

Climate Change and the Environment: Issues and Geoinformation Challenges

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Key words: Global Warming, Climate Change, Environment, Geoinformation

SUMMARY

This paper examines the issue of climate change and its impact on the environment. The effects of man's activities as well as those of natural phenomena on global warming, climate change and the environment are presented and discussed. The options that are available as response to global warming: mitigation, adaptation and possible human suffering as consequences of what cannot be avoided by mitigation and adaptation are presented. An overview of the Nigerian environment, preparedness for the impact of global warming and related problems are also presented. The status of environmental data and the need for environmental baseline survey and the creation of a comprehensive database for the country driven by geographical information system are presented and discussed. The paper then underscores the need for governments at all levels to adequately fund geoinformation production and cultivate the culture of its usage for adequate and proactive response to global warming, sustainable environmental management and national development.

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1. INTRODUCTION

Global warming is real. Its direct impact is on the climate and consequently on the environment, human life and socioeconomic activities. Many countries of the world are experiencing extreme weather conditions and climate change natural disasters which scientists have concluded are being induced by climate change. Scientists and major research centres in industrialised countries have concluded that human activities, through the emission of CO₂ into the atmosphere is the single major cause of climate change and the unpredictable weather conditions the world over. While the industrialized countries of the world, the major contributor to climate change have the capacity to respond to the impact of climate change, most developing countries do not have adaptive capacity to global warming. They therefore need assistance from developed countries to combat the effects of climate change on their environments and economic wellbeing.

The environment consists of all physical, social and cultural factors and the surroundings which support the existence and development of man and other organism. Man as part of the ecosystem is the most powerful force in it. Man as a resource is the most precious within the biosphere, but equally at the same time the most dangerous as man's activities, especially the exploitation of resources, sustenance and creation of wealth, produce potentially adverse effects not only on the immediate surroundings but also on the ecosystem. In all global warming and environmental issues, man is the problem and man is the solution. Without human activities the environment and nature will take care of the balance of the ecosystem in a sustainable manner. Therefore if man must continue to exist on earth, he must exploit and use natural resources in the most prudent and sustainable manner.

2.0 Global Warming

Global warming is “the increase in the average temperature of the Earth's near-surface air and the oceans since the mid-twentieth century and its projected continuation.” The scientific community has reached a consensus that global warming is real and that human activities are causing the warming trend. Global temperatures have steadily risen over the last century, and according to scientists, 2005 was the warmest year on record, and the warming trend is expected to continue through the 21st century and beyond. From various scientific researches, it has been estimated that average global temperature of the Earth surface increased $0.74 \pm 0.18^{\circ}\text{C}$ ($1.33^{\circ}\text{F} \pm 0.32^{\circ}\text{F}$) during the 100 years ending in 2005. Scientific climate modelling projections recently summarised by the Intergovernmental Panel on Climate Change (IPCC) indicate that global surface temperature will likely rise a further 1.1°C to 6.4°C (2.0 to 11.5°F) during the 21st century. http://en.wikipedia.org/wiki/global_warming.

The direct effect of global warming is **climate change**, which means the disruption of climate

pattern, and consequent impact on the environment and human life. **Climate** is the average state of the weather; it is fairly stable and predictable. **Weather** is the day to day state of the atmosphere; it is a chaotic non-linear dynamic system. In general climate means weather pattern that is, averages of variables like cold and hot, humid and dry, cloudy and clear, drizzles and downpour, breeze and blizzard, and other variables that can be measured at any given site.

Climate change refers to the change in the state of climate that can be identified by changes in mean or variability of its properties and that persists for extended periods, typically decades or longer. Climate change occurs when the amount of energy stored by the “climate system” is varied. The variation occurs when the balance, for example between energy received from the sun and the radiated energy is disturbed. This disturbance can be caused by a number of natural mechanisms such as variation in the earth’s orbit, variation in ocean circulation, and changes in earth’s composition. In recent times the disturbance is caused by human activities.

http://en.wikipedia.org/wiki/climate_change

2.1 Causes of Global Warming and Climate Change

The Intergovernmental Panel on Climate Change (IPCC) and major scientific organizations of industrialized countries have concluded that the increase in global temperature since the middle of twentieth century has been due mainly to human induced (anthropogenic) greenhouse gases concentration via the green house effect; while the warming effect of natural phenomenon such as solar variation contributed a small warming effect from preindustrial times to 1950, and from then a reverse cooling effect.

The United Nations Framework on Climate Change (UNFCCC) uses the term “Climate Change” for human induced change while the term “Climate Variability” is used for changes due to External Forcing. <http://www.ipcc/ch>. External forcing is climate change caused by change in the global energy balance owing to fluctuations in the Earth’s orbit, ocean circulation and atmospheric composition.

