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CLIMATE CHANGE, GLOBAL WARMING AND ADAPTABILITY FOR SUSTAINABLE GROWTH AND DEVELOPMENT IN NIGERIA

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ABSTRACT

There is global warming that is gradually changing the climate too. The objective of this paper is to examine the physical environment of the country vis-à-vis global warming and climate change with a view to making suggestions for adaptability for sustainable growth and development. Books and materials on physical environment of Nigeria were extensively read. News paper cuttings, magazines, journals and documents from the Federal and State Ministries of Environment were contacted. I listened to radio and television documentaries on the changing face of the earth. The country was divided into six geographical zones for data collection. Empirical observations were made on selected weather elements. Vegetation and other elements of the physical environment were studied. Weather records were obtained from six stations of IITA; and from Federal Meteorological stations across the country. Temperature, rainfall and relative humidity have increased. Cloud cover is more. Double maxima of rainfall and August break are no longer obvious. The hamattan lasts shorter period of time, less hazy but dustier. Wind directions have not changed significantly. Desert encroachment is obvious. Vegetations have changed mostly from natural to manmade. River courses have changed. Lengths, volumes and loads carried by rivers and streams have relatively increased. Acid rain is experienced. There is inclement warmth. The reclaimed lands are being covered by water again. There are new human and animal ailments and diseases. The challenges are not peculiar to Nigeria. It is global. The world is working towards zero emission; and identified with ozone recovery. Nigeria should not be left out. There must be legislations and environmental education that should address the global warming, climate change and their effects.

Keywords: Global warming, climate change, adaptability, sustainable growth and development, Nigeria.

INTRODUCTION

The ozone reaction *mechanism* is uniquely dependent on the rate of mass transfer into an aqueous system, and three operating regions of activity exist, (Velchi and Brain, 2007). The most significant for this study is what happen in the troposphere. It is found primarily in two regions: About 10% of the atmospheric ozone is the troposphere, the region closest to earth (from the surface to about 10-16kms). The remaining ozone (90%) resides in the stratosphere, primarily between the top of the troposphere and about 50kms altitude. It is the large amount of ozone in the stratosphere that is often referred to as the Ozone Layer, (Fahey, 2007). According to him, it is formed throughout the atmosphere in multi-step chemical processes that require sunlight. In the stratosphere, the process begins with an oxygen molecule (O_2) being broken apart by the ultraviolet radiation from the sun. In the lower atmosphere (troposphere), ozone is formed in a different set of chemical reactions involving hydrocarbons and nitrogen containing gases.

Seetharam and Udaya-Simba (2009) in their study of urban population found out that concentration of Sulphur dioxide at all locations showed a falling trend due to use of refined petro-products in the recent years; concentration of oxides of nitrogen (NOx) shows an increasing trend but was within the permissible limit. The increase may be attributed to increased use of LPG for vehicle; concentration of the suspended particle matter (SPM) showed the mixed trend. Increase in the volume of vehicles on the roads, infrastructure works are some of the reasons for increase, (Lokesh, 2006).

The initial step in the depletion of stratospheric ozone by human activities is the emission, on the earth's surface of ozone-depleting gases containing chlorine and bromine. Most of these gases accumulate in the lower atmosphere because they are unreactive and do not dissolve readily in rain. Eventually, these emitted source gases are transported to the stratosphere where they are converted to more reactive gases containing chlorine and bromine. These more reactive gases then participate in reactions that destroy ozone. Finally, when air returns to the lower atmosphere, these reactive chlorine and bromine gases are removed from earth's atmosphere by rain.

Meanwhile, it is mostly certain industrial processes, human production and consumer products that result in the emission of "halogen source gases" to the atmosphere. The gases bring chlorine and bromine to the atmosphere, which cause the depletion. Example is Chlorofluorocarbon (CFCs), once used in almost all refrigerators and air conditioning systems, it eventually reach the stratosphere, where they are broken apart to release ozone-depleting chlorine atoms. Other examples of human-produced ozone-depleting gases are the "halons", which are used in fire extinguishers and contain ozone depleting bromine atoms. It is for this reason that the production and consumption of all principal halogen source gases by human activities are regulated worldwide under the Montreal Protocol (Intergovernmental Panel on Climate Change, (IPCC), (2007).

Suffice it to say that there is a relationship between air pollution, ozone depletion, global warming and climate change (Dow and Downing, 2007 and World Health Organization, 2005). Among the consequences of air pollution is global warming that also contributes significantly to climate change, (Shaheen, 2000: 75-111 and Rao, 2006: 19-31). Figure 1 gives a fair simplified

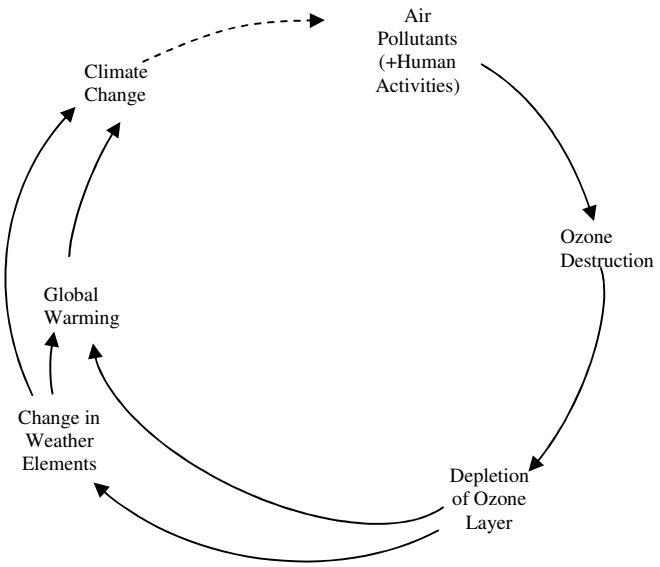

Figure 1: A simplified schematic representation of cycle of global warming phenomena

Gasoline/ Diesel Generators	Excavations and quarrying
Bio waste	Construction
Cooking Activities (Kitchen; Commercial and Domestic)	Reconstruction
Incineration	Renovation
Cleaning Activities	Animal Routes (Animal Rearing)
Combustion Activities	Bush Burning
Vehicular Emission	Forest Fire
Aviation	Thunder
Daily Activities	Playing/Sport Fields
Automobile Repair Works	Industrial Ethanol
Hospital Ethanol	Hotel /Restaurant/Bar/Brothel
Process Plant Discharge	Local Crafts
Demolition	Others (Specified)

Source: Aderogba, K. A. (2010) Field Survey

Figure 2: Major sources of pollutants (Unclassified)

schematic representation of the cycle: From air pollutants and pollution to destruction of ozone, to depletion of ozone layer through global warming and change in weather

elements to climate change. Also, Figure 2 shows the unclassified sources of pollutants found in the air. These include bio-waste, incineration, cleaning, combustion, construction, quarrying, excavation, bush burning, thunder, hospital ethanol and others, Figure 2.

