ERGONOMIC AUDIT OF HEAT AND NOISE POLLUTION IN RELATION TO OIL EXPLOITATION IN THE SOUTH- SOUTH REGION OF NIGERIA (A CASE STUDY OF IBENO ONSHORE GAS FLARING STATION AKWA IBOM STATE)

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

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DECLARATION

I, hereby declare that this research thesis "Ergonomic Audit of Heat and Noise Pollution In Relation To Oil Exploitation in the South- South Region of Nigeria (A Case Study of Ibeno Onshore Gas Flaring Station, Akwa Ibom State)" was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information hereby obtained from published and unpublished work of others has been duly referenced and acknowledged in the text.

.... 17/02/2010

Ekpa Victoria Bassey Date

CERTIFICATION

This is to certify that "Ergonomic Audit of Heat and Noise Pollution in Relation to Oil Exploitation in the South- South Region of Nigeria (A Case Study Of Ibeno Onshore Gas Flaring Station, Akwa Ibom State)" by Ekpa Victoria Bassey meets the regulations governing the award of the degree of Bachelor of Engineering (B.Eng) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific and engineering knowledge as well as well as literary presentation.

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External Supervisor	9/2/2010 Date

DEDICATION

This is for the gift of life, and for all who seek to preserve it. To God be the glory.

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ABSTRACT

This project is aimed at promoting workplace safety of engineers and technologists. In addition to having an awareness, safety measures and precautions are necessary. The staffs were observed to be compliant with the safety clothing requirements. The environmental conditions assessed were heat, measured by atmospheric temperature and noise levels in the vicinity of the onshore gas flaring station. The peak Sound Pressure Level (SPL_{max}) was used. The highest (SPL_{max}) value recorded around the gas flare area is 86dbA. It is within the 90dBA limit given by the Federal Ministry of Environment (FMENV). The atmospheric temperatures measured did not show a direct variation with the distance from the gas flare but with the altitude. The highest temperature recorded around the gas flare is 28°C. This is higher than the monthly average of two of the preceding years. Without quantifying the direct contributions of the gas flare to atmospheric temperature, the temperature difference maybe described as climatic variation.

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CHAPTER ONE

1. Introduction

1.1 Background of the Study

The concentrations of greenhouse gases were relatively stable, during the past 10,000 years. The Earth's temperature and climate was also stable. During this time, humans developed civilization and learned how to build cities, grow food, and invent machines.

It is possible that early farming and forest clearing had a warming effect on the earth beginning five thousand to eight thousand years ago. There are also a few examples of natural temperature shifts, such as the Medieval Warm Period, which was followed by the Little Ice Age in the fifteenth to eighteenth centuries. These were possibly not global in extent, and there is scientific disagreement over their causes which seem to have included periods of solar radiation increase and decrease as well as volcanic eruptions.

During the Industrial Revolution, in the early 17th century, people began to use coal and, later, petroleum, to supply heat in cities and run machines. CO_2 in the atmosphere, a by-product of burning both coal and oil, began to increase. Since then, CO_2 levels have risen by almost 35 %, methane concentrations (coming from rice fields, cattle, landfills, and leaks of natural gas) have more than doubled, and nitrous oxide concentrations (another by-product of oil) have gone up by about 15 %. Some chemicals invented by humans, like chlorofluorocarbons (CFC's), are also greenhouse gases. Increased greenhouse gases mean more heat is kept in the atmosphere. This led to a rise in both ocean and air temperature, at the end of the late 1800s. Between then and 1945, world temperature rose but then leveled off and even decreased a little through the 1960s.

The recent increase in atmospheric CO_2 is 200 times as great as any previous change known and the current level is 385 parts per million, the highest seen in 800,000 years of deep glacier ice core records. It shows no signs of decreasing. Since the 1970s, atmospheric heat has been rapidly increasing. Whereas the average temperature of the planet rose about 1°F (0.6°C) between the mid-nineteenth century and the end of the twentieth, in the past twenty-five years alone the temperature has risen just over 0.8°F (0.5°C). (The last ice age would have ended in only four hundred years—instead of many thousands—at this rate of heating.) The total heating from the late nineteenth century to 2005 is 1.4°F (0.8°C) (Wikipedia 2009).

These increases have a giant effect on weather, climate zones, plants and animals, sea life, glaciers and river flow. In response, our planet has been changing with warming winds and rising seas. At the poles and in mountains, ice is melting and glaciers are receding. Arctic sea ice reach the smallest summer extent ever recorded in the past few years. Even in Antarctica, where winter sea ice has been larger in extent recently, it melts back much more than before in the summers, affecting the food supply of whales and penguins. The planet has heavier downpours now but also deeper droughts. Down into the temperate zone, change is rearranging the boundaries of life. The plants and animals with which we share the planet are adapting and migrating, some even going extinct, because they have no choice.

The six billion humans on earth are also being affected by climate change. Coastal towns are suffering from rising sea levels, storms are getting more intense. 35,000 people died in European heat waves in 2003. However, we have choices to make to help correct and ameliorate global warming.

1.2 Statement of the Problem

Excessive burning of fossil fuels is the primary cause of global warming. The common term used to qualify the excessive burning of gas, especially by oil companies, is "gas flaring." The UN Conference on Environment and Development also concluded that the Niger Delta is a home to coastal rainforest and mangrove habitats and is considered "the most endangered river delta of the world.

1.3 Objectives of the project

- To determine the heat and noise levels associated with gas flaring at Ibeno , Qua Iboe terminal (QIT),
- To assess the working environment in the vicinity of the gas flare,
- To show the possible human health risks and environmental impacts,
- To show the need for safety measures, preventive, as well as predictive measures in the oil and gas industry.

1.4 Environmental Pollution

Environmental pollution is "the contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected" (Kemp, 1998).

"Pollution is the introduction of contaminants into the environment that cause harm or discomfort to humans or other living organisms, or that damage the environment" which can come "in the form of chemical substances, or energy such as noise, heat or light". "Pollutants can be naturally occurring substances or energies, but are considered contaminants when in excess of natural levels" (Wikipedia 2008).

