from the PAL dataset as part of its uncertainties is also highlighted. At the end of this chapter, a highlight on the three different techniques employed in analysing this data for vegetation change assessment across Nigeria is presented.

Chapter Five reports a preliminary assessment of the data prior to conducting the assessment of vegetation changes across Nigeria. This was done by using the original data acquired from the PAL dataset archive, the recomposited and derived rainfall data on selected sites from different vegetation zones of the country.

In Chapter Six the three different change detection approaches used in assessment of changes in vegetation across Nigeria are presented. This includes a Simple Image Differencing (SID) technique, Slope of Change from Regression (SCR) and Principal Component Analysis (PCA) using standardised principal components. Detailed results and brief discussion which includes the advantages and disadvantages of each technique for using it in vegetation change assessment are presented. A summary is then given at the end of the discussion about each technique.

Chapter Seven forms the general discussions chapter where the results of the three change detection techniques presented in Chapter Six are discussed in the context of other studies that used AVHRR data for vegetation studies, and the implications in the context of the country's ecological sustainability. Potential use of the data for studies in developing countries like Nigeria is highlighted, where the use of high spatial resolution satellite data such as SPOT, Landsat MSS or TM may not be possible on a frequent basis due to economic and other factors.

In Chapter Eight the final conclusions are presented with a summary and recommendations based on the findings from the study.