Responding to the Challenges of Global Climate Change in Nigeria through GIS mapping of Carbon IV oxide gas emission

Ugonna C. Nkwunonwo and Oluwasoye P. Mafimisebi

Abstract— Climate change is a global phenomenon and arguably the biggest threat to nature and humanity in recent times. In the developing countries (DCs), such as Nigeria, rapid growth in urbanization and demography increases the vulnerabilities of human populations to climate change events, such as flooding, landslide and hurricane. Responding to the challenges of global climate change (GCC) is focused on mitigating risks associated with climate change events, and assisting human populations to adapt to them. However, lack of accurate data, also limited access to technology, has caused major bottlenecks in achieving such goals in the DCs. To overcome such constraints, advantage should be taken of freely available data and open source applications by means of information technology (IT) and the internet, both of which can be used to good effect. Carbon IV oxide gas (CO_2) is a major greenhouse gas commonly emitted in a range of anthropogenic activities, such as cooking, lighting and solid waste disposal, but an important consideration while responding to the challenges of GCC has been how to reduce the emission of such a greenhouse gas. This paper discusses Geographic Information System (GIS) and IT as useful tools for responding to the challenges of GCC, and presents an assessment of CO_2 emission across the States of Nigeria, utilizing demographic data, while considering cooking, lighting and solid waste disposal. From the results, high scale emission of CO_2 is taking place in 14 states of Nigeria, accounting for more than half of the total CO_2 emission across the country from those anthropogenic activities considered, with Kano and Lagos States emitting the most. A regression analysis of those anthropogenic activities with emitted CO_2 shows that cooking contributes most to CO_2 emission in the country. This can be attributed to extensive use of firewood and kerosine in many places as substitutes for more convenient cooking energy, such as gas and electricity cookers, both of which are becoming too expensive to be afforded by average Nigerians. It is however believed that the results of this study will widen the awareness of GCC in Nigeria, as well as inform the decision-making of key stake holders towards economic planning and environmental management in respect of reducing CO_2 emission across the country.

Index Terms— Global climate change, Disaster, Developing countries, Anthropogenic activities, Carbon IV oxide gas emission, Human populations, Human vulnerabilities, GIS, Information Technology.

1 INTRODUCTION

Global warming, or global climate change (GCC) results from those anthropogenic activities which cause emission of greenhouse gases, especially carbon IV oxide gas (CO_2). Since the late 19th century, when GCC started to create interest, the threat has stimulated far-reaching debates about its adverse effects on human populations globally. Recent reports from the United Nations Intergovernmental Panel on Climate Change (IPCC) [1-3] predict continuous fractional increases in the average global land and sea surface temperatures, as well as in precipitation and sea-level. A number of published reports by the World Health Organization (WHO) have shown that climate change may account for much prevalent human disease, and intensify the spread of many diseases experienced in the tropics, such as malaria and typhoid fevers with diarrhea [4-6]. Many environmental hazards, for examples flooding and landslides, are also linked to GCC, and as [7] and [8] have argued, rapid growth in urbanization and demography compound climate change to worsen risk in urban areas.

Basically, the earth's atmosphere is made up of a mixture of gases in variable proportions, with nitrogen, oxygen, CO_2 and the rare gases dominating, and playing enormous roles in the global climate. These gases function in such a way as to balance the surface temperature of the earth by absorbing the radiant energy from the sun and transmitting certain amount to the earth to sustain both biotic and abiotic activities. Unfortunately, since the industrial revolution in the 1970's, human activities have increased the proportion of these gases – especially carbon II oxide (CO) and CO_2 – resulting in measurable increases in the average surface temperature of the atmosphere, oceans and continents of the earth globally (See figures 1 and 2) [9]. Equally, it is reported the variations in the mass of current glaciers and the arctic sea ice, which are melting at an apparently unprecedented rate, and are gradually being lost [10]. The depletions in vegetation covering rise in sea level and the increased frequency and intensity of precipitation are also reported [11-12]. It is possible to imagine some of the implications of these global phenomena, but research has shown more. For example, the increases in the surface temperature have severely impacted on many aspects of the biomes, such

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as weather condition, agriculture, wildlife and human health [9] [13-15].

Generally, GCC is identified over a long period of evaluation of those global phenomena mentioned in the preceding paragraph. Many studies (for example, [9-10]) have mentioned other causes of GCC, besides anthropogenic activities, examples are plate tectonics, solar output, orbit variations, volcanism, and ocean variability. But anthropogenic activities – especially those that seem to alter the natural balance of the environment [16] by modifying the land use / land cover (LU / LC) – do appear to be critical to GCC. Of most concern is the rate of ozone depletion as a result of increased emission of CO_2 from fossil fuel combustion, industrial activities, animal husbandry, agriculture and deforestation [17]. A typical example of CO_2 emission capable of causing climate change is combustion of crude oil combined with solid waste disposal shown in figure 3 below, which depicts such scenario in Port Harcourt, Nigeria.