Pollution is "the addition of any substance or form of energy (e.g., heat, sound, and radioactivity) to the environment at a rate faster than the environment can accommodate it by dispersion, breakdown, recycling, or storage in some harmless form" (Encyclopaedia Britannica, 2007).

Pollution is any undesirable degradation of the environment, be it natural or man-made. Waste is any undesirable substance accumulated as a result of utilising the resources in the environment. One of the steps toward environmental sustainability is to minimise both waste and pollution. A strain on the environment is population growth. This will greatly affect the future demand for energy and also increase the rate of pollution (Deju 1990).

1.4.1 Types of Environmental Pollution

There are three major types of environmental pollution:

- Air pollution
- Water pollution
- Soil pollution (contamination)

Some of the most important air pollutants are sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, volatile organic compounds (VOCs) and airborne particles, with radioactive pollutants probably among the most destructive ones (specifically when produced by nuclear explosions).

Water pollutants include insecticides and herbicides, food processing waste, pollutants from livestock operations, volatile organic compounds (VOCs), heavy metals, chemical waste and others.

Some soil pollutants are: hydrocarbons, solvents and heavy metals.

1.4.2 Sources of Environmental Pollution

1.4.2.1Fossil Fuel Sources

Fossil fuels are used for our obvious everyday needs (such as filling a car), as well as in the power-generating industry, they (specifically oil) are also present in such products as all sorts of plastics, solvents, detergents, asphalt, lubricating oils, a wide range of chemicals for industrial use, etc. (Wikipedia 2008). Fossil fuels also contribute to soil contamination and water pollution. Combustion of fossil fuels produces extremely high levels of air pollution. Fossil fuels also contribute to soil contamination and water pollution (Wikipedia 2008).

Common sources of fossil fuel pollution are:

(a)Industry:

- Power-generating plants

- Petroleum refineries
- Petrochemical plants
- Production and distribution of fossil fuels
- Other manufacturing facilities

(b)Transport:

- Road transport (motor vehicles)
- Shipping industry
- Aircraft

1.4.2.2 Other (Non-Fossil Fuel) Sources of Environmental Pollution

(a)Agriculture

Agriculture is worth mentioning as the largest generator of ammonia emissions resulting in air pollution. Chemicals such as pesticides and fertilizers are also widely used in agriculture, which may lead to water pollution and soil contamination as well.

(b)Trading activities

Packaging of products sold in supermarkets and other retail outlets is far too excessive and generates large quantities of solid waste that ends up either in landfills or municipal incinerators leading to soil contamination and air pollution.

(c)Residential sector

Domestic waste is another significant source of pollution generating solid municipal waste that may end up in landfills or incinerators leading to soil contamination and air pollution.

1.4.3. Effects of Environmental Pollution

Contact with contaminated soil may be direct (from using parks, schools etc) or indirect (by inhaling soil contaminants which have vaporized). Soil contamination may also result from secondary contamination of water supplies and from deposition of air contaminants (for example, via acid rain). Contamination of crops grown in polluted soil brings up problems with food security. Many effects of soil contamination appear to be similar to the ones caused by water contamination.

1.4.3.1 Environmental Pollution Effects on Humans

The following effects of environmental pollution on humans have been reported:

(a)Air pollution Effects

Reduced lung functioning, irritation of eyes, nose, mouth and throat, asthma attacks, respiratory symptoms such as coughing and wheezing, increased respiratory disease such as bronchitis, reduced energy levels, headaches and dizziness, disruption of endocrine, reproductive and immune systems, neurobehavioral disorders, cardiovascular problems, cancer, and premature death. (Colls, 2002)

(b)Water pollution Effects

The following waterborne diseases are caused by polluted drinking water: Typhoid, Amoebiasis, Giardiasis, Ascariasis, Hookworm.

The following waterborne diseases caused by polluted beach water: Rashes, ear ache, pink eye, Respiratory infections, Hepatitis, encephalitis, gastroenteritis, diarrhoea, vomiting, and stomach aches.

The following conditions are related to water polluted by chemicals (such as pesticides, hydrocarbons, persistent organic pollutants, heavy metals etc): Cancer, incl. prostate cancer and non-Hodgkin's lymphoma, Hormonal problems that can disrupt reproductive and developmental processes, Damage to the nervous system, Liver and kidney damage, Damage to the DNA.

Also, water pollution may also result from interactions between water and contaminated soil, as well as from deposition of air contaminants (such as acid rain). Damage to people may be caused by fish foods coming from polluted water (a well known example is high mercury levels in fish). Damage to people may be caused by vegetable crops grown / washed with polluted water. (Grinning Planet 2006)

(c) Soil contamination Effects

Soil contamination causes: cancers including leukaemia, neuromuscular blockage as well as depression of the central nervous system, headaches, nausea, fatigue, eye irritation and skin rash.

Lead in soil is especially hazardous for young children causing developmental damage to the brain.

Mercury can increase the risk of kidney damage; cyclodienes can lead to liver toxicity. (Wikipedia 2008)

1.4.3.2 Environmental Pollution Effects on Animals

(a)Air Pollution Effects

Acid rain (formed in the air) destroys fish life in lakes and streams. Excessive ultraviolet radiation coming from the sun through the ozone layer in the upper atmosphere which is eroded by some air pollutants may cause skin cancer in wildlife. Ozone in the lower atmosphere may damage lung tissues of animals. (Gardiner, 2006)

(b)Water Pollution Effects

Nutrient pollution (nitrogen, phosphates etc) causes overgrowth of toxic algae eaten by other aquatic animals, and may cause death; nutrient pollution can also cause outbreaks of fish diseases. Chemical contamination can cause declines in frog biodiversity and tadpole mass. Oil pollution (as part of chemical contamination) can negatively affect development of marine organisms, increase susceptibility to disease and affect reproductive processes; can also cause gastrointestinal irritation, liver and kidney damage, and damage to the nervous system. Mercury in water can cause abnormal behaviour, slower growth and development, reduced reproduction, and death. Persistent organic pollutants (POPs) may cause declines, deformities and death of fish life. Too much sodium chloride (ordinary salt) in water may kill animals. (Kopaska- Merkel 2000).

