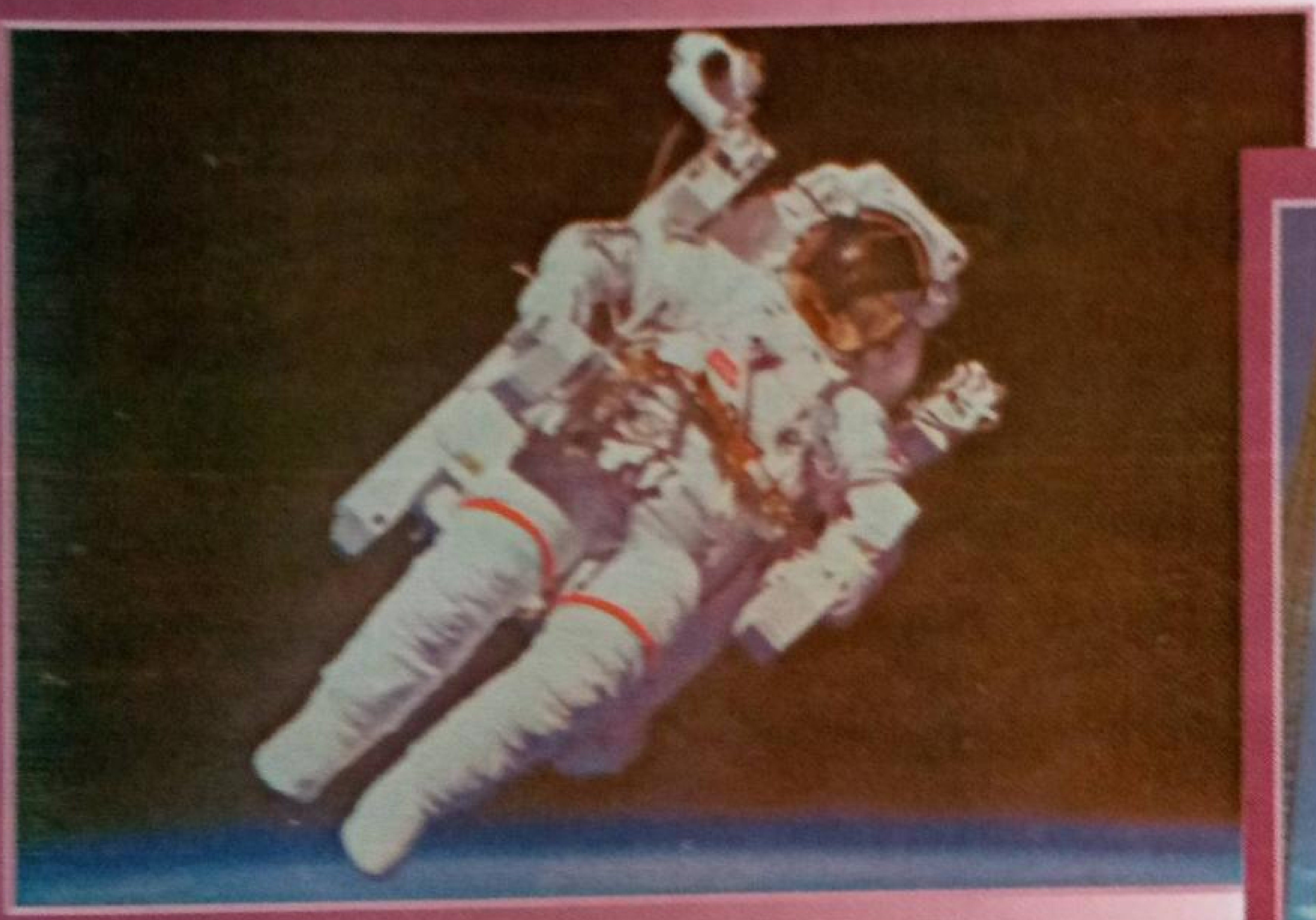
SCHOOL OF SCIENCE AND SCIENCE EDUCATION (S.S.S.E.)