2.1.1 Greenhouse Effect

This is the process by which radiative energy leaving a planetary surface is absorbed by some atmospheric gases, called greenhouse gases. The Sun is Earth's only external form of heat. It emits solar radiation mainly in the form of shortwave visible and ultraviolet (UV) energy. As this radiation travels toward the Earth, about 25% of the radiated energy is absorbed by the atmosphere and about 25% is reflected by the clouds and other gases back into space. The remaining radiation travels unimpeded to the Earth and heats its surface. The atmosphere acts like the glass in a glass greenhouse, allowing much of the shortwave solar radiation to travel through unimpeded, but trapping a lot of the long wave heat energy trying to escape back to space. The greenhouse gases transfer the energy to the surface and lower atmosphere and it is reradiated in all directions, including down towards the Earth’s surface. This process makes the temperature rise in the atmosphere just as it does in the artificial greenhouse.

2.1.2 The Earth's Natural Greenhouse Gases

In their natural state of occurrence the Earth's greenhouse gases do not constitute any danger to the environment. The Earth's natural greenhouse effect transfers energy to the Earth's surface and lower atmosphere; so that the temperature there is higher than it would have been if direct heating by solar radiation were the only warming mechanism. This process has a warming effect of about 33°C, without which the Earth will be uninhabitable. The major natural greenhouse gases are: water vapour which causes 36%-70% of greenhouse effect; carbon dioxide, CO₂, 9%-26%; methane CH₄ 4%-9% and ozone with 3%-7%. http://www.ace.mmu.ac.uk/eae/Climate_Change/Older/Greenhouse_Effect.html, http://en.wikipedia.org/wiki/global_warming

2.1.3 Anthropogenic Human-induced Greenhouse Gases

Researchers have shown that the main cause of global warming and climate change is the continued increase in the level of CO₂ as a result of emissions from fossil fuel combustion, deforestation and cement manufacture which are the major causes of CO₂. Fossil fuel combustion and deforestation produce the most significant CO₂ than cement production which is fingered as third largest producer of CO₂. The global CO₂ level will continue to rise due to continued burning of fossil fuel and land-use changes, especially deforestation. The rate of increase will however depend on economic, sociological and natural developments. See Tables 1 and 2 http://en.wikipedia.org/wiki/global_warming

2.2 Indicators of Global Warming

Global warming produces increase in global temperature which impacts directly on human life and the natural environment. Increasing global temperature is having serious effects and consequences for the world, including rising sea levels (Table 3), changes in climate patterns, change in the amount and pattern of precipitation, and more severe weather including stronger tropical storms, droughts, and heat waves, likely including an expanse of the subtropical desert regions. Other indicators of global warming include Arctic shrinkage and resulting Arctic methane release, shrinkage of the world's rainforest (already very damaged by deforestation from logging and farming), increases in the intensity of extreme weather events, changes in agricultural yields, glacier retreat, species extinctions and changes in the ranges of disease vectors. The recent natural disasters caused by tropical cyclones, hurricane; flooding in Bangkok Thailand, Australia and India; sea level rise, heat waves in Europe, coastal erosion and flooding due to high precipitations are attributable to global warming and associated extreme weather conditions. In the Sub-Saharan Africa, there had been persistent drought and desertification in recent years, and the trend is likely to continue. http://en.wikipedia.org/wiki/global_warming

The effect of global warming is not uniform all over the planet, Table 4. The northern hemisphere has more landmass than the southern hemisphere therefore the greenhouse effect is more intense. Furthermore the countries in this region are more industrialised and generate more CO₂ and hence higher warming due to greenhouse effect. The United States of America is the largest emitter of CO₂. While the industrialised nations contribute more to global warming and have the capacity to adapt to its effects, developing nations which contribute

least are most adversely affected.