(c)Soil Contamination Effects

Soil contamination can alter metabolism of microorganisms and arthropods in a given soil environment; this may destroy some layers of the primary food chain, and thus have a negative effect on predator animal species. Small life forms may consume harmful chemicals which may then be passed up the food chain to larger animals; this may lead to increased mortality rates and even animal extinction. (Wikipedia 2008)

1.4.3.3Environmental Pollution Effects on Trees and Plants

(a)Air Pollution Effects

Acid rain can kill trees, destroy the leaves of plants, can infiltrate soil by making it unsuitable for purposes of nutrition and habitation. Ozone holes in the upper atmosphere can allow excessive ultraviolet radiation from the sun to enter the Earth causing damage to trees and plants. Ozone in the lower atmosphere can prevent plant respiration by blocking stomata (openings in leaves) and negatively affecting plants' photosynthesis rates which will stunt plant growth; ozone can also decay plant cells directly by entering stomata. (Gardiner, 2006)

(b)Water Pollution Effects

Water pollution may disrupt photosynthesis in aquatic plants and thus affecting ecosystems that depend on these plants (Wikipedia 2008). Terrestrial and aquatic plants may absorb pollutants from water (as their main nutrient source) and pass them up the food chain to consumer animals and humans. Plants may be killed by too much sodium chloride (ordinary slat) in water (Kopaska-Merkel, 2000). Plants may be killed by mud from construction sites as well as bits of wood and leaves, clay and other similar materials (Kopaska-Merkel 2000). Plants may be killed by herbicides in water; herbicides are chemicals which are most harmful to plants (Kopaska-Merkel 2000).

(c)Soil Contamination Effects

Soil contamination may alter plant metabolism and reduce crop yields (Wikipedia 2008). Trees and plants may absorb soil contaminants and pass them up the food chain.

1.4.3.4Environmental Pollution Effects on Wider Environment

Apart from destroying the aquatic life in lakes and streams, acid rain can also corrode metals, damage surfaces of buildings and monuments, and cause soil acidification.

Pollution of water may cause oxygen depletion in marine environments and severely affect the health of whole ecosystems (Wikipedia 2008).

1.5 Crude Oil and Natural Gas

Crude oil is a mixture of comparatively volatile liquid hydrocarbons (compounds composed mainly of hydrogen and carbon with some nitrogen, sulphur, and oxygen) that occurs in the Earth's crust and is extracted for use as fuel and various petroleum products. Because crude oil is a mixture of widely varying constituents and proportions, its physical properties also vary widely. For example, the specific gravity, as measured on the American Petroleum Institute (API) gravity scale, may range from 10° to more than 60° and the colour from colourless to black.

Crude oil occurs underground, at various pressures from tens to hundreds of kilograms per square centimetre depending on the depth. Because of the pressure, it contains considerable natural gas in solution. The oil underground is much more fluid than it is on the surface, because the elevated temperatures there (on the average, the temperature rises 1° C for every 33 m [108 feet] of depth) decrease the viscosity.

Natural gas is a colourless, highly flammable gaseous hydrocarbon consisting primarily of methane and ethane. It is a type of petroleum that commonly occurs in association with crude oil. Natural gas, often found dissolved in oil at the high pressures existing in a reservoir, can be also present as a gas cap above the oil. Such natural gas is known as associated gas. There are also reservoirs that contain gas and no oil. This gas is termed non-associated gas.

1.6 Extraction of Oil and Gas

Petroleum is a naturally occurring hydrocarbon material that is believed to have formed in deep sedimentary beds from animal and vegetable debris. Petroleum may exist in gaseous, liquid, or near-solid phases either alone or in combination. The liquid phase is commonly called crude oil, while the more solid phase may be called bitumen, tar, pitch, or asphalt. When these phases occur together, gas usually overlies the liquid, and the liquid overlies the more solid phase.

Large platforms are built on the continental shelf. Wells are drilled and the extracted oil or gas is transported to the seashore by pipelines or stored in large floating reservoirs. Associated gases are:

- Transported by pipelines
- Re-injected into the oil bearing bed
- Processed at the platform (expensive but desirable from the environmental point of view).
- Flared (current practice but dangerous for platform equipment and causes air pollution problems).
- Burnt under the sea in special devices (new technology).

Pressurised gas is transported over long distances by pipes of diameter 1,420 approx., buried about 1m deep especially when crossing arable land. Sectionalising valves are provided every 30km, and compressor stations (gas turbines) needed every 100km (UN Economic Commission for Europe 1979).

1.7 Gas Flaring in the Niger Delta

The Niger Delta is Nigeria's largest wetland region and is the third largest wetland in the world. It covers over 70,000 square kilometers between latitude and longitude $4^{o}15^{'}$N, $5^{o}25^{'}$E and $4^{o}50^{'}$N, $7^{o}37^{'}$ E respectively. It is characterized by extensive interconnectivity of creeks, deltaic tributaries, flood plains, mangrove swamps and other coastal features. The Niger Delta has been declared a key zone for the conservation of the Western Coast of Africa on the basis of its extraordinary biodiversity. It harbors a large family and species of wildlife, especially important and fascinating variety of birds, some of which are endemic to Nigeria. Birds species recorded in Nigeria include about 940 species, of which 4 are endemic and 5 are rare or accidental (Wikipedia, 2007).

The production of oil, discovered in the Niger Delta 40 years ago, is having a devastating effect on Nigeria's largest wetland region. Oil production began in the Niger Delta about 45 years ago and so did the practice of flaring associated gas. The development of the oil industry continued during the 16 years Nigeria spent under military rule, and Nigeria has become a major source of oil for the developed world.

Today, Nigeria is Africa's largest oil producer and 11^{th} world largest. Oil exploration and exploitation activities has resulted to frequent oil leaks in the Niger delta, amounting to thousands of barrels of oil been spilled into the environment. Petroleum products released into the environment have an enormous impact on everything from animals to plants to people.