There had not been serious attention given to the depleting ozone layer, global warming and climate change until about four decades ago when it became obvious that anthropogenic damage to the earth's stratospheric ozone layer will lead to an increase in solar ultraviolet (UV) radiation reaching the earth's surface, with a consequent adverse impact, (Brain, 2004). According to him, more recently, there has been an increased awareness of the interactions between ozone depletion and climate change, which could also impact on human exposure to terrestrial UV. "The most serious effect of UV exposure to human skin is the potential rise in incidence of skin cancers". He went further to explain that risk estimates of this disease associated with ozone depletion suggest that an additional peak incidence of 5,000 cases of cancer per year in the United Kingdom would occur around the mid-part of this country. At the global level, among the major challenges of combating the menace is finance. But the next global meeting on climate change is coming up in Cancum, Mexico in December 2010 "where issues of financing will see significant progress," (Kortenhorst, 2010).

Shaheen (1992: 95) asserts that although zones is a serious pollutant at ground levels around the atmosphere, in the upper atmosphere (around 25-44 kms) the ozone layer in the stratosphere protects the earth and the people living on it by blocking ultraviolet radiation (UV) coming from the sun. According to him, it has been estimated by the American Environmental Protection Agency (AEPA) that each 1% decline in worldwide average of ozone will cause an increase in skin cancer by nearly 5%. It is the chlorofluorocarbon (CFCs) produced by humans that reach the upper atmosphere, where they cause destruction of the ozone; by doing so, they allow the harmful ultraviolet rays to reach the earth's atmosphere. In the upper atmosphere, the ultraviolet light breaks off a chlorine atom from chlorocarbon molecule, and then the chlorine attacks the ozone molecule, causing its break up. By then an ordinary oxygen molecule attacks itself to the chlorine to give chlorine monoxide. Subsequently, a free oxygen atom breaks up the chlorine monoxide and frees the chlorine again to start its process of destruction by attacking another ozone molecule, and the cycle goes on.

The importance and the gravity of the situation, led to the international conference sponsored by the United Nation Environmental Programme that was held in Montreal, Canada. It was at the conference that 24 nations signed a milestone accord which promised to cut the production and use of ozone-

destroying chemicals by 50% around the year 1999. The chairman to the conference declared: "There has never been an agreement like this on a global scale". Similarly, the administrator of the United States Environmental Protection Agency said:

> *"The signing shows an unprecedented degree of cooperation among nations of the world in balancing economic development and environmental protection".*

Chlorofluocarbons such as Freon are used as coolants in refrigerators and air conditioners, and they are important component in aerosol and plastic foams. The United States and European Community produce annually about 75% of the total world production of 1 million tons of CFCs. All of these will be reduced according to the Montreal Protocol; and which have actually started reducing (Fahey 2007 and Barnett, Adam and Lattenmaier 2005). This international pact also will limit the use of an ozone destroying group of fire suppressant chemicals called halons.

Fahey (2007), Barnett et al (2005) and, Cox, Betts, Jones, Spall and Totterdell (2000) believe that these compounds cause as much as 20 times the damage of CFCs. They are also of the view that up to 7% of the ozone belt, stretching 6 to 50 kms above the earth, has already been depleted. With the depletion of the ozone layer and its deterioration, ultraviolet radiation from the sun will cause drastic increase in skin cancer and cataracts. It will also lower resistance to infection and damage plant life, either directly or through a general warming of the earth – global warming.

Under normal and moderate conditions, CO_2 helps gases which come from man–made sources (electrical, transportation, industry and commercial building and homes) will end-up trapping more heat and thus contribute to global warming. It is believed that the increase in gas concentration and especially CO_2 has caused an increase in global average temperature of about 0.4 ^{O}C since 1950 (Shaheen, 2000: 96).

However, why do we care about atmospheric ozone? The ozone in the stratosphere absorbs some of the sun's biologically harmful ultraviolet radiation. Because of this beneficial role, atmospheric ozone is considered "good" ozone. In contrast, excess ozone at earth's surface that is formed from pollutants is considered "bad" ozone because it can be harmful to man, plants, and animals. The ozone that occurs naturally near the surface and in the lower atmosphere is also beneficial because ozone helps to remove pollutants from the atmosphere. In the absence of human activities on earth's surface, ozone would still be present near the surface and throughout the troposphere and stratosphere because ozone is a natural component of the clean atmosphere, (Fahey 2007). When ozone is massively "affected" and it reduces in amount, it leads to depletion of ozone layer which subsequently lead to global warming and climate change (Seinfeld and Pandis 1998 and Hansen, Schnitzerler, Strassmann, Doney and Roeckner 2007). The detailed chemistry of the processes is beyond the scope of this work.

However, the objective of the paper is to examine the physical environment of the country, Nigeria, vis-à-vis the changes in the face of global warming with a view to making suggestions for adaptation and sustainable development.

MATERIALS AND METHODS

The country lies within the tropical region of West Africa with an area of about 923,768 km^2 that is made up of 910,768 km^2 of land and 13,000 km^2 of water with a geographical coordinate of $10:00^0$ North, and $8:00^0$ East. Comparatively, it is slightly twice the size of California. Total land boundaries is about 4,037 km that is made up of Republic of Benin (773 km), Cameroon Republic (1,690 km), Chad (87 km) and Republic of Niger (1,497 km). Coastline is 853 km. Her maritime claim is 200m (or to the depth of exploration of continental shelf), 200 nm of exclusive economic zone and 12 nm of territorial sea. She has a variety of physical conditions.

The vegetation type typically reflects rainfall patterns, soil types and variations in altitude. In general, rainfall diminishes from the south and south-east towards the north. The coast has rain during all

months of the year while the north has rain for approximately half of the months of the year. The rainfall follows the hinterland movement of the moisture-laden south-west winds. It is essentially convectional. Double maxima used to occur in the south while a single maximum occurs in the north. In the coastal regions, the annual rainfall is of the order of 4,000mm in the south dropping to about 500mm in the extreme north. The assured supply of rainfall, especially during the raining season, and the consistent high temperature throughout the year make for plant growth everywhere, (Afolabi, 1973: 25).

Throughout the coastland is dense *Mangrove Forest*. It is fairly extensive in the Niger Delta. *Evergreen Rainforest* occurs inland from this. It has a considerable number of tree species, wood climbers, creepers and undergrowth. Mainly because of soil characteristics, a zone of oil palm bush breaks the west to east belt of the high rain forest in parts of the Eastern states. The *Derived Savannah* which is found next to the rainforest belt is usually regarded as rainforest modified by human activities especially extensive farming. The remaining parts of the country to the north is covered by a variety of *Savannah Vegetation* ranging from the *Southern Guinea Savannah* through *Northern Guinea* and *Sudan Savannah* to *Sahel Savannah* and *Semi-Desert* in the extreme north. Adamawa highlands and regions around Jos Plateau have *Mountain forest*. Most of these have been tampered with by man. What are found in most places are cultigens, distorted forest and savannah grasslands.