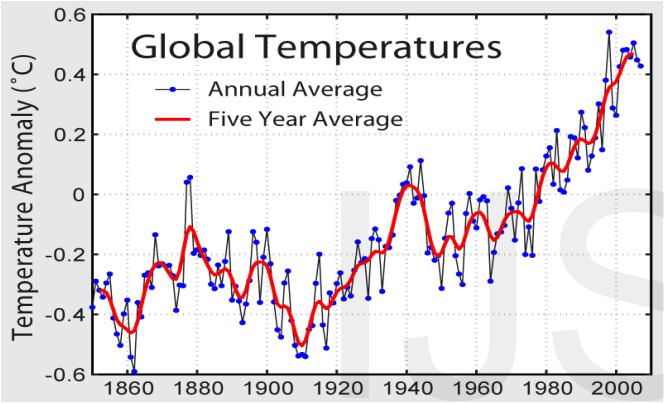

Figure 1: Global Temperature from 1850 to 2000. Source: http://stelian79.wordpress.com/2011/02/27/ Climate-change-and-global-warming/

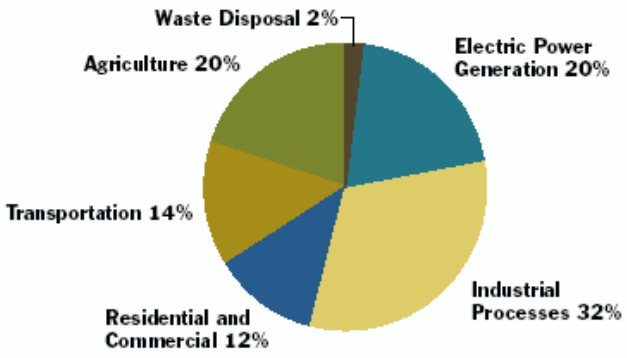

Figure 2: Worldwide sources of anthropogenic GHG emissions of CO_2, measured in 1990. Source: ttp://stelian79.wordpress.com/2011/02/27/ climate-change-and-global-warming/

It is important to know that of all the victims of GCC, none is threatened as much as human population. Recent reports by World Bank, United Nations, and IPCC, along with several media investigations show increasing vulnerabilities of human populations, and predict worse future scenarios [2] [18]. Considering the rate at which urban areas and their human populations are growing, especially in the developing countries (DCs), such as Nigeria, future GCC scenarios point to a catastrophic fate for human species. The frequency of environmental hazards in present times, such as flooding, landslides and hurricanes, which seem unprecedented support this claim. Equally, history tells us that periods of disruption – economic, ecological, etc. – accompanied by poverty and illness, as is the case in the world today, can lead to other social maladies (for examples, unemployment, global terrorism and tensions, local militancy in many oil-producing countries). Although, these realities have been ignored while a search is made for someone or some groups to blame, it is another reason for giving attention to building a society more resilient to cope with the effects of GCC. Given this increasing awareness of the problems of climate change, which may be easier to predict than prevent, the practical solutions, which have so far been limited, and the lack of absolute solutions, a reality which thus far has prevailed, how to respond to the challenges of GCC should be the likeliest alternative theme worth addressing.

Figure 3: Scene of Pollution and Spillage at Port Harcourt, River State. Source: http://ngm.nationalgeographic.com

In actual fact, response to GCC has received much attention in the literature (for example, [2] [19]), especially as it relates to assessment of its impacts, and mitigation of associated risks. However, the broad pattern and objectives of such roles has thus far been focused on finding ways to understand the patterns and occurrences of the adverse effects of GCC in order to mitigate their risks on human populations [13]. Such roles also embrace measures aimed at achieving the goals of assisting human population adapt to climate change [18]. Such objectives are built on the strong principles of response deliv-

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ery, and utilize methodologies that devlop empirical models to simulate future climate change scenarios and take the advantage to provide early warning and forecasts to protect in addition to human populations, critical infrastructure [20]. Over the years, a number of simple activities, which ranged from simple defense mechanisms to complex scientific approaches – energy conservation measures, engineering techniques and carbon sequestration have been carried out in respect of responding to climate change. However, integrated approaches, which suggest living with climate change events rather than fighting them, are being implemented in recent times [19] [20-21].

Integrated approaches can be said to have enabled the participation of the international community, government at all levels, local authorities, and other stake holders toward responding to the challenges of GCC. In particular, the Kyoto protocol and the United Nations Framework Convention on Climate Change (UNFCCC) [22] remain steps in the right direction. With part of the millennium development goals (MDGs) being to respond to the challenges of GCC, the United Nations, IPCC and World Health Organization (WHO) have been actively involved especially in widening global awareness. Moreover, the United States, United Kingdom and other developed countries have sustained the provision and distribution of relevant data and capacities through international agencies, such as National Aeronautics and Space Administration (NASA), US Geological Survey (USGS) and Ordinance Surveys (OS). Despite such positive actions, the need for a failsafe solution remains a major concern, and the number of human populations vulnerable to the effects of GCC keeps increasing. In many DCs, such as Nigeria, the challenge appears to have many dimensions. Apart from the teeming human populations and growing urban development, both of which compound the effects of climate change [7], it can be argued that the problem has generally not been well addressed [23]. Given the much loss of human lives and properties, the perception of climate change among the wider population can be adjudged as poor and inadequate to contribute meaningfully to building any coping capacities in the human populations. Access to accurate and relevant data has been minimal and more scientific and efficient methodologies for tackling climate change events have not been adequately applied in such places.