Figure 1

The Earth is getting hotter

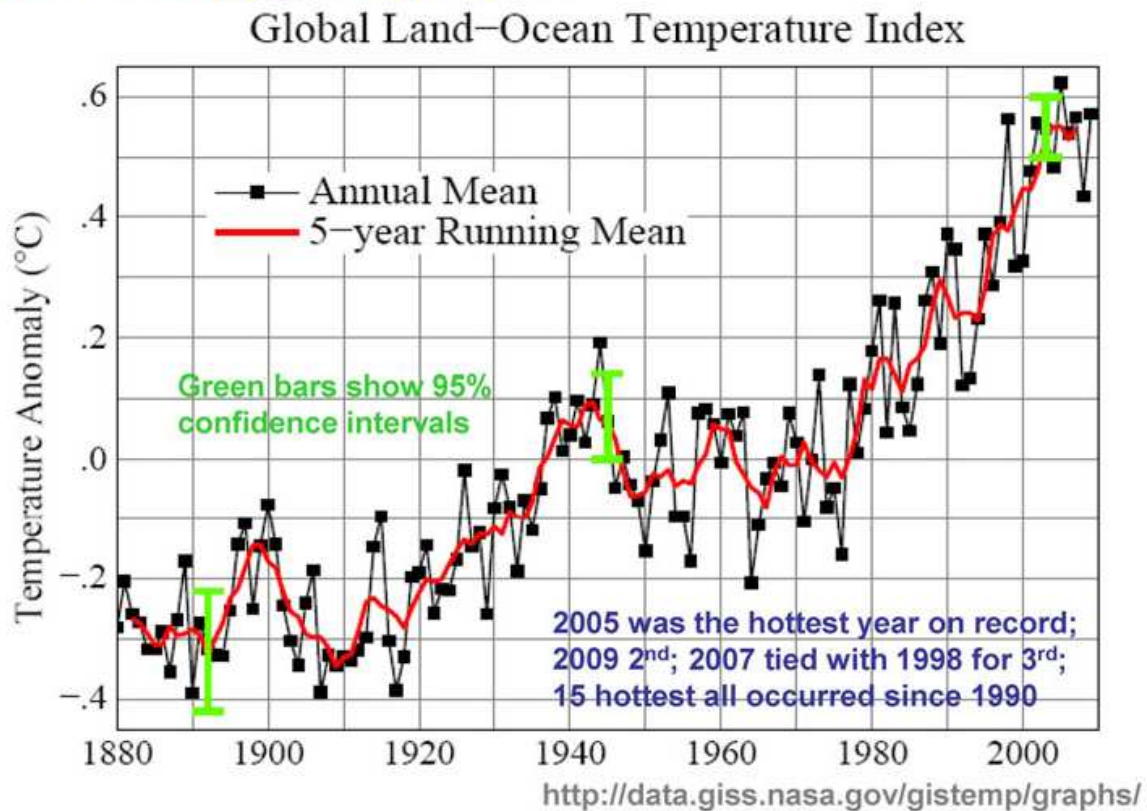


Figure 2 (Adapted from Holdren, 2010)