In broad terms, the south is essentially a zone of tree and root or tuber crops. The middle belt is of mixed root and grain crops. The north is predominantly for grain crops. According to Afolabi (1973: 27) "obviously, this pattern is related to the rainfall distribution in terms of its quality and dimension." The same way, Dow and Downing (2007; 11-27) assert in their book *The Atlas of Climate Change: Mapping the World's Greatest Challenge.*

October 2010 marked 50 years that it became independent. In the short time, the country has made some indelible marks in the comity of nations: leading athletes, musicians, captains of industry, and celebrated academics are Nigerians. The nation is represented in the Broadway and West End, from Nollywood to Hollywood; as Nobel Prize and Pulitzer Prize winners and most importantly in neighbourhoods and communities where Nigerians – regardless of their ethnicity or religion – work tirelessly to better the lives of their families and wider communities. Nigeria is a major player in the world oil and gas business: The sixth world largest reserve of crude and seventh largest producer.

Apart from the ones that are found dotting the outskirt of major cities and towns, manufacturing and other industrial processes and productions are most concentrated at the Lagos-Sango/Ota-Abeokuta-Ibadan industrial axis, Kano-Kaduna-Jos triangle, Assaba-Onitsha-Benin-Sapele-Warri Sector and Aba-Port-Harcourt-Enugu-Onitsha-Owerri Complex.

Literature on ozone, ozone depletion, global warming and consequences on man, plants, animals and generally on climate and climate change were read. Newspaper cuttings and magazines were read. Reports, communiqué and/or proceedings of conferences, workshops and seminars on ozone layer and depletion, global warming and climate change were perused. The research listened to television and radio documentaries on climate change, global warming and depleting ozone layer. Data/information derived from these sources is significantly represented in this work. Empirical investigations were carried out particularly on air and rain water. Data on weather elements were obtained from the Federal Meteorological Stations (FMS) and Institute of Tropical Agriculture (IITA) across the country. But emphases were on temperature, rainfall, Relative Humidity, cloud cover and particulates in the air.

In April, August and December 2010, as it was in the last five years before then, rain water was collected in each of the zones and analysed to ascertain the composition of the water particularly as acid rain was speculated. Federal Ministry of Environment and Federal Environmental Agency both at Abuja were visited and so also two State Ministries of Environment and Physical Planning in each of the geographical zones. Documents/records were perused and one relevant Director each in each of the State Environmental Protection Agencies. They responded to questions on pollution, pollutants,

controls and challenges. Areas of concern were enumerated and suggestions for adaptation to effects of global warming were made.

Familiarization tours of the different suburbs of the metropolis and the rural suburbs were carried out in two months – March and April, 2009. During the period, the researcher came to understand the different land use, predominant human activities, and types of industrial processes and productions, rural activities, and resultant effluents.

Two monarchs of not less than fifty-five years old in each of the geographical zones were also interviewed on their experiences of their immediate physical environment compared to what obtained in the past (over thirty-five years and beyond away). Weather elements were studied and empirical investigations were carried out on plants, animals, and physical elements of ecosystems and niches. These were studies for a period of five years. Agronomical measurements of soil attributes were similarly observed, studied and analysed. Forest rangers were interviewed and so also traditional and modern (mechanised) farmers. All of them commented on the structure, composition and sizes of forests, grasses, planting and harvesting of crops and crop yields.

Human activities in two cities and towns each of the six geographical zones of the country were studied, namely: North – west - Sokoto and Katsina; north – east- Yola and Maiduguri; north – central - Kaduna and Mina; south – west - Abeokuta and Ondo; south – east – Onitsha; and Enugu, and south – south - Port -Harcourt and Warri. Longman (2005) Senior Secondary Atlas and Macmillan Senior Schools Atlas (Duze and Afolabi, 2000) on Nigeria were used.

Each of the zones were picked one after the other, and the atlas maps, contents of the texts and physical observation were compared. Three text books, (Amayah 2003, Udo, 1982 and Iloeje 1991) were used. Chapters on the physical environments were read and compared with the content of the Atlases and the field observations. Man's activities and behaviour of animals and plants were noted and studied. The research took a tour of all the Geographical zones.

Human activities ranging from waste generation, disposal and management, creation of concrete surfaces, construction, reconstruction, renovation, excavation, quarrying, animal rearing, poultry farming and others were observed and studied. Bush burning, forest fire, smoke from automobiles, hotels, restaurants and homes and dusts from cattle routes, sport grounds (formal and informal) and others were observed and studied. Figure 2 above shows major sources of pollutants observed – 26 of them.

Six medical physicians, one in each zone, were interviewed and their hospital records examined to ascertain the common ailments and diseases that are associated with air quality. Similarly, records of ailments due to air pollution reported in the hospitals, on annual basis were obtained from National Hospital, Abuja.

The sources of pollution were categorized into five: (1) transportation and automobiles (2) fuel combustion in stationery sources (3) industrial processes (4) solid waste disposal and (5) others (miscellaneous). Hydrocarbons (HC), Carbon monoxide (CO), Particulates (Part), Sulphur oxides (SOx) and Nitrogen oxides (NOx) were measured for each of the sources of pollution (and pollutants) in grams per meter square. Experimental fields were set-up in twenty locations that show different land use and human activities.

RESULTS

There are a number of manufacturing, processing and packaging industries whose wastes as effluents and solid wastes are contributing to environmental pollution. Bush burning, heating at homes, small scale industries, exhausts of automobiles and electricity generators, chimney and others contribute to pollution and heat and global warming resulting from depleting ozone layer. The general increase in global average air and ocean temperature, widespread melting of snow, and rising sea levels led the

Intergovernmental Panel on Climate Change (IPCC) to report, in February 2007, that "warming of the climate system is unequivocal." Dow and Downing (2007) also submitted thus:

> *The world is experiencing increasingly uncommon weather, and implications for day-to-day life are becoming more apparent. Naturalists' observations of animal and plant behaviour suggest that ecosystems are already being forced to adjust. In April 2007, the IPCC stated with "high confidence" that recent warming has affected terrestrial, marine and fresh water biological systems, glaciers and rivers. Based on an analysis of over 29,000 data sets, contained in 75 studies from around the world, it concluded that over 90 per cent of the observed changes were consistent with climate change.*

Air Pollutants and Pollution

Table 1. Estimated emission of air pollutant by weight per annum

COMPONENTS	GASES & PARTICULATES					
	TOTAL	SO_x	HC	NO_x	CO	PARTICULATE
Fuel combustion in stationary sources	49.9	25.5	0.8	11.1	2.8	9.6
Transportation and automobiles	101.6	0.9	18.7	10.4	68.8	2.9
Agriculture and industrial processes	58.6	12.4	6.8	5.6	15.8	18.0
Solid waste disposal	33.2	1.4	3.9	2.6	11.8	3.1
Miscellaneous	48.5	1.6	10.8	3.5	18.8	13.8
Total	281.4	41.8	41.0	33.2	118.0	47.4

Source: Federal Environmental Protection Agency; and Field Survey.