It is on the basis of supporting the ongoing efforts of DCs in responding to the effect of GCC that this study was carried out, with focus on Nigeria, West Africa. The paper sets forth Geographic Information System (GIS) and information technology (IT) as tools to provide relevant data and capacity to address the nagging challenges of GCC. The paper also presents the results of assessment of CO_2 emission across the states of Nigeria, utilizing demographic data and GIS, while considering cooking, lighting and solid waste disposal. It is believed that the result of this research will widen the awareness of GCC in the wider population, and inform the decision-making of key stake holders in respect of GCC in Nigeria. The rest of the paper focuses on Nigeria's GCC experience, GIS and IT, internet system and GCC, study methodology, results and discussions.

2 NIGERIA AND GLOBAL CLIMATE CHANGE EXPERIENCE

Nigeria is in West Africa, lying between latitudes 4° and 14°N, and longitudes 2° and 15°E, with a total land area of some 924,000 km^2 (See figure 4). It is generally classed as sub-Saharan, and borders the Republics of Benin and Niger, Chad, and Cameroon, with a coastline of over 853 *km*. The hydrological features of the country are mainly the rivers Niger and Benue, which have their confluence at Lokoja, and flows further southwards to empty into the Atlantic, after bypassing the Niger Delta, which covering an area of about 75000 km^2 is reputed as the third largest mangrove, and the biggest freshwater swamps in the world [24]. The result of 2006 census showed 140 million inhabitants in Nigeria, but this population has grown steadily, and is presently estimated at more than 160 million people, making the country the seventh most populous country in the world [25-26]. By the United Nations projections, Nigeria is one of the eight countries expected to account collectively for half of the total world population increase from 2025–2050, and will by 2100, record a population amounting between 505 million and 1.03 billion people [27].

Figure 4: Map of Nigeria showing Political boundaries and physical features. Source: http://nigerianrome.org/about_nigeria/

With such alarming statistics about Nigeria, it will be easier to imagine the frequency of occurrence and the severity of impacts of climate change events in the country. From a regional perspective, Nigeria is one of the countries in Africa predicted to suffer the most from the effects of climate change, judged from indicators like population growth and urbanization. But other factors seem to render the northmost and southmost parts of the country most at risk to the effects of climate change (See figure 5). According to briefs issued by Building Nigeria Response to Climate Change (BNRCC) [28], the reality of climate change events in the country cannot simply be ignored. There have been real disruptions in seasonal cycles, and ecosystems balance in the country, with the result that some stable ecosystems such as the Sahel Savanna

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have become vulnerable, due to water scarcity and increasing risks of drought [28]. Moreover, the aquatic ecosystems, wetlands and their habitats are presently sources of overwhelming problems, especially at the coastal areas where human activities are stimulating unprecedented frequency and severity of flooding (see figure 6), with the rate of food production gradually declining. In a study by Cline, [29], Nigeria was among the countries estimated to experience the greater amounts of decline in agricultural yields (See figure 7). The situation suggests that more human population in the country will be impoverished, and a lot more will suffer from malnutrition. Already, about three-quarters (70%) of the populations in Nigeria are estimated to be living below $1 per day [30-31]. Based on the measure of mean per capita household expenditure, poverty prevalence in Nigeria reveals that almost all rural areas are ravaged by poverty, and cities being the hotspots of development, are rife with adverse effects of climate change [32]. As shown in Cline, [29], poverty rates in Nigeria are considerably higher in the north than in the south (See figure 8).

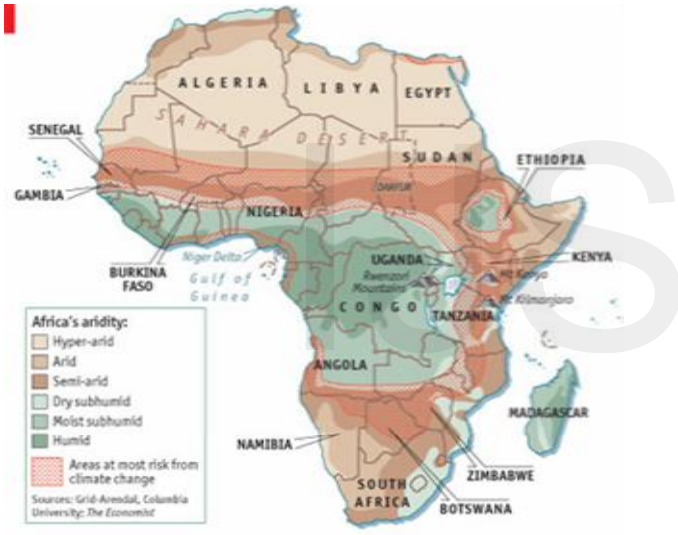

Figure 5: Climate change in Africa
Source: The Economist: Colombian University

Figure 6: Inhabitants of Ajegunle area in Lagos State affected by flooding Source: http://www.nigeriaclimatechange.org/ccinfo.php.