Flaring natural gas from oil fields as a by-product of crude oil production is also a common sight that dominates the skyline in the Niger Delta. It is the most visible impact of the oil industry on daily life. More gas is flared in Niger delta Nigeria than anywhere else in the world and this placed Nigeria as the world's biggest in gas flaring. Currently, there are more than 100 gas flaring sites," wrote Mr. G.G. Darah, a Nigerian commentator, in the Lagos-based *Guardian* newspaper, some of them have been burning ceaselessly for 40 years. The flares have contributed more greenhouse gases than all of sub-

Saharan Africa combined (Friends of the Earth, 2004). This has contributed to climate change, the impacts of which are already being felt in the region with food insecurity, increasing risk of disease and the rising costs of extreme weather damage. The flares also contain widely-recognized toxins, such as benzene, which pollute the air. Local people complain of respiratory problems such as asthma and bronchitis. According to the US government, the flares contribute to acid rain and villagers complain of the rain corroding their buildings. The particles from the flares fill the air, covering everything with a fine layer of soot. Local people also complain about the roaring noise and the intense heat from the flares.

No comprehensive study is known to have been carried out into the impacts of gas flaring and oil spillage on wildlife in the Niger Delta. However, communities firmly believe that the flaring and oil spills has led to very serious pollution of air and drinkable water, destruction of flora and fauna, destruction of properties and lives and has also caused regional crisis in the area.

Even in the absence of such a study, however, it is clear that flaring and oil spills harms people, wildlife and the environment. Whether intentional or accidental, large or small, oil spill and gas flaring have the potential to cause tremendous and far-reaching damage to wildlife, especially birds. Some may experience subtle changes in behaviours or short-term health problems; some may suffer immediate acute toxic effects and even die, whilst others may show the effects in the long-term depending on the route, duration and concentration of exposure.

1.8 Environmental Legislation in Nigeria

1.8.1 Main Statutes and Regulations Relating to the Environment

The major laws on the environment in Nigeria are:

- The National Environmental Standards and Regulations Enforcement Agency Act 2007 (NESREA Act);
- The Environmental Impact Assessment Act (EIA Act); and
- The National Oil Spill Detection and Response Agency Act2005 (NOSDRA Act).

The NESREA Act repealed the Federal Environmental Protection Agency Act (FEPA Act) and established the National Environmental Standards and Regulations Enforcement Agency (NESREA).The Agency has responsibility to enforce compliance with environmental standards, regulations, rules, laws, policies and guidelines. NESREA is also responsible for the protection and development of the environment, biodiversity conservation, sustainable development and the development of environmental technology.

The different states of the federation have also enacted environmental laws that are largely tailored to address their specific environmental challenges.

The major cross-sectoral regulator of the environment in Nigeria is the Federal Ministry of Environment (FMENV). However, NESREA is tasked with the responsibility of enforcing environmental standards for all sectors, except the petroleum sector. State environmental protection agencies (SEPAs) are involved in environmental regulation and monitoring in the states, within the area of competence allotted to them under the Constitution.

There are sector-specific regulators that monitor and enforce environmental regulations and standards. For instance, the Department of Petroleum Resources sets guidelines and standards for the petroleum industry in Nigeria.

There are concerted efforts, spearheaded by the FMENV, between the federal and state governments to harmonize all environmental regulations in Nigeria. To this end, there is an ongoing review of the National Policy on the Environment, focused on bringing the Nigerian environmental regime in line with global trends and the Millennium Development Goals (MDGs).

As at August 2007, the Nigerian Environmental Management Bill was being drafted. The bill, when enacted into law, will change the administrative structure of the environmental sector in Nigeria.

1.8.2 Main Features of Rules Governing Air Emissions

The NESREA Act and its subsidiary regulations prohibit the discharge of hazardous substances into the air. The Act empowers the NESREA to set air quality standards for human, animal or plant health, to control the concentration of substances in the air, to set standards for effluent discharges into the air and to develop the most appropriate means to prevent and combat various forms of atmospheric pollution. Pursuant to the NESREA Act, the National Effluent Limitations and Gaseous Emission Guidelines were developed for certain industries.

No industry or person is allowed to release any gaseous waste into the atmosphere without proper monitoring and authorization from the relevant government agencies charged with environmental protection. Such industries must install anti-pollution equipment for the detoxification of their gaseous effluent and chemical discharges. Such anti-pollution equipment shall meet the best available technology (BAT), or best practical technology (BPT) or the uniform effluent standards (UES).

Industries or persons generating gaseous waste must obtain permits for their operations. In addition, they are required to report on and obtain permits for their environmental management systems and waste management and disposal methodology.

Most associated gas produced in Nigeria in the process of petroleum production is flared. To reduce the level of flaring, the government enacted the Associated Gas Re-Injection Act to compel every company producing oil and gas in Nigeria to submit preliminary programs for gas reinjection and detailed plans for its implementation. Producers elected to continue flaring gas and pay the penalties prescribed under the Act.

Recently, however, a combination of the government gas flare-out policy and the opportunities presented to non-annex-I countries under the United Nations Framework Convention on Climate Change (UNFCCC) is encouraging project proponents in the oil and gas and other sectors in Nigeria to develop projects that will earn additional revenue through emissions trading.

1.8.3 Rules Governing Noise

The NESREA is responsible for identifying major noise sources and establishing noise abatement programs and noise emission standards as may be necessary to preserve and maintain public health or welfare. Further to this responsibility, the NESREA has recommended that noise exposure limits for workers should not exceed 90dBA daily for an eight-hour working period.

1.8.4 Specific Provisions Made for Climate Change

Nigeria has signed and ratified at least 40 international treaties on the environment. These include the UN Convention on the Law of the Sea (1982), the Convention to Combat Desertification (1994), the UN Framework Convention on Climate Change (1992) and the Kyoto Protocol (1997).

Nigeria ratified the Kyoto Protocol in December 2004. As a non -annex-I country, it has made no specific commitment other than to cooperate with the process, particularly by assisting with the monitoring and measuring of greenhouse emissions.