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

# 4th ANNUAL NATIONAL Conference



THEME:

## THE ROLE OF SCIENCE, TECHNOLOGY AND MATHEMATICS IN THE ATTAINMENT OF MILLENNIUM DEVELOPMENT GOALS

Date: 4th - 6th November, 2010

# Book of Readings

# 4th ANNUAL CONFERENCE
# SCHOOL OF SCIENCE AND SCIENCE EDUCATION (S.S.S.E)
# FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

ISBN: 978 – 38031 – 3 – 1

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**Theme:**

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**Edited by Dr. Y. A. Yahaya, Dr. S.S. Ochigbo, and Dr. D. I. Wushishi**

# 4th ANNUAL SCHOOL OF SCIENCE AND SCIENCE EDUCATION CONFERENCE

## FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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**HELD ON THE 4TH – 6TH NOVEMBER, 2010**
**AT THE CPES HALL**

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# Role of Remote Sensing and Geographic Information Systems in the Attainment of the Millennium Development Goals in Nigeria

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**Abstract**

Environmental degradation in the form of soil, air, water pollution, food insecurity, depletion of forest resources; endemic in Nigeria are issues of concern of the MDGs. For the actualization of MDGs 1, 6 and 7, effective management and planning of Nigeria natural resources which require precise, frequent and timely data is invaluable. This paper point out the extent of effects of environment problems and present application area of Remote Sensing (RS) and Geographic Information Systems (GIS) in ensuring food security, eradication of some diseases, access to quality and clean water, forest and biodiversity conservation and slum upgrading. The paper finally recommend the establishment of Remote Sensing and Geospatial unit in state and federal agencies in chargeof water resources, land and housing, environment and agriculture and natural resources for efficient monitoring and management of Nigeria physical environment.

**Key Words:** Environmental Problems, Environmental Sustainability, Remote Sensing (RS), Geographic Information Systems (GIS), Millennium Development Goals (MDGs).

## Introduction

Africa is synonymous with poverty, ignorance and disease; a sorry state that impoverish its people. The situation in Nigeria is not any better as poverty and hunger has become endemic in the society Inspite of the nation abundant land and mineral resources. The adoption of the Millennium Development Goals (MDGs) by the United Nation (UN) Millennium summit in September 2000 was hailed as it provides the third word countries especially Africa, the new opportunity and drive to alleviate poverty, reverse the deterioration in human development and ensure environmental sustainability. The challenges of depletion of Nigeria natural environment call for innovative approaches to be adopted to enhance resilience and for our environment to meet the MDGs.

Remote Sensing(RS) and Geographic Information Systems(GIS) offers potentials to solve many environmental problems by providing a means for generating information, regular monitoring and analysis to predict and visualize future scenarios and helping managers in taking informed decisions.Remote Sensing can be defined as a science and art of obtaining information about an object, area or phenomena through the analysis of data acquired by a device that is not in contact with the object area or phenomena under investigation (Thomas *et al*, 2004). ESRI (2008), define GIS as a special type of ICT that integrates hardware, software and data for capturing, managing, analyzing and displaying all form of geographically referenced information for comprehending geography and making intelligent decision.

The launch of Nigeria Sat 1 on the 27$^{th}$ September, 2003 is a watershed and a major breakthrough in the history of space application and space technology development in Nigeria and West Africa sub region particularly in the enhancement of sustainable development in Nigeria. The plan underway by Nigeria to launch a new earth observation satellite by year 2011 named Nigeria Sat 2 with multispectral resolution of 5 meters and 2 meters panchromatic resolution will add impetus to the application of space technology in monitoring the environment. Data from this satellite and in constellation with other satellite is useful in early detection of natural disaster for environmental management, ensuring food security, monitoring disease incidence, biodiversity management, improving water and sanitation and also slum upgrading which are the basic targets of MDGs 1 (Eradicate extreme poverty and hunger), 6(Combat HIV/AIDs, Malaria and other disease) and 7 (Ensure environmental sustainability) and which this paper will discuss succinctly.

**The Issues:**

Almost 57% of Nigeria live on less than a dollar a day (NPC, 2007). In general, poverty is more pervasive in the north than in the south on Nigeria. This is worsening by the growing crop lost of peasant farmers from diseases. Plant pathonic bacteria cause serious problems to farmers in Nigeria and because they tend to be thermophhilic in nature, they affect virtually all economic crops cultivated in Nigeria (Amusa and Odubaku, 2007). Information needed to monitor crop heath to ensure high crop yield, food security and the actualization of MDG 1 target 1 and 2 can be made possible through efficacious utilization of space technology.