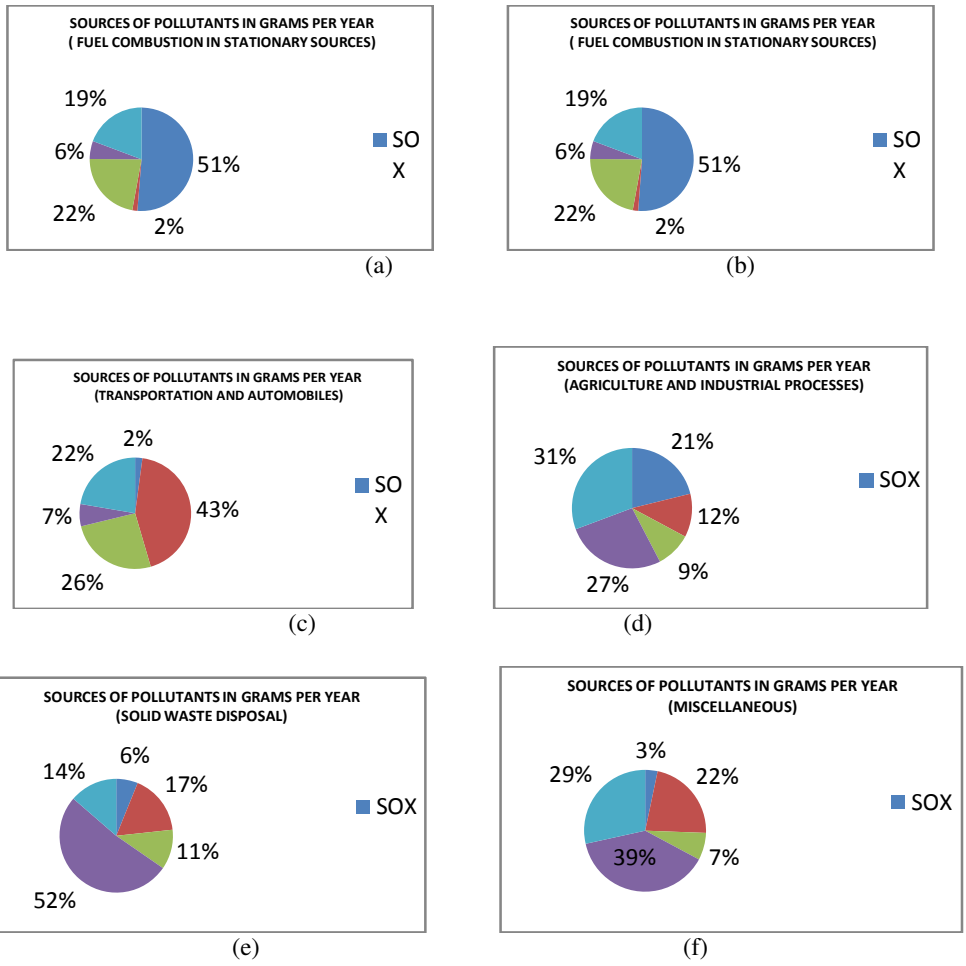

Figure 3: Amount of classified pollutants emitted per year in grams/meter at Abuja

They went further to emphatically assert that:

> *A single extreme weather event or change in the natural environment does not prove that human are changing the climate. However, the proven physical science, the history of recent observations, and the consistency in model assessment all support only one explanation: The emission of greenhouse gases by human activities is causing profound changes to climate system and to the world we live in.*

Air pollutants emitted per year on the average are best illustrated in Table 1 and Figure 3 (a) (b) (c) (d) (e) and (f) above. The estimated total concentration of all pollutants put together for the territory is 281.4g. This is made up of 41.0g of HC, 41.8g of Sulphur oxides, 33.2g of NOx, 118.0g of CO and 47.4g of particulates; Table I and Fig. 3 (a). The sources have some discrepancies which arise from the different assumptions made in the estimates (Rao, 2006: 37).

Table 2. Atmospheric air compared to WHO permissible standard

Component	Concentration (WHO's Std.)	Average Readings
Nitrogen	78.09×10^4	79.14×10^4
Oxygen	20.24×10^4	20.04×10^4
Argon	93×10^2	94×10^2
Carbon dioxide	3.2×10^2	3.6×10^2
Neon	18	18
Helium	5.2	5.9
Krypton	1.0	1.0
Xenon	8×10^{-2}	8×10^{-2}
Carbon Mono Oxide	1×10^{-1}	$2x\ 10^{-1}$
Methane	1.2	1.5
Nitrox Oxide	25×10^{-2}	27×10^{-2}
Nitric Oxide	6×10^{-4}	6×10^{-4}
Ammonia	6×10^{-3}	3×10^{-3}
Hydrogen Sulphide	2×10^{-4}	3×10^{-4}
Sulphur Dioxide	2×10^{-4}	2×10^{-4}
Hydrogen	5×10^{-1}	5×10^{-1}
Ozone	2×10^{-2}	1.9×10^{-2}

Source: World Health Organization (2005) and Field Survey

Fuel Combustion in stationery sources gives total emission of 49.9 grams per annum. SOx is 25.5, HC is 0.8, NOx is 11.1, CO is 2.8 and Particulate is 9.6gramms per annum, Table 1 and Figure 3 (b). Transportation and automobiles give total emission of 101.6g, that is, SOx is 0.9g, HC is 18.7g, NOx is 10.4g, CO is 68.8g and particulate is 2.8g; Table 1 and Figure 3 (c). Agricultural and Industrial processes contributed total emission of 58.6gramms. That is 12.4g, 6.8g, 5.6g, 15.8g and 18.0g respectively; Table 1 and Fig 3 (d). Solid waste disposal total emission is 33.2g. The breakdown is 1.4g, 3.9g, 2.6g, 11.8g and 3.1g respectively; Table 1 and Fig 3 (e). Miscellaneous pollutants total emission is 46.5g. This consists of 2.6g of SOx, 10.8g of HC, 5.5g of NOx, 18.8g of CO and the particulates account for 18.8g; Table 1 and Fig. 3 (f).

On the average, the observed composition of air compared to the atmospheric dry air of World Health Organization permissible standard in ppm is as shown in Table 2. Nitrogen is 79.14 x 10^4ppm as against 78.09 x 10^4ppm. The concentration of oxygen is 20.04 x 10^4ppm as against 20.94 x 10^4ppm. Other components show similar variations in concentration except Neon

(18ppm), Krypton (1.0ppm), Xeron (8.10^{-2}ppm), Sulphur-dioxide ($2.\ 10^{-4}$ppm) and Hydrogen ($5x10^{-1}$ppm). Table 2.

There are spatial variations in the concentration of these pollutants. The high density residential areas such as Mushin, Isolo, Agege, Bariga, Apapa Amukoko and Mafolukun in Lagos and Kubwa, Kuje, Lugbe, and Pape at Abuja experience high concentrations than Maitama, Jabi, Gwarimpa, and Asokoro residential areas of Abuja and Ikoyi, Victoria Island in Lagos.