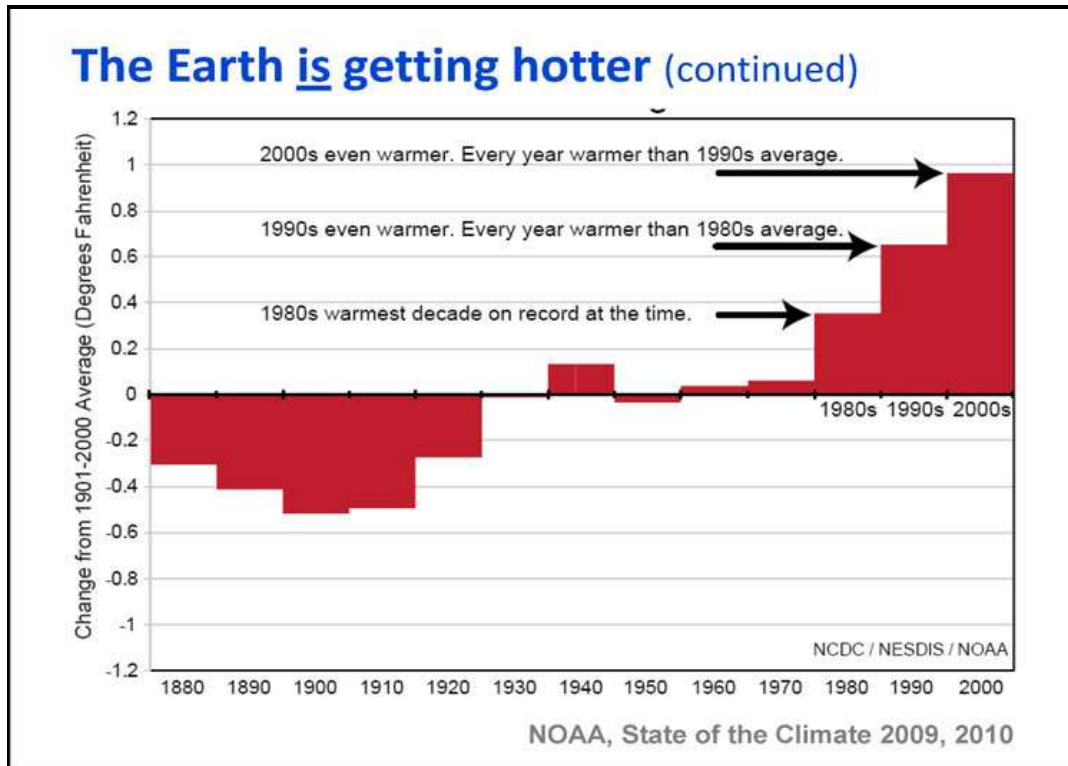
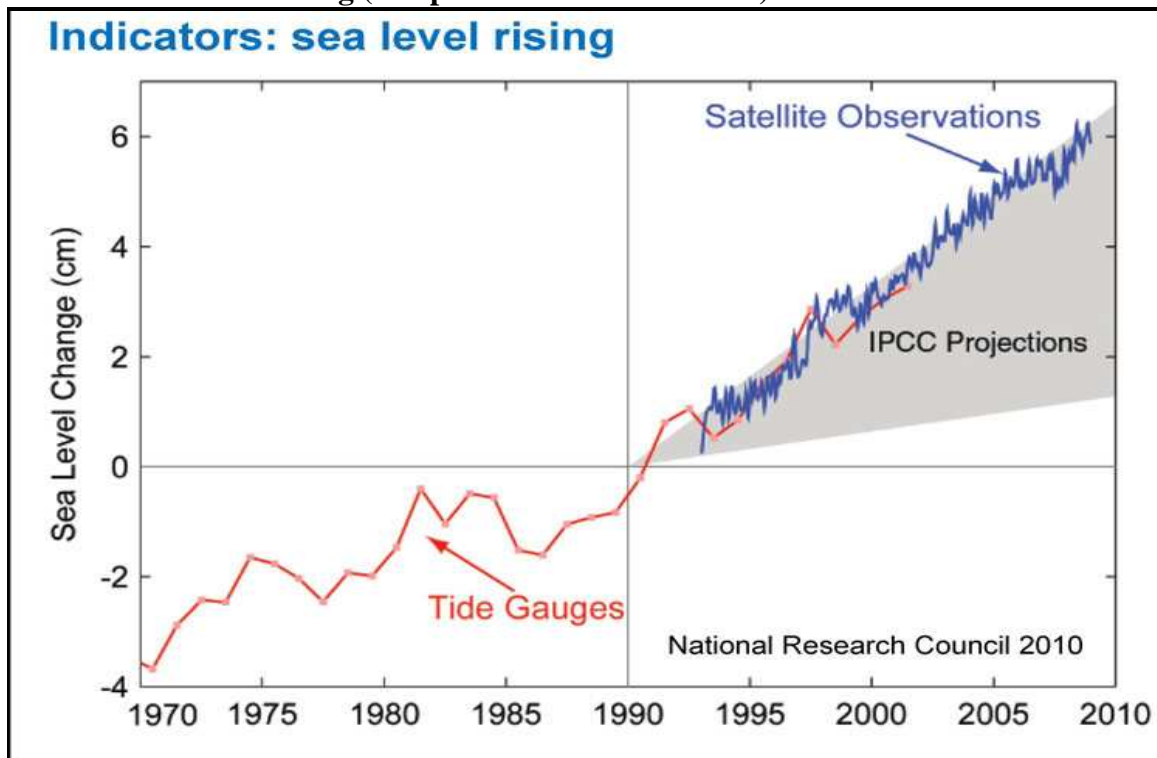


Table 3: Sea Level Rising (Adapted from Holdren 2010)



2.3 Response to Global Warming

The available options are: mitigation to reduce further emissions; adaptation to reduce the impact of global warming on the environment and human life.

2.3.1 Mitigation

This means that the measures must be taken by various nations to reduce rate and magnitude of global climate change caused by human activities. According to IPCC, the mitigation options includes reduction in burning of fossil fuels and reduction of greenhouse gases and soot from the energy sector; reduction of deforestation; increase in reforestation and afforestation; modification of agricultural practices to reduce emissions of greenhouse gases and build up soil carbon. Other mitigation options include: geo-engineering to reverse the effect of global warming by creating cooling effects which will offset greenhouse heating; and conceiving the development of technology for clean the greenhouse gases from the atmosphere. It has been estimated that at present the cost and benefit of mitigating global warming are approximately the same.

In general, the IPCC concludes, without mitigation global warming will reach a point where it will be impossible for some natural systems such as ecosystem to cope and therefore may go into extinction. As for humans the cost of adaptation will be so prohibitive that many will not cope. It is therefore essential to do a little of mitigation and a little of adaptation.

2.3.2 Adaptation

Adaptation means that we should take measures to reduce the adverse impact of global warming on human life and the environment. Some of the options that are available include: changing the cropping patterns; stopping further development on wetlands, flood plains, and close to sea level; developing crops that are resistant to drought, heat and salt; strengthening public health and environmental engineering defences against diseases; designing and building new water projects for flood control and drought management; construction of dykes and storm surge barrier against sea level rise (Holdren, 2010).