As many rural areas are poorly developed, there tends to be rapid migration into the cities, resulting to explosion of the cities, and subsequent modifications of the natural LU/LC patterns. In such situation, the adverse effects of climate change are intensified, causing worsened living conditions of the inhabitants.

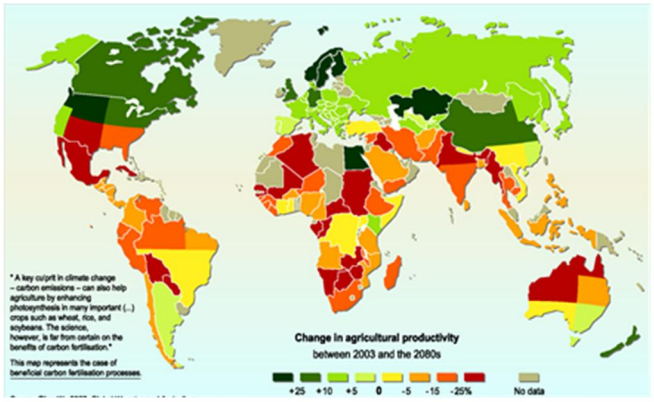

Figure 7: Projected impact of climate change on agricultural yields.
Source: Cline, (2007), Global Warming and Agriculture.

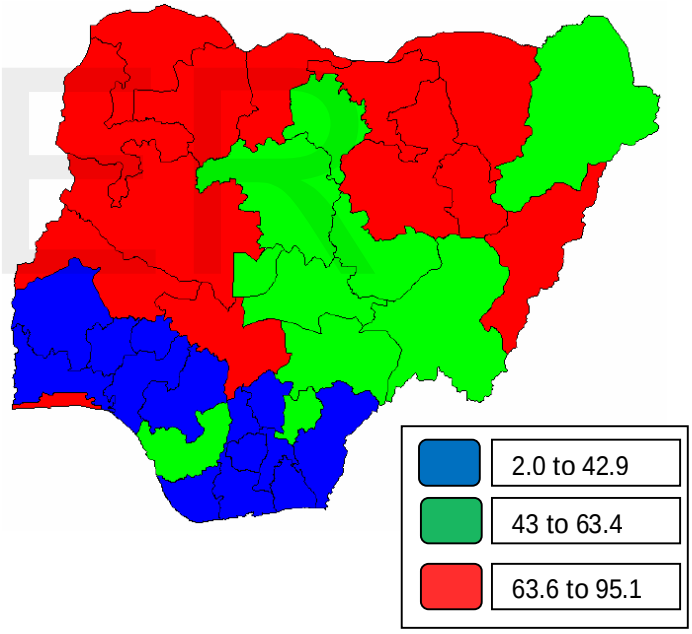

Figure 8: Distribution of "Relative Poverty", based on a measure of mean per capita household expenditure.
Source: Poverty Profile for Nigeria, National Bureau of Statistics, 2005.

Climate change in Nigeria is also attended by sea-level rise with its range of consequences, which includes fiercer weather, increased frequency and intensity of storms, floods, hurricanes, droughts, and increased frequency of combustion. It has a cumulative effect on natural resources and alteration of the natural balance of the ecosystem, and consequently an increased mortality rate never before experienced in history. In a study by McMichael *et al.,* [33], Nigeria was estimated to

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record increased mortality rates along with other DCs, due to climate change (See figure 9). Another important issue of climate change in Nigeria is CO_2 emission. See figure 10 for statistics of CO_2 emission across the globe. As socio-economic status and type of lightning and cooking energy seem to correlate, it is popular with most people living in DCs to provide energy for a number of anthropogenic activities by less convenient means, such as fire wood and kerosene, which emit considerable amounts of CO_2 to the atmosphere. For Nigeria, looking at the estimated human population, the conclusions one may draw in respect of CO and CO_2 emission can be alarming. According to the Federal Ministry of Environment (FME) [34], current estimates in the country indicate that there are emissions of over 1115 *grams* and 1090 *grams* of Methane from combined livestock population, and from rice production respectively. Savanna combustion alone emits 109 *grams*, 3.4 *grams* and 2890 *grams* of Methane, Nitrogen II and CO respectively.