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Again, highest concentrations of particulates were recorded in the dry seasons. Combinations of all pollutants put together reduce the visibilities that have led to cancelation of flights into and out of Abuja, Kano, Port-Harcourt, Sokoto, Maidugiri and Lagos a number of times.

A housewife in one of the residential estates at Abuja has this to say:

> *.... never lived in a city like this before, it can be very hot in the months of February, March to early April.... live and eat with dust .... dust the chairs and tables and mob the floor, go to work/market, before you come, the whole place is covered with heavier dust and particles. You cannot wear a piece of shirt twice neither could you shine (polish) your shoe and wear it two times..... change handkerchiefs every day, wash/dust cars every day.... wet floors morning and evening. In minutes, furniture, files, documents and wares in the offices gather dusts.... cold and catarrh and body irritations are not uncommon. Abuja is a typical city.*

The situations may not be significantly different in other cities and towns of the country particularly during the dry hamattan seasons.

Hospital records show sharp increase in the number of ailments/diseases related to poor quality of air over a period of eight (8) years. Salient among these are cough, sore throat, constriction of the chest, headache, eye irritation, nasal discharge and others. Table 3 and Figure 4 show the hospital records of illness caused by poor air quality at Abuja (2002 -2009). Reported cases of Headache were the largest. It was 1,484 in 2002 but increased to 1,881 in 2009. An increase of 27.43%. Cough was 501 in 2002 but increased to 801 cases (59.88%) over a period of just

Table 3. Hospital records of illness caused by poor air quality at Abuja (2002 – 2009)

Some Representative Symptoms	YEARS 2002	2003	2004	2005	2006	2007	2008	2009
Cough	501	616	601	664	651	736	781	801
Sore Throat	473	530	572	596	582	601	656	666
Constriction Of The Chest	317	284	310	341	411	480	431	455
Headache	1484	1411	1621	1653	1677	1652	1684	1881
Eye Irritation	489	530	640	618	661	733	742	810
Nasal Discharge	553	601	811	864	592	783	779	701
Others (Specified)	210	272	181	306	288	281	298	291

Source: National Hospital, Abuja.

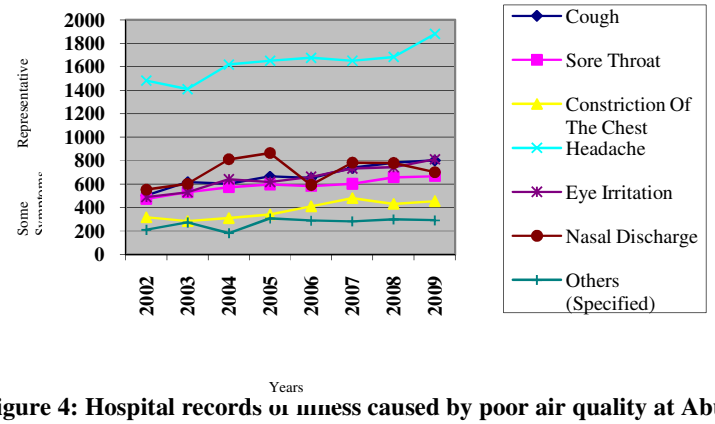

Figure 4: Hospital records of illness caused by poor air quality at Abuja (2002 – 2009)

Source: National Hospital, Abuja

8years. Other cases (Specified) were 210 in 2002, though decreased to 181 (13.81%) cases in 2004, the number shut up to 306 in 2005. That is an increase of 31.37%. Table 3 and Figure 4 are more revealing. Again, there are variations with seasons of the year. Headache and Nasal discharge cases are reported every month with no significant variations. Cough, eye irritation, sore throat and constriction of the chest are reported more during the dry seasons. They are most serious during the cold, dry and hazy harmatan months. Rarely could there be a family of up to five without a member, at least, run nose before the end of the season, every year. The extreme north in particular records worse conditions.

Rainfall and Inclement warmth:

Rainfall, temperature, pressure, Relative Humidity wind direction and speed have established measurements as it is in literature. But Table IV shows the variance from the established average monthly readings of temperature, rainfall and Relative Humidity in Lagos Metropolis. There is no noticeable variation shown for the five years of rainfall in the months of January, February and December. November shows a negative of 0.01mm. Other months of the year show positive variations. The least are 0.11 mm and 0.12 mm in March and April. It is as high as 1.10 mm in June; and 0.91 mm, 0.94 mm, 0.82mm, 0.61 mm and 0.68mm in May, July, August, September and October respectively. The mean variation is 0.44 mm. Similarly, the temperature has shown some positive variations for every month except June and July only, 0.0^{o}C. March experienced the highest, 0.8^{o}C. January (0.4^{o}C), February (0.4^{o}C), and April (0.6^{o}C) similarly experience

Table 5. Average climate variability in selected cities

Months	Rainfall (mm)			Temperature (CO			Relative Humidity (%)		
	Lagos	Kano	Aba	Lagos	Kano	Aba	Lagos	Kano	Aba
January		0.00			+ 0.4			+1.1	
February		0.00			+ 0.4			+1.3	
March		0.11			+ 0.8			+1.6	
April		0.12			+0.6			+3.1	
May		0.91			0.2			+4.2	
June		1.10			0.0			+4.8	
July		0.94			0.0			+4.2	
August		0.87			+0.1			+4.2	
September		0.61			+0.1			+4.1	
October		0.68			+0.2			+4.1	
November		-0.01			+0.2			+3.8	
December		0.00			+0.4			+3.1	
Mean		**0.44**			**+0.3**			**3.4**	

Source: Field Survey

Table VI. Changes in Elements of Micro-Climate around Landfills in Lagos, Kano and Aba.

Element	Average Change		
	Lagos	Kano	Aba
Cloud Cover	2.6%		
Temperature	1.7%		
Air Pressure	-1.1%		
Relative Humidity	4-8%		
Wind Direction	Unnoticeable		
Wind Speed	-2- - 3%		
Visibility	-20 - -30%		
Radiation Intensity	-17- -25%		
Rainfall	Unnoticeable		
Illumination	-12 - -50%		
Gaseous (SO^{+}) Pollutant	10-30%		
Nuclei Solid	21 times		
Solid Dust	35 times		
Organic Bacteria	25-45 times		
Ionization (Total)	8-16 times		
Others	8-20 times		

Source: Filed Survey

positive change from the established figures. The mean is 0.3^{o}C. The mean Relative Humidity is 3.4%. There is no month with negative deviation. It is plus throughout. It is highest in June (4.8%), May (4.2%), July (4.2%), August (4.1%) and October (4.1%). It is lowest only in January, February and March 1.1%, 1.3% and 1.6% respectively. Table 4. More importantly, the so called August break is no longer obvious in the month of August; and neither could the double maxima.

Furthermore, Table 5 shows average change observed in elements of weather and composition of air around three landfills, one each at Lagos, Kano and Aba. The elements noted include cloud cover, temperature, aim pressure, wind direction and speed, rainfall, sun illumination, organic bacteria, ionization (total) and others. Cloud covers increase by 2.6%, temperature by 1.7%, air pressure by 1.1%, and Relative Humidity by 4.8%. Wind speed decreased by -2 - -3%, visibility by -20 - -30%; organic bacteria is 25- 45 times more, nuclei solid is 21 times more and ionization (total) is 8-16 times more. Wind direction and rainfall do not show any noticeable change, but wind speed reduced by -2 - -3%. Table 6.