2.3.3 Which is the Better Option: Adaptation or Mitigation?

It is evident that mitigation alone cannot work because global warming is already occurring and cannot be stopped. Equally adaptation alone will not work because adaptation will get costlier and less effective as global warming grows. Therefore what is needed is enough mitigation to avoid the unmanageable consequences of global warming, and enough adaptation to manage the unavoidable. Both mitigation and adaptation will not totally eliminate the impacts of global warming; there will still be some of the impacts which cannot be treated under mitigation and adaptation, which humans have to suffer. Therefore to avoid the amount of suffering, a lot of effective mitigation and a lot of adaptation have to be done. (Holdren, 2010)

3.0 ENVIRONMENTAL ISSUES

3.1 Evidence of Global warming and Climate Change in Nigeria

Developing countries like Nigeria are least prepared for the impact of global warming. Global warming is real and evidence abounds in the country. Although the country has been lucky not to have experienced major climate-change-induced natural disasters, the effect of climate change is evidenced by rise in sea level and erosion along the nation's coastline; the weather pattern is no longer distinct in the country, we have witnessed very hot weather conditions and high precipitations leading to flooding which ruined crops in parts of the country creating food scarcity, the latest being Jigawa State; gully erosion has sacked many communities especially in Edo and Anambra States; as a result of persistent drought, the Lake Chad has almost dried up, while there had been persistent desert encroachment in the north. The dearth of statistical data and non-collection environmental data in a systematic manner make it difficult to estimate in concrete terms the overall effect of climate change on: agriculture and food supply, flooding and erosion, health risks diseases spread, water resources, wildlife, level of CO₂ emission and trends in temperature increase, and their effects on the social and economic systems of the country. A comprehensive audit of the environment is needed to quantify the effects of global warming and the level of degradation and loss of biodiversity, so that we can start to put in place some mechanism for responding to these challenges.

3.2 Environmental Sustainability

Sustainability is defined by the World Commission on Environment and Development (WCED, 1987) commonly called the "Brundtland Commission" as "development that meets the needs of the present without compromising the ability of the future generation to meet their needs". Sustainable Development has also been defined as "a process of social and economic betterment that satisfies the needs and values of all interest groups, while maintaining future options and conserving natural resources and diversity" (IUCN,1980).

Sustainable development is a dynamic process. To continually meet the needs of the present generation means that there must be continued economic growth. Economic growth in turn must ensure that minimum damage must be done to the environment. The major resources that determine the wellbeing and quality of human life are shelter, air, water, energy, food, raw material and the environment. These basic resources must be exploited in such a manner that the needs of future generation will not be compromised while satisfying the needs of the present generation. To achieve this knowledge and action are required. In the Nigerian context, like most developing nations, there is no adequate information on the location and state of resources, their rate of exploitation and socioeconomic activities and their impact on the environment. In other words resources are not being exploited in a sustainable manner. The current situation is exacerbated by climate change which is affecting the availability and or quality of these resources.

3.3 Monitoring and Managing the Environment

The first step in responding to global warming and other environmental issues is to have adequate knowledge of the extent and nature of the effects of climate change on the environment. Thus before the environment can be meaningfully monitored and protected, all parameters defining the environment must be relatively and spatially located to create a spatial

database. Information about the status of these parameters can then be treated as metadata and linked to the database. In other words when we know the parameters defining the environment and the natural interrelationship which helps to maintain a balanced ecosystem, then we can start to put in place all measures to ensure that the initial balance is maintained by cautioning the activities of man; co-operating with and taking measures to check some adverse effects of some natural occurrences on man and the environment. Therefore adequate framework for monitoring and managing the environment must be put in place; which framework should be proactive in nature rather than correcting distortions of existing physical development planning. This means that actions should continually be taken to respond to the ever increasing environmental challenges and to plan ahead of challenges that are likely to face both the rural and urban centres of the country, using adequate geoinformation.

3.4 Geoinformation Tools for Environmental Monitoring

The most basic tool for monitoring and managing the environment is geoinformation. The world is becoming an information society and “information infrastructure” is regarded in developed nations as infrastructure like road, electricity, telecommunication, portable water, etc. In fact without geoinformation these essential infrastructures cannot be implemented and sustainably managed. The most basic of all information infrastructures is geoinformation, since all other information is location specific. Location is very important; everything happens somewhere, nothing happens nowhere. If we have a good knowledge about the nature of the location of where things happen, and the impact on the people and the environment, then “we can plan better, manage risks better and use our resources better.” The main components of the geoinformation tool are: up-to-date topographical maps, remote sensing, geospatial information systems (GIS).