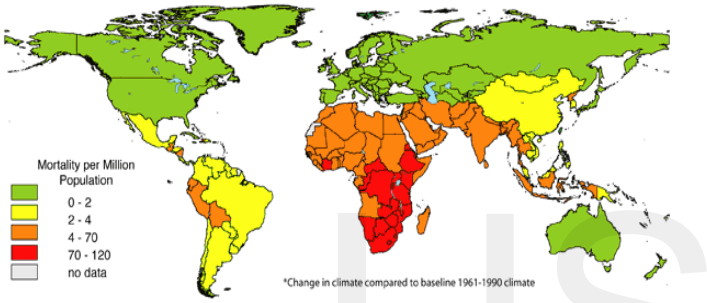

Figure 9: Estimated deaths attributed to Climate change in the year 2000. Source: McMichael *et al.*, 2004

Despite such alarming account of greenhouse gas emission in Nigeria, the country, over a period of two decades, has been active in addressing issues of climate change [35], The establishment of the Federal Environmental Protection Agency (FEPA) [36] with a number of subsidiary committees can be a reasonable evidence for this claim. Although, the agency has been rescinded in 2007, for a more integrated one, known as National Environmental Standard Regulation and Enforcement Agency (NESREA), through its operations, a number of issues, particularly with respect to climate change adaptation were addressed, and the gap between increasing climate change events and how to respond to them seems shortened.

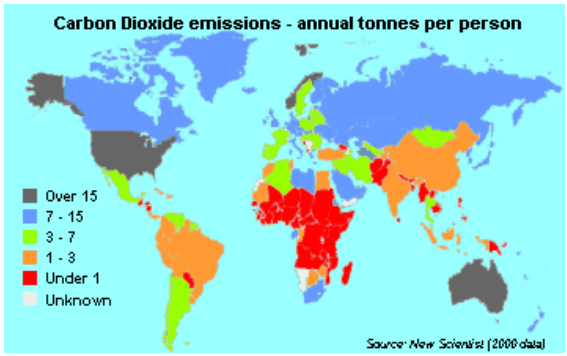

Figure 10: Carbon Dioxide emission across the globe. Source: http://warmingworld.newscientistapps.com/

A number of ministries, departments and agencies in the country, such as Department of Climate Change (DCC), Federal Ministry of Environment (FME), Office of the Surveyor General of the Federation (OSGoF), Centre for Geodesy and Geodynamics, National Space Research and Development Agency (NASRDA), Disaster Monitoring Centre (DMC), research centers, institutions and other non-governmental agencies have been committed to assisting the human population in the country to adapt to climate change realities, and to mitigate recuring adverse effects of climate change. A number of studies have also addressed climate change, particularly, as it pertains to assessment and analysis of its causes, the mitigation measures targeted to the vulnerabilities of places, as well as policy issues [16, 24, 28, 35]. However, with the severity of recent events and the consistent modification of LU/LC patterns by human beings, in a bid to support his existence, more attention is required. Moreover, due to the uncertainties associated with climate change realities in many places, it is almost impossible to find a perfect solution to its many adverse effects. Being a global phenomenon, the relevance of data sharing for staying current with events and for contributing solutions cannot be overemphasized. Unfortunately, Nigeria, where the impacts of climate change may be quite severe, there is poor access to up-to-date data and the technology to enable a meaningful mitigation activities is either not sufficiently put in place or lacking entirely.

3 GIS and Information Technology in Responding to Global Climate Change

GIS, an acronym for Geographic Information System, can be said to have been built upon the knowledge that geographical features can be represented as entities on plain surfaces, such as maps, by means of models and algorithms created from mathematical equations and computer codes, and can be applied to any fields of human endeavor directly or otherwise. By such assumption, GIS is thus relevant to a wide-range of human activities, as long as the input data can be associated with valid geographic identities. In such cases, spatial data can be identified and defined as one-off input data for any GIS operations. GIS may be a computer system that records, stores, and analyzes data that relate to the surface of the earth, but can be more technically defined as a collection of computer hardware, software, people and purposes that synthesizes data that spatially relates to the earth [37].

Information Technology (IT) is mainly concerned with computer hardware and applications, and is about the major driving force of many developmental activities in recent times. Almost all human activities today may be controlled by IT, and with the fast-paced trend of modern society, one can be sure it will still find relevance in the future. Specifically, IT is required for data management of all sorts – creation, storage and retrieval, manipulation, display, security and sharing – and has been able to reduce spatial separation within the global. By this advantage, many difficulties with data sharing, technology transfer and social networking are being solved by just a click of the mouse. Today we have a widespread par-

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lance "Global village" signifying that the separation between places around the globe, with respect to distance and time is getting smaller and smaller. While IT is a major component of GIS, its full functionality is augmented by GIS, and the advantages of this synergy with regards to GCC can be summarized as follows;

1. GIS and IT can be said to be breaking geographic boundaries, forming what might be referred to as a seamless link between different locations across the globe. By creating cabled and wireless systems, both technologies have enhanced data and collaboration between experts in a much quicker and more convenient way.

2. With a number of existing software and hardware, GIS and IT promise enhance productivity, greater profitability, clutter free working conditions and global clientele, which are of greater applications to issues of GCC.

3. GIS and IT can provide technical support for both pre- and post-GCC-event.

4. GIS and IT can create platforms for decision making and can guide decision-making towards resource allocation, for example, through the production of maps to delineate important aspects of climate change scenario, such as vulnerability, coping capacities, and risk zones within an area.