Under Nigerian law, it is necessary to incorporate a treaty into domestic legislation before it can have the full force of law. Environmental international treaties are signed and ratified by Nigeria but, in almost all cases, they are yet to be implemented into the laws of Nigeria, although section 12 of the Constitution provides for this process. The effect of the non-implementation of such treaties is that courts in Nigeria may not enforce them.

1.9 Effects of Exploitation of Oil and Gas on Agriculture

(a) **Air Pollution**: Combustion products of flared associated gases and in the case of oil spills, evaporation of lighter hydrocarbon fractions.

(b) **Water Pollution**: Rare and small oil spills may be overcome through bacterial degradation. Large oil spills have impact on marine flora and fauna and on fishes. Brines diluted in seawater have ecological effect on marine communities.

(c) **Land Use:** Limited land use restrictions (proximity of buildings and trees). Tree planting is not allowed 3m on either side of pipelines.

(d) Noise: Noise is emitted from regulating, metering, and compressor stations (exhausts, air intake, engines, and compressors) of about 80-90db. Compressors stations in rural areas should not exceed 35-40db (UN Economic commission for Europe, 1979).

1.10 Heat

Heat is the energy that is transferred from one body to another as the result of a difference in temperature. If two bodies at different temperatures are brought together, energy is transferred i.e. heat flows—from the hotter body to the colder. The effects of this transfer of energy usually, but not always, is an increase in the temperature of the colder body and a decrease in the temperature of the hotter body. The important distinction between heat and temperature (heat being a form of energy and temperature a measure of the amount of that energy present in a body) was clarified during the 18th and 19th centuries.

The two units of heat most commonly used are the calorie and the British thermal unit (BTU). The calorie (or gram-calorie) is the amount of energy required to raise the temperature of one gram of water from 14.5° to 15.5° C; the BTU is the amount of energy required to raise the temperature of one pound of water from 63° to 64° F. One BTU is approximately 252 calories. The calorie used in measuring the energy content of foods is the large calorie, or kilogram-calorie, equal to 1,000 gram-calories.

1.11 Noise

Noise is unwanted sound. Sound is physically a rapid alteration of air pressure above and below atmospheric pressure, which can be detected by the human ear. However, it can also be a change in water pressure or any other pressure-sensitive medium. The difference between noise and sound is in the perception of the person hearing it.

The word "noise" comes from the Latin word nausea meaning "seasickness", referring originally to nuisance noise. Industrial noise is usually considered mainly from the point of view of environmental health and safety, rather than nuisance as sustained exposure can be very harmful. Since noise is a sound, technical terms are expressed in terms of sound.

1.12 Justification

Crude oil exploitation is causing damage to the environment (both the natural environment and the built environment), with man being an integral part of both. The social or environmental demerits by far outweigh the economic gains. The health and safety hazards involved put those who work and live in oil producing areas at great risk.

The concept of sustainability has grown out of the need to reconcile conflicts between economic development and the conservation of the environment. The 1987 Brundtland Commission on Environment and Development defined sustainable development as 'development that meets the needs of the present, without compromising the ability of future generations to meet their own needs' (Encarta 2008). The ideal of sustainable development is not confined to agriculture, but agriculture is an important part of it.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 The Environment

The natural environment, commonly referred to as the environment is a term that encompasses all living things occurring naturally on earth. The environment is composed of:

(a) Complete ecological units that function as natural systems without human intervention, including all vegetation, animals, microorganisms, soil, rocks, atmosphere and natural phenomena that occur within their boundaries.

(b) Universal natural resources and physical phenomena that lack clear-cut boundaries, such as air, water, and climate, as well as energy, radiation, electric charge, and magnetism, not originating from human activity.

As such, the environment is a huge pool of resources that helps us satisfy our needs and fulfil our wants. It is dynamic and responds to changes in natural processes. The study of the environment is an interdisciplinary task, though areas of concern may differ. (Deju, 1990)

It is the common understanding of the natural environment that underlies environmentalism — a broad political, social, and philosophical movement that advocates various actions and policies in the interest of protecting what nature remains in the natural environment, or restoring or expanding the role of nature in this environment. While true wilderness is increasingly rare, wild nature (e.g., unmanaged forests, uncultivated grasslands, wildlife, wildflowers) can be found in many locations previously inhabited by humans (Wikipedia 2008).

2.2 Relationship between Environmental Engineering and Agricultural and Bio-Resources Engineering

Environmental engineering (Reible,1998; Mihelcic,1999) is the application of science and engineering principles to improve the environment (air, water, and/or land resources), to provide healthy water, air, and land for human habitation and for other organisms, and to remediate polluted sites. Environmental engineering involves water and air pollution control, recycling, waste disposal, and public health issues as well as a knowledge of environmental engineering law. It also includes studies on the environmental impact of proposed construction projects. Some consider environmental engineering to include the development of sustainable processes.

Environmental engineers conduct hazardous-waste management studies to evaluate the significance of such hazards, advise on treatment and containment, and develop regulations to prevent mishaps. Environmental engineers also design municipal water supply and industrial wastewater treatment systems(Beychok,1967; Tchobanoglous, 2003) as well as address local and worldwide environmental issues such as the effects of acid rain, ozone depletion, water pollution and air pollution from automobile exhausts and industrial sources(Turner, 1994, Beychok, 2005). Briefly speaking, the main task of environmental engineering is to protect public health by protecting (from further degradation), preserving (the present condition of), and enhancing the environment.

Environmental engineering emphasizes several areas: process engineering, environmental chemistry, water and sewage treatment (sanitary engineering), waste reduction/management, and pollution prevention/cleanup. Environmental engineering is a synthesis of various disciplines, incorporating elements from the following:

- Agricultural engineering
- Biology
- Chemical engineering
- Chemistry
- Civil engineering
- Ecology
- Geography
- Geology
- Mechanical engineering
- Public health

2.3 Natural Resources

Natural resources are derived from the environment. A natural resource is often characterized by amounts of biodiversity existent in various ecosystems. Natural resources (economically referred to as land or raw materials) occur naturally within environments that exist relatively undisturbed by mankind, in a natural form. The earth provides water, food, energy and minerals. Energy, commonly defined as the ability to do work, is the source of power. Natural energy sources include: direct solar energy, hydro-energy, sea currents, geothermal energy, petroleum, natural gas, coal, nuclear energy, bio-energy, and fermentation of waste (assisted by photosynthetic bacteria). Many of them are essential for our survival while others are used for satisfying our wants (Deju *et al,* 1990).