3.4.1 Topographical Base Maps

Up-to-date digital topographical maps at appropriate scales are key factors in environmental monitoring and management. Large-scale maps must be produced and updated at regular intervals of not more than 5 years. The major advantage of base maps is its geometric infrastructural content to which all other geospatial datasets are referenced. Secondly the thematic contents of maps such as cultural features and topography provide a wealth of information on time-series changes and pre-disaster state of the environment. A comparison of the baseline condition to subsequent environmental base maps will facilitate assessment and inventory of damage and other human factors, and influence decisions on appropriate actions. Such maps are used to address the following questions: what exists at a particular location; what is the condition of what currently exists; and conditions that we want to attach to what we plan to exist; what changes had occurred in an area or location over time; what is the concentration of certain activities and where are they located?

The availability of adequate geoinformation will facilitate the production of maps of basic environmental datasets such as Land Use and Land Cover, Topography, Demographics, Ecology, Hydrology, Soils, Infrastructure, Air Quality, Climatology and Water Quality. Other specialised maps for environmental monitoring and management are Township Cadastral and Geological Maps for appropriate planning of location of utilities, sanitary landfills and toxic

waste dumps, as well as location of industrial and dam sites.

3.4.2 Application of Remote Sensing

Apart from mapping, provision of information on the environment through monitoring is an important aspect of environmental management. The need to detect early changes in the environment cannot be overemphasized. This monitoring is best accomplished by remote sensing methods through aerial photography and space satellite imagery. Environmental information that could, among others, be remotely collected include: deforestation pattern, ocean pollution, desertification, atmospheric changes, oil spillage, effluent discharge, coastal erosion, slum and urban growth and other ecological and thematic changes due to climate change.

3.4.3 Geographical Information System (GIS)

A standard GIS system is capable of performing spatial analysis on the following queries which are very essential to decision making and subsequent actions on climate change and other environmental issues: location of what exist in a particular place; identification of condition of what exists at a given location, and location of where certain conditions are satisfied; trends in the differences of features within an area over time; analysis of multi-temporal data; modelling what happens, for example, if settlements are located in a certain low land areas. The foregoing analyses can be performed, with various factors taken into consideration; to respond to climate change induced natural disaster only in a GIS environment. Web enabled GIS is now available for efficient exchange of geodata for response to environmental issues.

One of the major advantages of GIS is that it has the capability of bringing together hitherto separate discipline for the purpose of integrated analysis. The ability to integrate spatial data of different themes and resolution as well as non-spatial data makes GIS a powerful tool for the monitoring global warming trend and management of the environment; as various indicators can be analysed and integrated.

3.5 Geoinformation Challenges

Appropriate response to global warming and climate change induced natural disaster as well as the implementation of a comprehensive environmental database must be based on the use of current digital topographical maps and other geoinformation tools as described herein. But the most important of these tools is current topographical base maps at appropriate scale. Unfortunately, these are not readily available in most developing countries. This makes geoinformation requirement a major capital component of all development projects. The implication of this is that government and her agencies are caught napping whenever there is a development project that requires such information. This has led to production of project specific maps and duplication of efforts and waste of scarce resources. In most cases adequate geodata usage is sidetracked to the detriment of many development projects. Whereas all that is necessary is for government to put in place a systematic programme for geoinformation production, as its use cut across all sectors of the economy.

Apart from being the main ingredient in all development projects geoinformation is now being used in many developed nations as a tool for improving service efficiency in spatially enabled Government services, where “location” or “place” is used as key means of organising their businesses. Government services can only be spatially enabled if the society is spatially enabled; and the society can be spatially enabled if geoinformation is made readily available ubiquitously as “common goods” and made available to citizens and businesses for decision making and improved productivity. This is the major challenge for the nation. It is therefore imperative that governments at all levels embark on comprehensive mapping of their geographical space, and evolve a policy to make the exercise sustainable.

4.0 WHAT SHOULD WE DO?

4.1 How Should Nigeria Respond to Global Warming?

Global warming is a reality. Therefore the nation should be proactive in her response to the phenomenon and its challenges and should not wait until much damage is done which will be very costly to correct. Developing nations like Nigeria should not fold their arms and wait for international donor agencies and Research Institutes to provide wholesale solutions their global warming issues. They must take up the challenge and seek cooperation and collaboration with International Agencies in other to create opportunities for technology transfer.

There are a number of adaptation and mitigation options that the country can embark upon using the existing government institutions, which do not require any elaborate capital outlay but the right political will to ensure enforcement and compliance. The Agriculture and Research Institutions should commence research into crops that are resistant to drought and heat. The River Basin Authorities should commence the study, design and construction of new water projects for drought management and erosion control. The Ministries of Environment should start addressing the rapid erosion of the nation’s sandy coast by construction of dykes and storm surge barrier against sea level rise; while further development on wetlands, flood plains, and areas close to sea level, especially by the poor who are most vulnerable to disasters, should be stopped.