Malaria account for about 50 percent of outpatient consultation which has become a social and economic problem which consume about US$3.5million in government funding and US$2.3million from other stakeholders in various control attempt in 2003 (WHO, 2005). It is responsible for over 90% of reported cases of tropical disease in Nigeria (Alaba and Alaba, 2003). Tuberculosis is also endemic in Nigeria environment with its highest incidence (49%) in the northeastern and northwestern part of the country (WHO, 2009).The realization of MDG 6 of eradication of disease like malaria and tuberculosis still appears elusive even though effort is made in recent times by Nigeria government to make the environment free of these diseases. A lot need to be done to achieve this laudable targets and one sure way is through the utilization of space technology by stakeholders in the health sector.

World forest declined during the 1990s at an annual rate of 2.6% (398,000 hectares per year) (FAO, 2005). The lost of tropical forest represent one of the most significant anthropogenic impacts on the global environment and also serious consequences for biodiversity conservation (Brooks et al, 2000) .Nigeria has an estimated forest cover that ranges from 9.7milion hectares to 33.5million hectares and suffers annual depletion at the rate of 3.5% (FDF, 2001). It noted that Sahara desert is encroaching southward at a rate of about one kilometer per year. (Jonathan, 2009) in the United Nation summit on MDG, in Network stressed that between year 2000 and 2010, Nigeria area covered by forest shrank by one – third from 14.4% to 9.9%. This record signifies lost of forest resources and biodiversity in Nigeria which will make realization of MDGs 7 difficult if measures are not put in place to manage the forest reserves to ensure environmental sustainability. Deforestation affects biodiversity. Change in plant diversity particularly through habitat alteration, fragmentation and deforestation can increase the risk of malaria transmission through effects on mosquito survival, density and distribution (Yasuoka and Leven, 2007).

Climate change as a result of Ozone depletion has become an issue of concern globally and it is affecting Nigeria in many ways. In 2004, Nigeria was the highest emitter of $CO2$ in Africa producing an estimated 31.1 million metric tones of carbon and $CO2$ emission per capita of 0.24 metric tones of carbon and has resulted to climate change which adversely affect the production of C4 crops ( e.g. millet, sorghum, sugarcane and maize) known as common cereal in Nigeria as many of them are functioning at near optimal condition (Rosenzweg and Hillel, 1998). The bulk of Co2 emission in Nigeria is from the transport sector. The manufacturing sector contributes only 11 percent of $CO2$ emission. Nigeria mean urban particulate matter (PM10) concentration is 95mg/m3 and it causes an estimated 14,700 deaths annually (WHO, 2007).

The proportion of the world population lacking access to improved water source remained stable at approximately 17% due to population growth (UNFPA, 2003). (Prasada and Sujata, 2003) noted that more than a billion world population lack accsess to safe drinking water and almost 2 billion people lack adequate sanitation. About 3 million people die every year from diseases caused by unsafe water. Some United Nation estimates suggest that based on the medium projection of future population growth, to attain MDGs 7, target 10 by 2015 will mean providing an additional 1.6 million people with access to safe drinking water and additional 2.2 billion people with access to improved sanitation system. The world fresh water supply, fresh water consumption and access to sanitation services are all very unevenly distributed across the globe. (Falkenmark, 1997). In Nigeria, water pollution occurs in both rural and urban areas. In rural areas, drinking water from natural sources such as rivers and streams is usually polluted by organic substances from upstream users who use water agricultural activities (Lawrence, 1997). The major industries responsible for water pollution in Nigeria include petroleum, mining (for gold, tin and coal), wood and pulp, pharmaceutical, textiles, plastics, iron and steel, brewing. The problem associated with the lack of adequate water resources in the country threaten to place the health of about 40 million people at risk (WHO, 2005).

Almost 1 billion people equivalent to 32% of the world urban population live in slums, majority of them in developing world and if no serious action is taken, the number of slum dwellers worldwide is projected to rise over the next 30 years to about 2 billion (Kofi, 2003). (Herr and Karl, 2002) estimates also suggest that the number of slum dwellers ranges from 837 to 930 million; meaning that 28 to 30 % of the world urban population lives in slums. Development of slums in Nigeria urban centres today is propelled by the haphazard nature of spatial development as a result of the failures of relevant physical planning authorities in the area of development control and settlements of disputes. The projection of urban population growth mentioned above have several important implications for MDGs 7, target 11. First, the target of improving access to basic services for 100 millions slum dwellers is an extremely modest goal considering that the number of slum dwellers in 2020 will number well over 1 billion (UN,2005). Infact, the modest target of helping only 100 million slum dwellers implies that the proportion of urban residents without access to basic services could be greater in 2020 than it is today even if the MDG goal is met.