Natural resources may be further classified in different ways.On the basis of origin, resources may be divided into:

i) **Biotic** - Biotic resources are the ones which are obtained from the biosphere. Forests and their products, animals, birds and their products, fish and other marine organisms are important examples. Minerals such as coal and petroleum are also included in this category because they were formed from decayed organic matter.

ii) **Abiotic** - Asiatic resources comprise of non-living things. Examples include land, water, air and minerals such as gold, iron, copper, silver etc.

Considering their stage of development, natural resources may be referred to in the following ways:

i) **Potential Resources** - Potential resources are those which exist in a region and may be used in the future. For example, mineral oil may exist in many parts of India having sedimentary rocks but till the time it is actually drilled out and put into use, it remains a potential resource.

ii) **Actual Resources** are those which have been surveyed, their quantity and quality determined and are being used in present times. For example, the petroleum and the natural gas which is obtained from the Bombay High Fields. The development of an actual resource, such as wood processing depends upon the technology available and the cost involved. That part of the actual resource which can be developed profitably with available technology is called a reserve.

With respect to renewability, natural resources can be categorized as follows:

i) **Renewable Resources** - Renewable resources are the ones which can be replenished or reproduced easily. Some of them, like sunlight, air, wind, etc., are continuously available and their quantity is not affected by human consumption. Many renewable resources can be depleted by human use, but may also be replenished, thus maintaining a flow. Some of these, like agricultural crops, take a short time for renewal; others, like water, take a comparatively longer time, while still others, like forests, take even longer.

ii) **Non-renewable Resources** - Non-renewable resources are formed over very long geological periods. Mineral resources are anything of economic value that may be extracted from the earth. Non renewable resources (minerals) may be further classed into metallic and non metallic minerals. Since their rate of formation is extremely slow, they cannot be replenished once they get depleted. Out of these, the metallic minerals can be re-used by recycling them. But coal and petroleum cannot be recycled. Water is one of the few non renewable resources which is not permanently consumed and may become a reusable resource.

2.4 Atmospheric Pollution

The atmosphere of the Earth serves as a key factor in sustaining the planetary ecosystem. The thin layer of gases that envelops the Earth is held in place by the planet's gravity. Dry air consists of 78% nitrogen, 21% oxygen, 1% argon and other inert gases, carbon dioxide, etc.; but air also contains a variable amount of water vapour. The atmospheric pressure declines steadily with altitude, and has a scale height of about 8 kilometres at the Earth's surface: the height at which the atmospheric pressure has declined by a factor of *e* (a mathematical constant equal to 2.71...) (NASA 2007, Pelletier 2002). The ozone layer of the Earth's atmosphere plays an important role in depleting the amount of ultraviolet (UV) radiation that reaches the surface. As DNA is readily damaged by UV light, this serves to protect life at the surface. The atmosphere also retains heat during the night, thereby reducing the daily temperature extremes.

Atmospheric pollution (also commonly called air pollution) is derived chiefly from the spewing of gasses and solid particulates into the atmosphere. Many pollutants—dust, pollen, and soil particles—occur naturally, but most air pollution, as the term is most commonly used and understood, is caused by human activity. Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or damages the natural environment, into the atmosphere.

2.4.1 Air Pollutants

An air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made (USEPA, 2008). Pollutants can be classified as either primary or secondary. Usually, primary pollutants are substances directly emitted from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulfur dioxide released from factories. Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone - one of the many secondary pollutants that make up photochemical smog. Some pollutants may be both primary and secondary: that is, they are both emitted directly and formed from other primary pollutants.

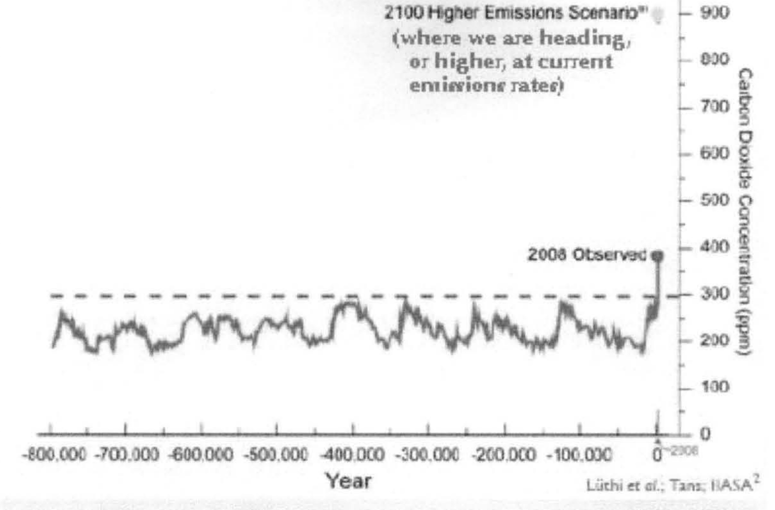
Major primary pollutants produced by human activity include:

(a) Sulphur Oxides (SO_x) - especially sulfur dioxide, a chemical compound with the formula SO_2. SO_2 is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulfur compounds, their combustion generates sulfur dioxide. Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.

(b) Nitrogen oxides (NO_x) - especially nitrogen dioxide are emitted from high temperature combustion. Can be seen as the brown haze dome above or plume downwind of cities. Nitrogen dioxide is the chemical compound with the formula NO_2. It is one of the several nitrogen oxides. This reddish-brown toxic gas has a characteristic sharp, biting odor. NO_2 is one of the most prominent air pollutants.

(c) Carbon monoxide - is a colorless, odorless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

(d) Carbon dioxide (CO_2) - a greenhouse gas emitted from combustion but is also a gas vital to living organisms. It is a natural gas in the atmosphere.