The mitigation options should start with the gas flaring and oil pollution in the Niger Delta which should be tackled with all the force of government and stopped forthwith. Deforestation should be reduced by encouraging mechanised farming and use of cooking gas instead of wood fuel, while concerted efforts should be made to address afforestation and reforestation. The Ministry of Science and Technology and Universities of Technology should start research into “Clean - Energy Technologies,” Solar Energy, as an ultimate alternative to fossil fuel burning.

A National Climate - Change Adaptation/Mitigation Task Force with members drawn from various relevant Parastatal, Ministries, NGOs, Research Groups and relevant Institutions should be set up to address various responses to global warming as well as carry out national research programme on the effects of global warming on the country. The Lagos State

Government has organised two Global Warming Summit in the country should be commended for this. Other State Governments and especially the Federal government should take a cue from Lagos State to discuss global warming issues at the state and national levels. However, as a starting point to the response of global warming the current impact of phenomenon on the environment must be known by carrying out a national environmental baseline survey.

4.2 Environmental Baseline Survey

The nation should take advantage of the current debate and international attention to climate change to confront her environmental problems which are being compounded by global warming, by taking a holistic approach to her response to the impact of global warming and other environmental issues. The first step is to have adequate knowledge of the status of the nation's environment through the conduct of national environmental baseline survey.

4.2.1 Environmental Data

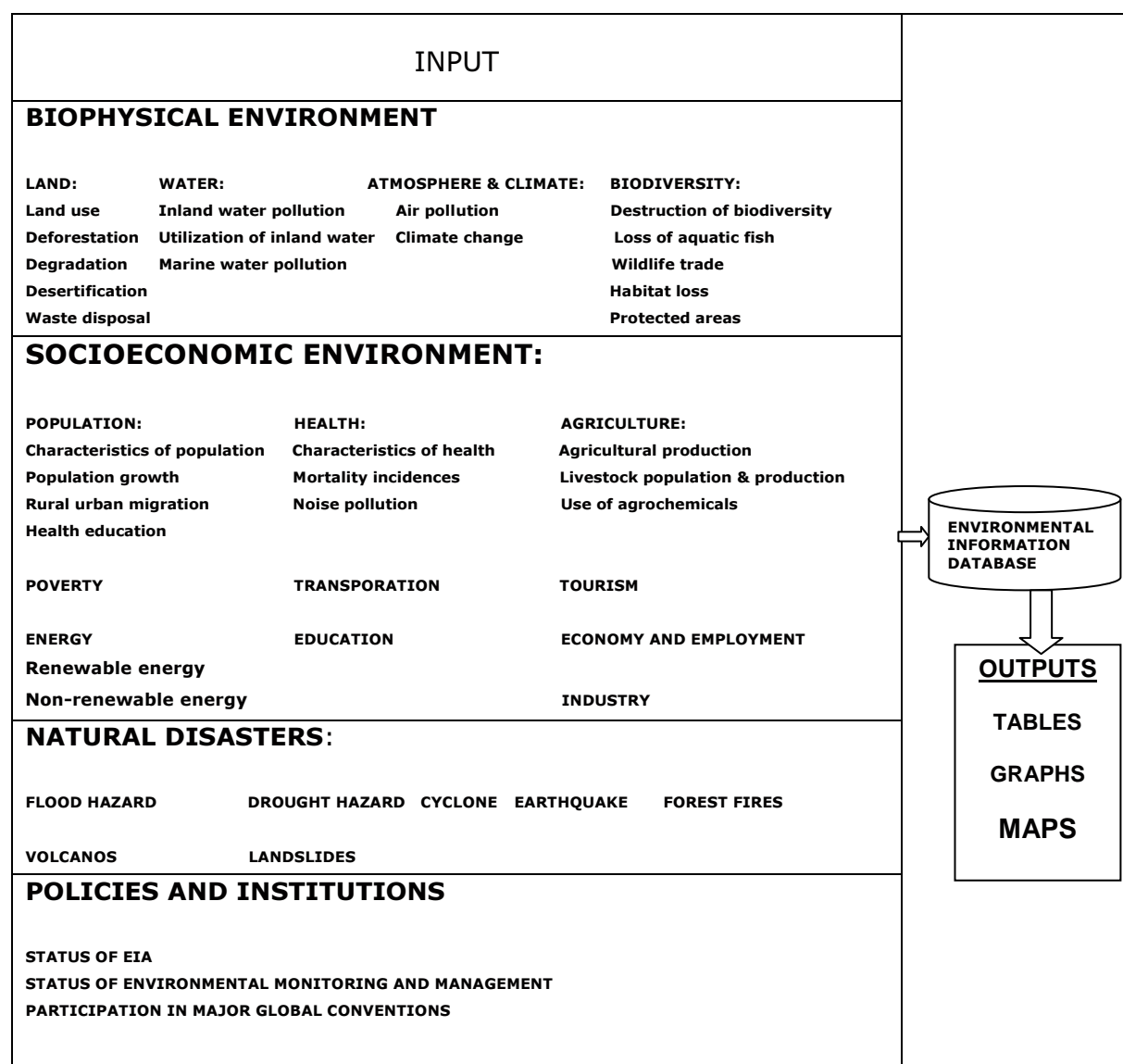
Information on the environment is essential to managing environmental problems. This information is obtained through the collection of relevant time series environmental data – statistics – and the development of an environmental database. Environmental statistics is a set of variables on the environment systematically and multi-temporally collected to indicate changes over time, cause of change and effect of the change on the environment and human wellbeing. Thus two types of data are needed; these are the baseline condition and the time-series changes in the baseline condition.