**Remote Sensing and Geographic Information for Food Security (Crop Monitoring and Damage Assessment)**

Agriculture plays an important role in the survival of any nation. Proper monitoring of crop will ensure good yield. Assessment of health of crop, as well as early detection of crop infestation, is critical in ensuring good agricultural productivity and food security. Stress associated with moisture deficiencies, insects, fungal and weed infestation must be detected early enough to provide an opportunity for the farmers to mitigate. This process requires that remote sensing imageries be provided on a frequent basis and be delivered to the farmer in intervals of few days.

Remote Sensing has a number of attribute that lend it to monitoring the health of crops. One advantage of optical sensing is that it can see beyond the visible wavelengths into the infrared, where wavelength are highly sensitive to crop vigour as well as crop stress and crop damage. Remote Sensing imagery also gives the required spatial overview of the land and can aid in identifying crops affected by condition that are too dry or wet; affected by insects weed or fungal infestation or weather related damage.

Healthy vegetation contains large quantities of chlorophyll, the substance that gives most vegetation its distinctive green colour. In referring to healthy crops, reflectance in the blue and red parts of the spectrum is low since chlorophyll absorbs this energy. In contrast, reflectance in the green and near infrared spectral region is high. Stressed or damage crops experience a decrease in chlorophyll content and changes to the internal leaf structure. The reduction in chlorophyll content result in a decrease in reflectance in the green region and internal leaf damage results in a decrease in near infrared reflectance. These reductions in green and infrared reflectance provide early detection of crop stress. Examining the ratio of reflected infrared to red wavelength is an excellent measure of vegetation health. This is the premise behind some vegetation indices such as the normalized differential vegetation index (NDVI). Healthy plants have a high NDVI value because of their high reflectance of infrared light and relatively low reflectance of red light.

### Remote Sensing and Geographic Information Systems for Malaria Risk and Prevalence Area Mapping

Radarsat sensors that produce SAR imageries are mostly preferred for malaria risk mapping because of its ability to penetrate thick cloud. The combine use of remote sensing and GIS provides a strong tool for monitoring environmental conditions that are conducive to malaria and mapping the disease risk to human population. Images to be used must geo-corrected, registered, filtered and enhance in order to obtain useful input for the image classification. Image analysis should be better performed using eCognition software: a classification analysis package that use an object – based approach rather than the traditional pixel – based routine. Classified polygons can be extracted as GIS layers for use in malaria risk map generation procedure. The premise of assessing areas risk of malaria infection is based on the maximum distance a malaria – carrying mosquito can travel from its breeding ground to infect human host. For this reason, a two or three kilometer buffer zone around the classified laval breeding ground should be used. Since laval breeding flourish in wetlands, the wetland class will be considered for GIS analysis using ARC GIS and a risk map can be generated to show the populated area that lie within the two kilometer or three kilometer buffer zone around the wetland.

For malaria prevalence mapping, an epidemiological data of malaria cases are often correlated with satellite – based vegetation health (VH) indices to investigate if they can be used as a proxy for monitoring the number of malaria cases. Mosquitoes which spread malaria are mostly sensitive to environmental conditions especially to changes in weather. VH indices which characterize weather conditions can be tested as indicators of mosquito's activities in the spread of malaria. Satellite data is often presented by the following VH indices: Vegetation Condition Index (VCI), Temperature Condition Index (TCI) and Vegetation Health Index (VHI). The VH indices are derived from radiances and measured by the Advance Very High Resolution Radiometer (AVHRR) flown on NOAA afternoon polar orbiting satellite. Assessment of sensitivity of the VH can be performed using correlation and regression analysis for detection; surveillance and numerical estimate of the number of malaria cases. Result obtained can be used in ARC GIS or Arcview GIS environment to map malaria prevalence area.