Analysis of air bubbles trapped in an Antarctic ice core extending back 800,000 years documents the Earth's changing carbon dioxide concentration. Over this long period, natural factors have caused the atmospheric carbon dioxide concentration to vary within a range of about 170 to 300 parts per million (ppm). Temperature-related data make clear that these variations have played a central role in determining the global climate. As a result of human activities, the present carbon dioxide concentration of about 385 ppm is about 30 percent above its highest level over at least the last 800,000 years.
Adapted from GlobalChange.gov (2009)

Fig. 2.1 800,000 Year record of Carbon Dioxide Concentration

(e) Volatile organic compounds - VOCs are an important outdoor air pollutant. In this field they are often divided into the separate categories of methane (CH_4) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhance global warming. Other hydrocarbon VOCs are also significant greenhouse gases via their role in creating ozone and in prolonging the life of methane in the atmosphere, although the effect varies depending on local air quality. Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukemia through prolonged exposure. 1,3-butadiene is another dangerous compound which is often associated with industrial uses.

(f) **Particulate matter** – Particulates alternatively referred to as particulate matter (PM) or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to particles and the gas together. Sources of particulate matter can be manmade or natural. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged over the globe, anthropogenic aerosols—those made by human activities—currently account for about 10 percent of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.

(g) **Toxic metals**, such as lead, cadmium and copper.

(h) **Chlorofluorocarbons (CFCs)** - harmful to the ozone layer emitted from products currently banned from use.

(i) **Ammonia (NH_3)** - emitted from agricultural processes. Ammonia is a compound with the formula NH_3. It is normally encountered as a gas with a characteristic pungent odor. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous.

(j) **Odors** - such as from garbage, sewage, and industrial processes

(k) **Radioactive pollutants** - produced by nuclear explosions, war explosives, and natural processes such as the radioactive decay of radon.

Secondary pollutants include:

(a) **Particulate matter formed from gaseous primary pollutants and compounds in photochemical smog**: Smog is a kind of air pollution. The word "smog" is a portmanteau of smoke and fog. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulfur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by sunlight to form secondary pollutants that also combine with the primary emissions to form photochemical smog.

(b) **Ground level ozone (O_3)** formed from NO_x and VOCs. Ozone (O_3) is a key constituent of the troposphere (it is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer). Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night. At abnormally high concentrations brought about by human activities (largely the combustion of fossil fuel), it is a pollutant, and a constituent of smog.

(c) **Peroxyacetyl nitrate (PAN)** - similarly formed from NO_x and VOCs.

Minor air pollutants include:

(a) A large number of minor hazardous air pollutants.

(b) A variety of persistent organic pollutants, which can attach to particulate matter.

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bioaccumulate in human and animal tissue, biomagnify in food chains, and to have potential significant impacts on human health and the environment.

2.4.2 Sources of Atmospheric Pollution

Sources of air pollution refer to the various locations, activities or factors which are responsible for the releasing of pollutants in the atmosphere. These sources can be classified into two major categories which are: anthropogenic and natural sources.

2.4.2.1Anthropogenic sources (human activity)

(a) "Stationary Sources" include smoke stacks of power plants, manufacturing facilities (factories) and waste incinerators, as well as furnaces and other types of fuel-burning heating devices

(b) "Mobile Sources" include motor vehicles, marine vessels, aircraft and the effect of sound etc.

(c) Chemicals, dust and controlled burn practices in agriculture and forestry management. Controlled or prescribed burning is a technique sometimes used in forest management, farming, prairie restoration or greenhouse gas abatement. Fire is a natural part of both forest and grassland ecology and controlled fire can be a tool for foresters. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.

(d) Fumes from paint, hair spray, varnish, aerosol sprays and other solvents

(e) Waste deposition in landfills, which generate methane. Methane is not toxic; however, it is highly flammable and may form explosive mixtures with air. Methane is also an asphyxiant and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement

(f) Military, such as nuclear weapons, toxic gases, germ warfare and rocketry

2.4.2.2 Natural sources

(a) Dust from natural sources, usually large areas of land with little or no vegetation.

(b) Methane, emitted by the digestion of food by animals, for example cattle.

(c) Radon gas from radioactive decay within the Earth's crust. Radon is a colorless, odorless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.

(d) Smoke and carbon monoxide from wildfires.

(e) Volcanic activity, which produce sulfur, chlorine, and ash particulates.

2.4.2.3 Indoor Air pollution

A lack of ventilation indoors concentrates air pollution where people often spend the majority of their time. Radon (Rn) gas, a carcinogen, is exuded from the Earth in certain locations and trapped inside houses. Building materials including carpeting and plywood emit formaldehyde (H_2CO) gas. Paint and solvents give off volatile organic compounds (VOCs) as they dry. Lead paint can degenerate into dust and be inhaled. Intentional air pollution is introduced with the use of air fresheners, incense, and other scented items. Controlled wood fires in stoves and fireplaces can add significant amounts of smoke particulates into the air, inside and out (Duflo, 2008). Indoor pollution fatalities may be caused by using pesticides and other chemical sprays indoors without proper ventilation. Carbon monoxide (CO) poisoning and fatalities are often caused by faulty vents and chimneys, or by the burning of charcoal indoors. Chronic carbon monoxide poisoning can result even from poorly adjusted pilot lights. Traps are built into all domestic plumbing to keep sewer gas, hydrogen sulfide, out of interiors. Clothing emits tetrachloroethylene, or other dry cleaning fluids, for days after dry cleaning. Though its use has now been banned in many countries, the extensive use of asbestos in industrial and domestic environments in the past has left a potentially very dangerous material in many localities.

Biological sources of air pollution are also found indoors, as gases and airborne particulates. Indoors, the lack of air circulation allows these airborne pollutants to accumulate more than they would otherwise occur in nature. These are outlined as follows:

(a) Pets produce dander; people produce dust from minute skin flakes and decomposed hair.

(b) Dust mites in bedding, carpeting and furniture produce enzymes and micrometre-sized faecal droppings, inhabitants emit methane.