5. GIS and IT create models, representing real-life situations, which in respect of a future occurrence can be applied to places where data are lacking, in order to make decision on how to prepare, judging from a similar event that has happened in the past.

6. Operations in GCC event mitigation that involve repetition and speed are better handled by means of GIS and IT.

7. The synergy between GIS and IT enables the integration of the contribution of various team members through cross-discipline interpretation and software functionality.

8. Provision of new methods for visualizing data sets through the use of several methods of representing symbols.

9. GIS and IT enable dynamic mapping and creation of digital databases.

10. Both operations support and enhance more complex data analyses, with results presented in more dynamic formats, such as charts, queries, and other statistics.

11. Sharing of data and integration of access to centralized databases via computer networks or the internet through web-based GIS.

12. Linkage of multiple software applications and formats.

13. Data are archived into a centralized medium and will be useful for revision in future study of the areas, for example GIS database (Geodatabase).

14. Ability to compare and integrate various datasets.

15. Both operations provide more convenient ways to evaluate the potential impact of a particular environmental activity (EIA).

16. Both technologies enable the analysis of different types of data, such as satellite imagery, digital aerial photo mosaics, seismic surveys, surface and subsurface geology studies, etc.

4 Specific functions of GIS in Responding to Global Climate change

Indicators, such as glaciers, sea level, poverty, rise in earth surfece temperature can be used to enhanve better understanding of GCC. Such indicators can be modeled by means of GIS and IT, to provide the bases for decision making. Researchers over the years have explored this power of GIS in solving a myriad of environmental issues relating to GCC. Being able to integrate all spatial data, GIS transforms raw data into useful information and presents the results in a bespoke format. Some of the specific functions of GIS most often taken advantage of, while responding to GCC are map making, surface generation, database creation and management, integration of various datasets. In particular, surface generation is a very important function of GIS. As surfaces are key component of the environment, knowing them has been fundamental to delineating the exact impact of climate change in an area. Surfaces are often described in two-dimensions, showing natural and manmade features, and in three-dimensions by means of DEMs / DTMs. GIS is utilized to extract contours and other vector layers of the topography from popular DEMs, for example Shuttle Radar Topographic Mission (SRTM) and Advanced Space-borne Thermal Emission and Reflection Radiometers (ASTER). See figures 11 and 12 below, for surfaces generated using GIS.

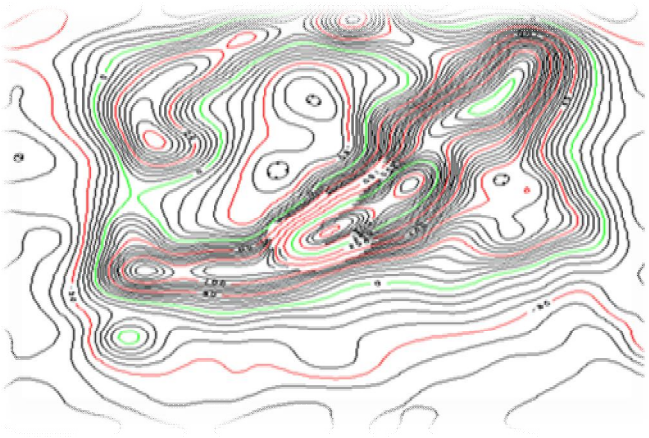

Figure 11: Contours representing a part of Nigeria generated from 90*m* resolution SRTM, by means of GIS

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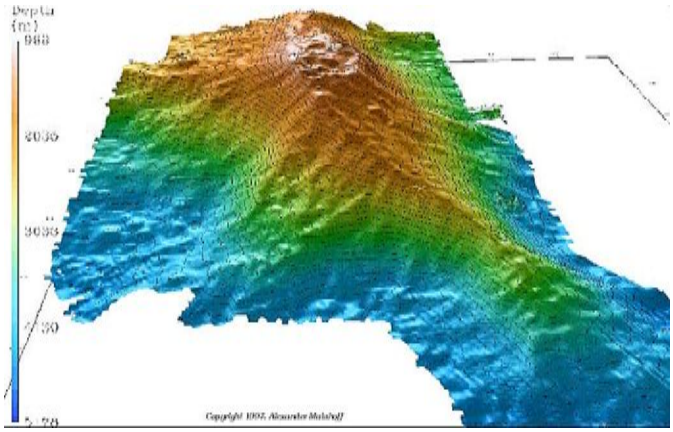

Figure 12: DEM representing a part of Nigeria generated from 90 m resolution SRTM, by means of GIS.

5 INTERNET SYSTEM AND GLOBAL CLIMATE CHANGE

According to recent online resources, for example the Wikipedia [38], the internet is a global system of interconnected computer networks that use the standard internet protocol suite (TCP/IP) to serve billions of users worldwide [38]. It is a network of networks that consists of millions of private, public, academic, business, and government networks of local to global scope that are linked by a broad array of electronic and optical networking technologies. The internet carries a vast array of information resources and services, most notably the inter-linked hypertext documents of the World Wide Web (WWW) and the infrastructure to support electronic mail. The origin of the internet dates back to the 1960's through the United States military agencies, and recently the technology has advanced in coverage and accessibility. By 2009, over a quarter of the population of the global was estimated to be using the internet. A treatment of the background and other issues relating to the internet system can be found in [38].