### Remote Sensing and Geographic Information Systems for Forest Monitoring and Biodiversity Conservation

Forest are a valuable resource providing food, shelter, wildlife habitat, fuel and daily supplies such as medicinal ingredients and paper. Forests play an important role in balancing the Earths CO2 supply and exchange, acting as a key link between the atmosphere, geosphere and hydrosphere. The main issues concerning forest managers are depletion due to natural causes such as fire and infestation or human activity such as clear cutting, burning and land conservation and monitoring of health and growth for effective commercial exploitation and conservation. Depletion of forest has long term effects on climate, soil conservation, biodiversity and hydrological regime, and thus a vital concern of environmental monitoring activities and MDG 7.

**(i) Forest Burn Mapping:** Forest fires attributed human activities and some times natural factors spread quickly and threaten settlements and wildlife, eliminate timber supplies and temporarily damage conservation areas. Information is needed to help control the extent of fire and to assess how well the forest is recovering following a burn. Remote sensing and GIS can play significant role in monitoring forest fire and in developing a total forest fire management system. Fire detection and monitoring requires a large spatial coverage, moderate resolution and a very quick turnaround to facilitate response. Remote sensing thermal data is best for detecting and mapping ongoing fire because NOAA AVHRR thermal data and GOES meteorological data are very effective for use to delineate active fires and remaining "hot spots" hen optical sensors are hindered by smoke, haze and darkness. Multispectral optical and near infrared data are preferred for observing stages of growth and phenology in a previous burn.

With remotely sensed data, the relative ages and area extent of burned areas can be defined and delineated health of successive vegetation assessed and monitored. Comparing burn areas to active fire areas provide information as to the rate and direction of movement of the fire. Remote sensing data integration with GIS can facilitate route planning for both access to and escape from a fire and support logistic planning for fire fighting and identifying areas no successfully recovering following a burn.

**(ii) Biodiversity Conservation:** Biodiversity loss is mostly associated with forest resources depletion through large scale human activities. It conservation for environmental sustainability through the use of space technology is pertinent. Remote sensing provides timely data for regular monitoring and conservation of biodiversity. This can be made possible through the use of satellite with very high spatial resolution such as IKONOS with 4m multispectral resolution and 1m panchromatic and Quickbird with 1m multispectral resolution and 0.6 – 0.8 panchromatic. There two approaches to the remote sensing of biodiversity. One is the direct remote sensing of individual organisms, species assemblages, or ecological communities from airborne or satellite sensors. Hyperspectral sensors make this possible by slicing the electromagnetic spectrum into many discrete spectral bands, enabling the detection of spectral signatures that are characteristic of certain species or communities. The other approach is the direct remote sensing of biodiversity through reliance on environmental parameters proxies. Many species are restricted to discrete habitats, such as woodland, grassland, or sea grass beds that can be clearly identified remotely. By combining information about the known habitat requirements of species with maps of landcover derived from satellite imagery, precise estimates of potential species ranges and pattern of species richness are possible (Woody *et al*, 2003).

**Remote Sensing and Geographic Information Systems for Air Pollution Studies**

Remote Sensing provides spatial measurements of air polluted related phenomena and turns out to be an extremely flexible tool for integration with other established monitoring techniques (Mofoluso, 2008). Satellite Earth Observation through its unique synoptic spatial capabilities, could contribute to the comparison of urban air quality information at regional, continental and international levels. Atmospheric studies, particularly air pollutant measurements, pollutant dispersion modeling, air quality assessment, particulate matter concentration and aerosol optical thickness (AOT), tropospheric ozone concentration as well as stratospheric ozone layer depletion have been widely carried out using in-situ measurements and mathematical models and recently with the aid of satellite remote sensing(Mofoluso, 2008).

Application of satellite remote sensing in air pollution studies includes assessment of atmospheric constituents, acquiring weather related data and earth based information such as landuse, vegetation, infrastructure, pollution, demography and so on. The information obtained from the remote sensing data can be used as inputs into atmospheric dispersion models and GIS. Sensors on board space satellites have various specific applications for mapping concentrations and spatial distribution of air pollutants. The sensors include Advance Very high Resolution Radiometer (AVHRR); Total Ozone Monitoring Spectrometer (TOMS), Moderate Resolution Imaging Spectroradiometer (MODIS), Ozone Monitoring Instrument (OMI). With space technology, however in-situ data needed to be added to verify and improve the accuracy of information.