4.2.2 Environmental Data Collection

Environmental data collection should cut across all aspects of the nation's socioeconomic activities and therefore all stakeholders in the public and private sectors must be adequately involved. At present environmental data are been collected by various ministries, agencies, environmental NGOs, environment Consultants/Researchers, academic institutions and other private initiatives. The activities of government organs responsible for environmental issues in the country and the various agencies are not coordinated, despite the fact that the Federal Environmental Protection Agency had existed since 1988 and the Federal Ministry of Environment was created in 1999. Thus, available data are not coordinated, standardized and comprehensive enough to be used for creating an environmental database.

Adeyinka et al, (2005) submitted that “there are a lot of environment-related data in Nigeria which are not readily available as they are usually scattered in the various Government Agencies/Departments in form of technical reports/publications or in files that are not easily accessible as a comprehensive database for this purpose is yet to be put in place.” There is therefore the need for an environmental baseline survey of the country. This database will then form the basis of future measurements. The database must reflect all environmental indicators of climate change, biophysical environment, socioeconomic environment, natural disasters as well as appropriate policies and institutions. See Table 4.

Table 4: Framework for an environmental information Database



Source: UNEP/EAP-AP—State of the Environment Data Collection and Reporting Training for South Asia (unpublished).

5.0 CONCLUDING REMARKS

Global warming is real. Its impacts on socioeconomic activities and human life are palpable. But Nigeria, like many developing nations has not put in place any sustainable policy measure to respond to this phenomenon. The Lagos State Government of Nigeria in its efforts at addressing environmental issues caused by global warming and climate change has organised Annual Global Warming and Climate Change Summit in Nigeria since March 2009. The effort is very commendable and the Federal Government should take a cue from the Lagos

state government in charting the course for combating the effects of global warming and climate change in the country. The general public, outside the academia and the scientific bodies, is not aware of the causes of climate change and therefore need to be educated so that everyone could play his/her part in combating the effects of climate change. In addition to organising the State Summit, global warming and climate change education should be carried to the Local Government Areas, Ward level and also be thought at schools in order to ensure that individual responsibility in responding to the phenomenon are imbibed early in life. In addition, as a starting point in her response to the effects of climate change, Lagos State should carry out an environmental baseline survey and create an environmental database using her current digital mapping as a base. This will be the basis for future measurements and for determining the extent of mitigation to avoid the unmanageable, and adaptation to manage the unavoidable impact of global warming. The Federal Government should take a cue from the Lagos initiative and set into motion national global warming response measures.

The country has a myriad of environmental problems which is a challenge to governments and scientific communities; and measures must be urgently put in place to confront them. The nation environment and natural resources are currently not being exploited and managed in a sustainable manner. Environmental data collection is not coordinated and hence cannot be used to create an environmental information database, which is a prerequisite for a meaningful and sustainable environmental management. There is therefore the urgent need to carry out a nationwide baseline survey of the impact of global warming on the environment, implement a systematic environmental data collection, and create a national environmental database based on adequate geoinformation. This will require appropriate funding and political will to implement. But we cannot do otherwise, as the environment is our most precious asset. All stakeholders must partner with government, armed with appropriate statistical data, to put in place measures to sustainably manage our environment and respond to impacts of climate change and other environmental issues.

The world is becoming an information society and “information infrastructure” is prerequisite to all developments. The most basic of all information infrastructures is geoinformation, since all other information is location specific. We must map to be able to assess, predict and plan against the impacts of global warming and foreseeable environmental inclemency. Government at levels must therefore pay adequate attention to geoinformation production and put in place a mapping policy to drive surveying and mapping activities; as the application of geoinformation products cut across all sectors of the economy.

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BIOGRAPHICAL NOTES

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