The contribution of internet system towards responding to the challenges of GCC can be surmised from the basic services rendered by the internet, which include information, data transfer and communication. Some of the contributions include, but not limited to the following;

1. Internet technology has the potential to facilitate the increase in awareness of GCC.
2. Internet can facilitate everyone's participation, share of views, exchange of knowledge and easy flow and transmission of ideas in the subject of GCC.
3. Internet enhances transfer of data necessary for the study of GCC. Some data are published free on the internet like the satellite data, rainfall data, temperature and other climate parameters data. This makes it possible for researchers to find the data they need for their studies.
4. Internet makes easy for real-time study. This removes the limitations placed by spatial and temporal variations.
5. The internet can create an avenue for tutorial, easy and free access to suitable software, which enhances studies of GCC

It will be needful to emphasize that the benefits of the internet notwithstanding, there are also a couple of limitations like access (not everyone has access to internet). Other limitations are; acquisition of internet infrastructure and literacy on the use of these infrastructure.

7 DATA AND METHODOLOGY

Data

The only data for the study are the 2006 Nigerian census results, published by the National Population Commisiion (NPC) [25]. A major limitation with the census data is the scale at which they are presented. The data were generalized according to the States of the country, and were based on head counts. A study of this nature requires more detailed data, and based on this limitation, the authors argue that the study could have provide better results if the data had been based on housing units with included industries. There is assumption. Another limitation with the census data is presenting only few anthropogenic activities - cooking, lighting and solid awaste disposal. Other key human activities like animal husbandry, oil refinning, fishery, and core industrial activities were not considered.

Methodology

The census data were entered into MS EXCEL spreadsheet, to represent the three anthropogenic activities, which are, cooking, lighting and slolid waste disposal. Although, these activities have been argued to often contribute the most to the emission of greenhouse gases [9], inclusion of other activities, for example animal husbandry, oil refining and fishery may give a better representation CO_2 emission across Nigeria. The census data gave head counts of human populations that cook with gas, solar, electricity, fire wood, animal dung, and 'other means'. 'Other means' could imply the use using generator in particular and so on. The study excluded electricity and solar, as their contribution to CO_2 emission has not been shown to be substantial. Except in cases of inferno, cooking with electricity may contribute insignificantly to the greenhouse gases. Similarly, solar and electricity sources were excluded from lighting activity. All means of disposing solid waste in Nigeria, which includes burning, collecting, buried by household, approved and unapproved dump sites were analyzed. The data were first normalized, to obtained z-scores, in order to carry out correlation analysis using the study results with the anthropogenic activities considered in the study. The data were individually reduced for each anthropogenic activity and the resulting scores collectively analyzed by means of simple equal weighting. The final scores representing the states of Nigeria are given in table 1. Finally, the results were exported to ESRI ArcGIS 10.1 for final interpretation and mapping. The indices obtained from the analyses were mapped into five graduated scales, representing very high emission, high emission, medium emission, moderate emission and low emission.

7 RESULTS AND DISCUSSIONS

The result of the study shows high scale emission of CO_2 is taking place in 14 States of Nigeria, with Kano and Lagos States emitting the most (See figures 13). The recorded amount of CO_2 emission in those places, based on the considered anthopogenic activities,

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accounts for more than half (60%). Other major contributing States are Kaduna, Katsina, Oyo and Rivers.

States	Norm Cooking	Norm Lighting	Norm Solid waste	Emission Index
Abia	0.168	0.249	0.160	0.192
Adamawa	0.137	0.334	0.144	0.205
Akwa Ibom	0.281	0.518	0.293	0.364
Anambra	0.243	0.355	0.306	0.301
Bauchi	0.268	0.567	0.288	0.374
Bayelsa	0.032	0.160	0.026	0.072
Benue	0.254	0.544	0.263	0.354
Borno	0.247	0.480	0.256	0.327
Cross River	0.186	0.328	0.181	0.231
Delta	0.282	0.390	0.310	0.327
Ebonyi	0.066	0.269	0.077	0.137
Edo	0.202	0.133	0.210	0.182
Ekiti	0.099	0.189	0.100	0.130
Enugu	0.207	0.339	0.223	0.256
Gombe	0.058	0.179	0.061	0.099
Imo	0.235	0.456	0.282	0.324
Jigawa	0.213	0.540	0.268	0.340
Kaduna	0.425	0.584	0.429	0.480
Kano	0.543	1.000	0.687	*0.743*
Katsina	0.322	0.672	0.403	0.466
Kebbi	0.115	0.290	0.137	0.181
Kogi	0.181	0.267	0.179	0.209
Kwara	0.086	0.084	0.087	0.086
Lagos	1.000	0.177	1.000	*0.726*
Nasarawa	0.023	0.139	0.021	0.061
Niger	0.226	0.334	0.225	0.262
Ogun	0.308	0.194	0.305	0.269
Ondo	0.245	0.312	0.243	0.267
Osun	0.217	0.196	0.226	0.213
Oyo	0.499	0.499	0.499	*0.499*
Plateau	0.165	0.341	0.159	0.222
Rivers	0.435	0.550	0.434	0.473
Sokoto	0.185	0.400	0.204	0.263
Taraba	0.065	0.276	0.068	0.136
Yobe	0.057	0.213	0.061	0.110
Zamfara	0.110	0.350	0.152	0.204
FCT Abuja	0.000	0.000	0.000	0.000