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**Remote Sensing and Geographic Information Systems for Water Quality Monitoring**

Remote Sensing data provides the synoptic view of water body obtain to measure the characteristics of an area rather than a point; can integrate several characteristics with one composite measurements and the ability to improve models with continuous or frequent feedback from satellite measurements. Remote sensing and GIS technologies are the effective, cheaper and valuable tools in monitoring water quality parameter in coastal level and freshwater bodies (Lakes, rivers , ground water and reservoir) compared to in-situ where measurement is restricted to selected sampling (Norsali and Mohammed, 2010). Remote Sensing and Geographic Information Systems can be used to produce water quality parameter in the form of map algorithm or models by various platforms of satellite imagery with various resolution such as Landsat, SPOT, Nigeria Sat 1, IKONOS, IRS, CZCS, hyperspectral and SeaWIFS. Hyperspectral imaging has greater potential because of its simultaneous collection of images covering many narrow contiguous wavelengths band that allows various aspect of water quality to be measured and monitored. Each water quality parameter such as suspended matter, phytoplankton concentration, turbidity and dissolved organic matter has their own chlorophyll estimation reflectance within the range of 400 – 850nm

Suspended matter/ sediments are the most common pollutants in surface water and increase the radiance from surface water invisible near infrared ranged of the electromagnetic spectrum (Ritchie and Chariles, 1996). Remote Sensing techniques can be used to estimate and map the concentration of suspended matter in inland water, providing both spatial and temporal information. Remote Sensing studies of suspended have been using various satellite platform such as Landsat, SPOT, IRS, Nigeria Sat 1, Coastal Zone Colour Scanner (CZCS) and Sea Viewing Wide Field of View Seasor (SeaWIFS). Studies have shown a significance relationship between suspended matter and radiance or reflectance from both single matter and radiance or reflectance from either single band or combination of some bands in satellite or airborne platforms.

Chlorophyll is one of the phytosynthetic agents contributing to the colour of water. Remote Sensing has also been used to measure chlorophyll concentration and patterns. Most remote sensing studies of chlorophyll in water are based on empirical relationship between radiance in narrow bands or bands ratio and chlorophyll concentration. Measurement from aircraft, Landsat, SPOT, Nigeria Sat 1, SeaWIFS has a variety algorithm and wavelength to map chlorophyll of the oceans, estuaries and fresh water. In principle, chlorophyll absorption occurs in short wavelength. Hyperspectral sensors have been considered as the future sensors to measure chlorophyll concentration in water.

**Remote Sensing and Geographic Information Systems for Slum Upgrading (Urban Renewal)**

Slums play many roles in city life. As the place of residence of low-cost labour, they keep the wheels of the city working in many different ways. It is associated with inefficient accessibility, lack of basic amenities and all form of social vices. Continuous expansion of slum will distort or present very ugly environmental scenery. Hence, the need for its upgrading. Slum upgrading through urban renewal can be better achieved through the application of remote sensing and GIS. High resolution imagery from satellites such as IKONOS with 4m, 1m multispectral and panchromatic resolution and Quickbird with 1m, 0.6m multispectral and panchromatic resolution will produce images that will clearly show the physical condition of the environment. Interrelationship of buildings, roads and other elements that make up the landscape will be vividly seen on the imageries and this will offer opportunity for easy mapping of blight areas, ensure easy renewal exercise and proper planning.

The basic image processing technology such as extraction, enhancement and classification can be carried using eCognition software to map the character of the slum area.

Condition of roof which is an aspect of housing condition and slum assessment can be measured through thermal remote sensing of roof materials. The classified images can be imported into a GIS environment where digitization of edges of all elements of an area is carried out. GIS has many capabilities that ranges from data integration, overlay, queries, Buffering and modelling which make it a powerful tool. GIS buffering function can be used to create a buffer zone of some metres from both side of a road for the purpose of providing efficient accessibility and this indicate the number of building that will give to the road expansion. This will aid rehabilitation of the urban structure as the number of buildings to be demolished and household to be compensated is ascertained.

**Conclusion**

The MDGs provide a framework and an impetus for the world to accelerate the pace of development and improve human welfare for sustainable development. This paper has demonstrated that the role remote sensing and GIS plays in environmental monitoring and management can not be over emphasized. As such, for Nigeria to actualize the laudable goals and targets of the MDGs, it must structure her conducts to give space technology adequate attention and set up remote sensing and geospatial unit in agencies in charge of agriculture practices, water resource management, forest resource management, land management and urban development.

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