Table 7. Typical concentrations of particulates and SO_2 in cities and towns.

Community	Particle Concentration ug/m^3	SO_2 Concentration ug/m^3
Amukoko	148	166
Ajegunle	144	201
Itire	127	158
Agege	138	148
Surelere	140	204
Ebute meta	132	142
Oshodi	151	310
Ikoyi	94	119
Yaba	139	211
Ikeja	154	281
Ketu	138	188
Maryland	126	169
Mushin	131	158
Egbeda	128	181
Isolo	129	171
Alapere	131	188
Lagos Island	108	129
Ajah	91	131
Shomolu	134	182
Victoria Island	98	128
Bariga	131	161
Average	135	171

Source: Field Survey/ Lagos State Environmental Protective Agency

Though these variations appear localized to the dumpsite and immediate surroundings, there seemed to be similar situations round the year and at least for average radius of 500-750 meter for each of the several massive landfills across the country.

Again, concentrations of particulates and sulphur dioxide (SO_2) in the dry air, on the average, were found to be 135 ug/m^3 and 171 ug/m^3, respectively. Highest concentrations of particulate were found at Amukoko, Ajegunle, Surulere, Oshodi and Ikeja with 148ug/m^3, 144ug/m^3, 140 ug/m^3, 151 ug/m^3 and 154ug/m^3 respectively. It is lowest at Ikoyi (94 ug/m^3), Lagos Island (108 ug/m^3), Ajah (131 ug/m^3) and Victoria Island (98 ug/m^3). Similarly, the Sulphur dioxide concentration is lowest, less than 150 ug/m^3 at Agege (148 ug/m^3), Ebute Meta (142 ug/m^3), Ikoyi (119 ug/m^3), Lagos Island (129 ug/m^3) and Victoria Island (128 ug/m^3). It is as high as 201 ug/m^3 at Oshodi, 211 ug/m^3 at Yaba, and 281 ug/m^3 at Ikeja. These conditions are favourable for formation of water droplets and acid rains, (Seinfeld et al1998 and Walther et al 2002).

Acid Rain:

The carbon dioxide (CO_2) and water (H_2O) in the air react together to form carbonic acid, but unpolluted rain water also contains other chemicals (Likens, Keene, Driscoll and Buso 1996):

$$H_2O(l) + CO_2(l) \longrightarrow H_2CO_3\,(aqu)$$

Carbonic acid then ionized in water forming ions concentration of hydronium and carbonate ions:

$$2H_2O(l) + H_2CO_3(aqu) \rightleftharpoons CO^{2-}{}_{3(aqu)} + 2H_3O^{+}{}_{(aqu)}$$

Table 8. Selected Locations and dew/fog/rain water with pH Levels in Lagos Metropolis

Locations	pH Readings
Ikeja	3.1
Ilupeju	4.2
Mushin	3.7
Isolo	4.1
Apapa	3.2

Source: Field Survey

Acid deposition as an environmental issue includes additional acid to H_2CO_3.

Occasional pH readings in rain fog and dew water of below 3.8 were observed for industrialized Ikeja (3.1), Ilupeju (4.2), Mushin (3.7), Isolo (4.1) and Apapa (3.2) industrial axis of the metropolis, leading to industrial acid rain. Table 8.

Combustion of fuels creates sulphur dioxide and nitric oxides. They are converted into sulphuric acid and nitric acid (Berresheim, Wine, and Davies, 1995): In the gas phase, sulphur dioxide is oxidized by reaction with the hydroxyl radicals via an intermolecular reaction thus:

$$SO_2 + OH^{\cdot} \longrightarrow HOSO_2^{\cdot}$$

This is followed by

$$HOSO_2^{\cdot} + O_2 \longrightarrow HO_2 + SO_3$$

In the presences of water, sulphur trioxide (SO_3) is converted rapidly to sulphuric acid

$$SO_{3(g)} + H_2O_{(l)} \longrightarrow H_2SO_{4(l)}$$

When clouds are present, the loss rate of SO_2 appears to be faster than can be explained by gas phase chemistry alone. This is due to reactions in the liquid water droplets (Likens, Discoll and Buso, Mitchel, Lovett, Bailay, Siccama, Reiner and Alewell 2002). There are hydrolyses reactions – sulphur dioxide dissolves in water and then, like carbon dioxide, hydrolyses in a series of equilibrium reactions follows:

$$SO_{2(g)} + H_2O \rightleftharpoons SO_2.H_2O$$

$$SO_{2.}\ H_2O \rightleftharpoons H^+ + HSO_3^-$$

Large volumes of traffic, electricity generating plants and facilities, wastes generated from different sources, pollutants and pollutions of the air, water and land, landfills and their poor management and others have resulted in the presence of these oxides, particulates and the reactions.

DISCUSSION

The ozone layer is getting depleted; and the depleting ozone layer in the troposphere is leading to global warming. This will eventually result in remarkable climate change. Global warming and climate change is resulting in drastic departure from the natural environment to man-made. This is characterized by phenomena that are foreign to the system: The higher concentration of pollutants in the air. These impact greatly on sustainability and development throughout the country.

So much particulates and oxides of many elements are in the air that is breathing in. In the dry season, storms stir up dust and sound reducing visibility and causing irritation of the respiratory track. The presence of sulphur dioxide in a dust-laden atmosphere is dangerous to respiratory tract, the lungs and indirectly, the heart.

The physical environment has shown great departure from the known records:

- Physical features e.g. coastal features and other land forms that have changed in shape, size depth and heights. Most of the determined and known height have changed;

- Temperature and pressure on the average do not remain what are in test books and reference materials as temperature is relatively higher on the average days and nights during hot seasons when urban dwellers, drink more (water and other drinks), shower and stay under water for longer period; prefer lighter dresses, seek for cool rooms and/or offices and prefer more ventilated living apartments and offices;

- Vegetations have changed in composition and area extent. Ecosystems and niches are fast changing: aquatic is assuming characteristics of terrestrial types of ecosystem;

- Rainfall, dew and Relative Humidity have shown great departure from what are in texts, reference materials and known (Afolabi, 1973, Iloeje, 1991, Udo, 1982 and Amayah,2003) – rainfall is increasing, relative humidity is decreasing, dew is decreasing and temperature is relatively higher, giving an inclement warmth;

- Rivers and streams carry more loads in wider width and increased volume of water;

- Lengths of some of rivers and streams have increased while others have shortened. There may be no one that will remain the same after several years of existence. Some changed in courses and others have changed in directions of flow;

- Agricultural practices have changed with predominant weather conditions, soil types, high breed crops and new technologies;

- Crop yields have drastically dropped in many cases, new varieties of plants/ crops, birds and animals have been introduced while some are gradually going into extinction;