Table 1: Final scores of and results of analysis of CO2 emission for the 36 States of Nigeria and FCT.

A regression analysis of those anthropogenic activities considered and the result of CO_2 emission shows that cooking contributes most to CO_2 emission in the country (See table 2). This can be attributed to extensive use of firewood and kerosine in many places as a substitute for more convenient cooking energy, such as gas and electricity, both of which are becoming too expensive to be afforded by average Nigerians. Also, when compared with the map of population density of Nigeria (figure 14), the result of CO_2 emission in the country tends to correlate positively. Those States with higher population density appear to have a greater tendency to emit more CO_2 than the others. It is believed that these results will widen the awareness of GCC in Nigeria, as well as inform the decision-making of key stake holders towards economic planning and environmental management in respect of reducing CO_2 emission in the country.

Regression Statistics	
Multiple R	*0.92153312*
R Square	*0.849223291*
Adjusted R Square	*0.844915385*
Standard Error	*0.065321387*
Observations	*37*
Emission source	**Coefficients**
Cooking	*0.835641*
Lighting	*0.651083*
Solid waste	*0.823814*

Table 2: Regression Result showing the strength of various sources of Carbon Dioxide emission in Nigeria.

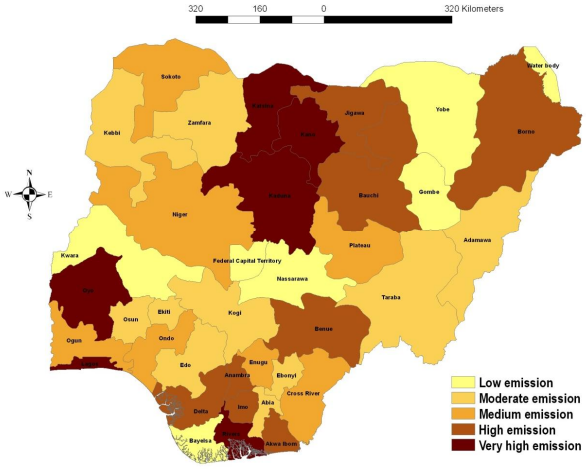

Figure 13: Carbon IV Oxide gas emission index in Nigeria, showing nine States of the country where emission of the gas is most experienced

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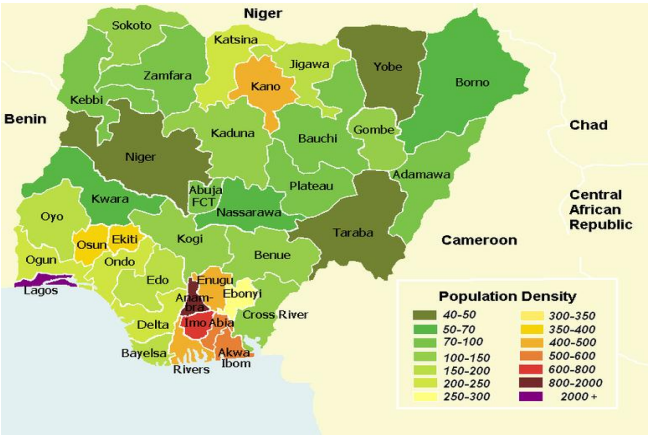

Figure 14: Population density of the states of Nigeria.
Source: http://en.wikipedia.org/wiki/File: Population_density_map_of_Nigerian_states_-_English.png

9 CONCLUSION

Global climate change is arguably the biggest threat to nature and humanity and how to address the incresaing challenges of its events have been addressed in this study. GIS and IT have both been discussed as useful tools for achieving the goal of providing data and capacity for responding to climate change events. This study also presents the results of assessing the CO_2 emission across the States of Nigeria. The results obtained show a high level of CO_2 emission taking place in 14 states of Nigeria with Kano and Lagos States emitting the most. Cooking activity was found to contribute the most to CO_2 emission across the country. While these results have been satisfactory, and can be used to widen the awareness of global climate change in the wider population, as well as inform the decision-making of stake holders towards economic planning and enviornmental management in view of reducing CO_2 emission in Nigeria, the authors feel strongly that there had been few limitation to the study, due to the quality of data used. As a result, it is recommended for future studies that higher resolution data, which provides insight into other anthepopgenic activities, besides those considered in this study be utilized. Moreover, future studies should also endeavour to validate the results obtained in this study.

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