- Climate change coupled with overgrazing, over cropping and continuous chemical applications, have turned the soil types to “man-made,” and highly impoverish;

- Lakes, ponds and swamps have dried up and a few have retreated; and the seasonality characteristics of the stream and rivers have changed;

- Rocky systems have changed/ reduced in size, height, shape and area extent and some of the metamorphic rocks have further metamorphosed;

- Solid wastes are generated more and the consequences of poor disposal and management have been compounding pollution situations that are also warming the atmosphere and more hazardous to lives and property;

- Dusts are being generated than ever before and these are fast leading to ozone depletion, global warming and climate change. More seriously, cases of lung disease and associated ailments have relatively increased in number;

- Length of seasons (dry/hamatan and wet seasons) have drastically changed and so also the period each lasts;

- The hamatan is particularly too mild but more dusty, and it lasts for shorter period of time;
- New human diseases and ailments are now reported in hospitals and at homes while some have probably gone into extinction and others are exhibiting new symptoms requiring new treatments; and
- Also animals and plant diseases are exhibiting new symptoms and demanding new treatments.

The foregoing has shown drastic departure from the known weather elements and characteristic components of normal air at normal temperature and pressure: inclement warmth and acid rain are becoming obvious. Specifically, there are various symptoms and behaviours of man and other life forms exhibiting these:

- Animals and birds prefer to stay more under shades, look for and drink more water;
- Human being complain more about heat, drink more, and preferably cool drinks;
- Umbrella and sunshades are becoming more popular and useful;
- Residents request for more ventilations in their new building, and offices while old structures are being renovated to provide for better ventilations;
- Though no electricity from national grids to effect cooling of houses and offices, residents were forced by circumstances to buy electricity generating plants and facilities to fan/cool their offices, houses and drinks;
- There have been unbearable stifling humidity that pervaded the atmosphere for weeks and the dense haze has been producing uncomfortable heat and dust in the months of dry seasons;
- Both days and nights are extremely very hot and the temperature become inclement- this is particularly unbearable during hot seasons- December to April. The extreme inclement warmth in March/April of 2010 is what Lagos residents are yet to come to terms with;
- Early rains are more acidic and turbid – wearing dull appearance.
- Sachet water (*pure water*) is now very common and it is taken sporadically and frequently by travellers and traders at the parks, markets and business centres;
- Children now play more with water than they do with sand;
- Relatively, residents of urbanized centres now patronise beaches, (where there are any) restaurants and bars more often to cool off from the hot days and inclement warms of offices and homes;
- More drinks, bear, stout, beverages, soft drinks, chocolates drinks and other are sold and consumed more than ever before;
- Heat related ailments/diseases are reported more often in hospitals for children, adults and aged; and
- Some plant species are going into extinction and others ones are now emerging and aquatic ecosystems are assuming terrestrial attributes.

Adeyemo (2010) writes on Nigerian reservation/conservations; and in particular, that historians tell about a government reservation in Ibadan that was maintained actively in the colonial era:

> *It was the original idea of the colonialists in the 1940s. It stretched from Queen Elizabeth Road to Adeoyo Agbadagbudu area. This area was designed to prevent desert encroachment and for the economic use of the wood, for example, as electric poles. The successive*

> *governments even encouraged the "plant a tree" campaign as a means to keep many areas green and to fight desert encroachment.... Igbo Agala has an exclusive attachment call Bower Tower from where one views the entire city. .... Bower Tower was named after the colonial administrator. It is estimated over. .... over 80 years away. It was illegal to collect firewood from there as it was a reserved area. There were wardens, asogba, at the time whose jobs were to keep the forest free from wood poachers. .... Unfortunately, the forest has since lost its environmental appeals. Successive governments have downplayed the importance of conservation and neglected to look after one of Ibadan's antique treasures. .... is a far cry from what it was designed to be. It has been desecrated. .... There is a new policy whereby the land has been allocated for building of residential areas, social/club house and the new Olubadan of Ibadan's palace is being built in the green belt zone.*

The Igbo Agala, as conceived, was to prevent flooding and erosion, and by extension, to conserve the trees, preserve the animals and serve as massive green area for the ancient city. With this, like most other reservation/conservation areas it is not only Ibadan, but the entire nation (and of course Africa) that has lost one of the environmental appeals and antique treasures. The environmental consequences are far more damaging, gravious and devastating.

Generally, the elevated levels of hydrogen ions low (pH) caused by the emission of compounds of ammonia, carbon, nitrogen, and sulphur react with water molecules in the atmosphere to produce acid; and acid rain.

The smoke stacks, and exhausts of electricity generating plants spew out the basic ingredients of acid rain. These combine with water vapour in the atmosphere and return to the earth's surface in the form of acid rain. This has been taking place for a number of years, but little or nothing has been done about it. The problem is becoming graver. Incidentally, winds carry the acid rain pollutants for long distances, and the pollutants emitted from one community travel to cause serious arm to other communities far away from the source of emission.

Wet deposition of acids have been occurring when any form of precipitation (rain, dew and fog) removes acids from the atmosphere and delivers it to the earth surface, on plants, buildings rocks, and on man and animals. These result from the deposition of acids produced in the raindrops or by precipitation removing the acids either in clouds or below clouds. "Wet removal of both gases and aerosol are both of importance for wet deposition," (Seinfeld and Pandis 1998).

Though unconscious of the magnitude, it is already a threat to lives and property. In the weeks of 28th March, 2010, there were threats of rain and there were frenzied outburst made by residents of Lagos Metropolis as they dash in different directions following the shower that fell in various parts of the metropolis - Ogba, Agege, Mafolukun, Oshodi, Ijesha, Mushin and a few other suburbs of the Metropolis in the south. Within the few minutes of the light shower, all hell broke loose as people scampered from what they feared and earlier been announced as acid rain.

The Chief Executive Officer, European Climate Foundation, Kortenhorst, Jules (2010), for instance, realised the significance of deforestation to global warming, lamented and pointed thus:

> *…… deforestation is somewhere around 18 per cent of total emission. But it is the area where we can most quickly and for relatively little cost, have the biggest impact. And once we cut down a forest, the way back takes thousands of years. …. Reducing Emission from Deforestation and Forest Degradation (REDD) is seen to be a quick and very effective mechanism to reduce emissions …. The logging industry will be heavily affected and in developing countries, this is a big issue.*

Furthermore, he affirm that there is a growing agreement on what a solution to

deforestation can look like among the 15 – 20 countries that really matter in this debate:

"in particular the forest countries and the large developed countries that are willing to put up money to help half deforestation. ….. appreciate the impact on the logging industry. … would we not like to move to sustainable forest instead of the logging that now takes place? It will allow for ongoing export earnings safe guard the rain forest, keep the jobs, but increase the price of hardwood …. it will be a win-win."

Hassan (2010) , a free lance writer in the Daily Trust of Tuesday, September 21, 2010 remarked on Climate Change and food scarcity in Nigeria when he writes:

The impact of climate change on food production is gradually being felt by most rural farmers in the forms of delayed rains, floods, disease outbreaks and the continued degradation of the soil, making it difficult to cultivate crops that will give a bumper harvest. .... The prices of major food commodities such as cereals, onions, garlic, tomatoes, yam and others are therefore expected to shoot up in Nigeria especially due to recent incidences of flood and irregular rainfall that have affected major food .... The growing challenges that climate challenges is posting on food production and ultimately on the final prices of food items in the market means number of individuals that would be affected by hunger may gradually rise except if the challenge is dealt with headlong. ..... erosions, either winds or water as well as floods are becoming a yearly occurrence ..... due to changing climate.

However, adaptation and sustainability on the surface of the earth is a necessity and human race have to work towards these. What must Nigeria and Nigerians do, therefore for adaptability and sustainability?

FOR ADAPTABILITY AND SUSTAINABLE GROWTH AND DEVELOPMENT

Nigeria is part of the world that is being progressively gradually plagued by the global warming and climate change. There are gradual adaptability to the changes; but there may probably come the time when the changes may become unbearable. She is significant to the world in the business of oil and gas, at least. Therefore, sustainability of the physical environment must be ensured:

- drastic and cogent measures must be taken to ensure that electricity is readily available and cheaper for urban dwellers to enable then cool their houses, offices, indoor recreation centres and to prevent heat related diseases such as stroke and measles and for other uses;

- The design and construction of buildings for both commercial and residential purposes must take cognisance of inclement warmth;

- Though the state government has embarked on tree planting, this should be intensified, encouraged and supported by all tiers of government, individuals, corporate bodies and philanthropies. The government could institute a programme to be titled "A family, a tree Project", and in the same spirit, old abandoned forests must be resuscitated by replication;

- Water is life, sanitation is dignity: there must be concerted efforts to make potable water readily available for cooling, bathing, washing, drinking, recreation and production processes; and for sanitation so as not to compound the inclement warmth;

- Industrial, vehicular and domestic activities leading to air pollutants and pollutions, depleting ozone layer and also resulting in acid rain must be further comprehensively studied towards reducing it from sources. The developed world is targeting zero emission, Nigeria should join the raise;

- Following from above, Nigeria should pass a bill that will be very decisive on emission, and target zero emission by 2015;

- The resources for environmental sustainability should be given very serious priority and in turn;

- Environmental education should be given high priority in schools' circular and at the adult and non-formal levels of education; and

- Environmental Impact Assessment and certification of every project, be it government or non-governmental, must be carried out without prejudice.

  There was an agreement that was reached between nine European nations and Canada during a meeting held in Ottawa in 1984 calling for reduction of Sulphur oxides by at least 30% within ten years. Similar agreement should be reached between the governments of Nigeria and those of other West African countries particularly the neighboring countries to adopt similar measures. Also, and with the immediate effect:

- There must be Environmental Impact Assessment of every human activity carried out and certified by the appropriate government agencies, and Federal Government Environmental Protection Agency has a great role to play;

- Concerned city development authorities and estate developers in particular should not allow cropping, burning and grazing in the adjacent and nearby vacant lands around cities and towns;

- Campaign and incentives for shifting to efficient and high-energy laden fuels by government and government agencies is imperative;

- There must be Clean Air Act that must be passed into law. It will have far reaching effects on control of ozone depletion. Emission for automobiles will be drastically reduced. The real culprit in smog formation will also be substantially reduced;

- Behavioural changes in residents should be encouraged to reduce if not completely give-up burning of bush, grasses and incense during prayers, mosquito coils and others; and

- Environmental education should become parts of syllabuses at every level of education in Nigeria.

Undoubtedly, adaptation to climate change is imperative. Every factor leading to adaptation of these phenomena will go beyond technical, political or economic to the socio-cultural and perpetual. Therefore, there must be sufficient awareness through community heads, school programmes, environmental education in adult and non-formal education, and advertisements, campaigns, jingles on radio and television; newspaper and magazine publications and others should be used. All of these and more others should be directed at influencing the behaviour of the citizens and others towards zero emission.

Global warming and climate change are not localized to Nigeria. There is no other nation or territory or region that Nigeria and Nigerians will migrate to and inhabit. The seriousness of global warming and climate change could be disturbing and drastically lead to unsustainable development. The situations must be nipped in the bud; and the governments and people of Nigeria must wake up to the responsibilities of challenging global warming and climate change.

Above all, governments must make effort to reduce the production of oxides and particulate into the atmosphere. Whatever could lead to acid rain within and around the metropolis need to be prevented as the effects of acid rain can last for generations: The effects of pH level change can stimulate the continued leaching of undesirable chemicals into otherwise pristine water sources; killing of vulnerable insects and fishes; and blocking efforts to restore native life.

A number of international treaties on the long range transport of atmospheric pollutants have emerged and agreed, for example, Sulphur Emission Reduction Protocol under the Convention on Long-Range Transboundary Air Pollution. Government of Nigeria can apply to be part of such bodies and their policies and programmes.

There are now emission trading. In the regulatory scheme, every current polluting facility is given, or may purchase on an open market, an emission allowance for each unit of a designated pollutant it emits. Operators can then install pollution control equipment, and sell portions of the emission allowance they no longer need for their own operations, thereby recovering some of the capital cost of their investment in such equipment. The intention will be to give operators economic incentives to install pollution controls.

CONCLUSION

The paper has established that Nigeria is not an island from the rest of the world. Environmental quality is getting deteriorated. The impact of global warming and climate change is gradually being experienced as it is in other parts of the world. The nation that is fast growing will likely experience more industrial and other urban activities that will result in additional air pollution, poor air quality and thus facilitate warming that will be unsustainable. There must be environmental education that should dwell on ozone layer, global warming, climate change and their consequences in the processes of man-environment interaction. The challenges of depleting ozone layer, global warming and climate change for sustainable development will indirectly or directly aggravate the endemic problems of unemployment, kidnapping, AID, power failure, corruption, poor road network, religious and political violence, child labour, killings and rituals, pipeline vandalism, dilapidating economic system, unsecured educational system and others plaguing the nation if not quickly nip at the board and/or work out modality for adaptation by man, animals and plant species.

Environmental Impact Assessment (EIA) of every activity must be determined before the commencement of such activity. The results of such assessment should give input into the planning and forecasting for sustainable environment of air, water, land and others.
Every stakeholder, government, non-governmental organization (NGOs) politician and philanthropy has to work in collaborative efforts to reduce the adversities of global warming and climate change. Globally, and specifically for Nigeria, there must be massive and focused research efforts into air quality to ensure sustainable environment for sustainable development.

Research and development should be intensified and focused on global warming and its effects. In particular, Nigeria and Nigerians should be identified with ozone recovery as some other nations of the world. The importance of green is enormous in an age of global warming. As the cities and towns are expanding with multiplicity of functions and land use, more has to be consciously done to build parks and create open spaces for recreation and relaxation and for the purpose of “green.” Incidentally, it is only governments that can take decisive measures to plan and build conservation areas. Governments must stand firm and committed to these challenges and responsibilities.

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