(c) Mould forms in walls and generates mycotoxins and spores

(d) Air conditioning systems can incubate Legionnaires' disease and mould,

(e) Houseplants, soil and surrounding gardens can produce pollen, dust, and mould.

2.4.3 Consequences of Atmospheric Pollution

Atmospheric pollution is a key contributor to global warming and climate change. The urban heat island phenomenon traps heat in thermal mass like concrete and black roads which absorb, store and then re-emit this heat to the urban air at night. This hot city phenomenon has far-reaching environmental sustainability and human liveability implications, ranging from the aggravation of health problems such as heat stress, increasing the intensity of urban air pollution, and contributing to extreme weather events—in addition to the ever-increasing use of air-conditioners, with flow-on impacts for energy supply, brownouts and greenhouse gas emissions.

The global climate is rapidly deteriorating—ice shelves are melting, sea-levels rising, and the Gulf Stream conveyor belt threatened while waves of hurricanes brew over hot oceans, and devastating weather extremes of all natures are more and more prevalent in every corner of the globe (Wikipedia 2008).

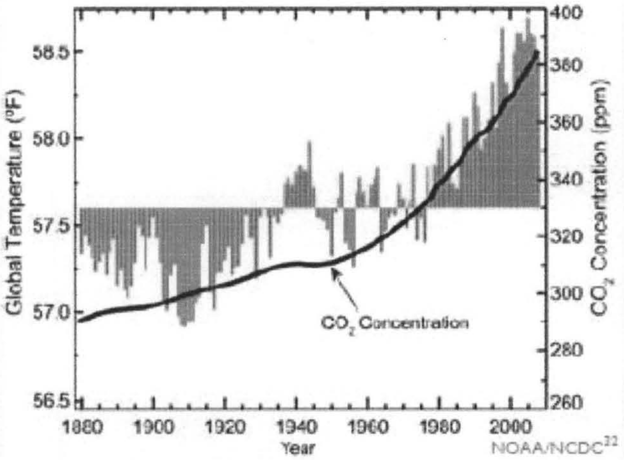
2.5 Global Warming

Global warming refers to an increase in the Earth's average surface air temperature. Global warming and cooling in are not necessarily bad, since the Earth has gone through cycles of temperature change many times in its 4.5 billion years. However, as used today, global warming usually means a fast, unnatural increase that is enough to cause the expected climate conditions to change rapidly and often cataclysmically.

Evidence of previous cool and warm periods has increased, but the rapid and sustained heat gain especially since the 1970s remains unparalleled in recent earth history. All this evidence, plus the vast range of changes to plants, animals, storms and glaciers which correlate strongly to the measured temperature rise, caused world climate scientists to declare in 2007 that "Warming of the climate system is unequivocal," and that there is more than a 90 percent assurance that "most of the observed increase in global average temperatures since the mid-20th century is due to the observed increase in anthropogenic greenhouse gas concentrations."

2.5.1 Causes of Global Warming

The Intergovernmental Panel on Climate Change (IPCC) concludes that increasing greenhouse gas concentrations resulting from human activity such as fossil fuel burning and deforestation are responsible for most of the observed temperature increase since the middle of the 20th century.(IPCC, 2009) The IPCC also concludes that natural phenomena such as solar variation and volcanoes produced most of the warming from pre-industrial times to 1950 and had a small cooling effect afterward. (Hegerl, 2007; Caspar, 2007). These basic conclusions have been endorsed by more than 45 scientific societies and academies of science, including all of the national academies of science of the major industrialized countries (Royal Society, 2005).



Global annual average temperature (as measured over both land and oceans). Red bars indicate temperatures above and blue bars indicate temperatures below the average temperature for the period 1901-2000. The black line shows atmospheric carbon dioxide (CO_2) concentration in parts per million (ppm). GlobalChange.gov(2009)

Fig. 2.2 Global Temperature and Carbon Dioxide

2.5.2 Effects of Global Warming

An increase in global temperature will cause sea levels to rise and will change the amount and pattern of precipitation, probably including expansion of subtropical deserts. (Lu, 2007). The continuing retreat of glaciers, permafrost and sea ice is expected, with warming being strongest in the Arctic. Other likely effects include increases in the intensity of extreme weather events, species extinctions, and changes in agricultural yields.

Climate is the accumulation of weather effects—wind, rainfall, heat, cold—experienced in a place over many years, an average of thousands of days' worth of weather. Climate is what one expects in a certain place; weather is what occurs day by day. One result of global temperature increase or decrease is climate change, referring to a shift in not only average local temperature but also rain- and snowfall, cloudiness and storms, the seasons, and river flow, with associated impacts on the biosphere, the portion of the Earth and its atmosphere that supports life.

Climate change is the variation in global or regional climates over time. It reflects changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years (Ledley, 1999)

Climate change refers to any significant change in measures of climate (such as temperature, precipitation or wind) lasting for an extended period (decades or longer). Climate change may be limited to a specific region, or may occur across the whole Earth [Miller, 1970].

In recent usage, especially in the context of environmental policy, the term "climate change" often refers only to changes in modern climate, including the rise in average surface temperature known as global warming. In some cases, the term is also used with a presumption of human causation, as in the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC uses "climate variability" for non-human caused variations.

2.6 Stratospheric Ozone Depletion

Three forms (or allotropes) of oxygen are involved in the ozone-oxygen cycle: oxygen atoms (O or atomic oxygen), oxygen gas (O_2 or diatomic oxygen), and ozone gas (O_3 or triatomic oxygen). Ozone is formed in the stratosphere when oxygen molecules photo -dissociate after absorbing an ultraviolet photon whose wavelength is shorter than 240 nm. This produces two oxygen atoms. The atomic oxygen then combines with O_2 to create O_3. Ozone molecules absorb UV light between 310 and 200 nm, following which ozone splits into a molecule of O_2 and an oxygen atom. The oxygen atom then joins up with an oxygen molecule to regenerate ozone. This is a continuing process which terminates when an oxygen atom "recombines" with an ozone molecule to make two O_2 molecules. The overall amount of ozone in the stratosphere is determined by a balance between photochemical production and recombination.

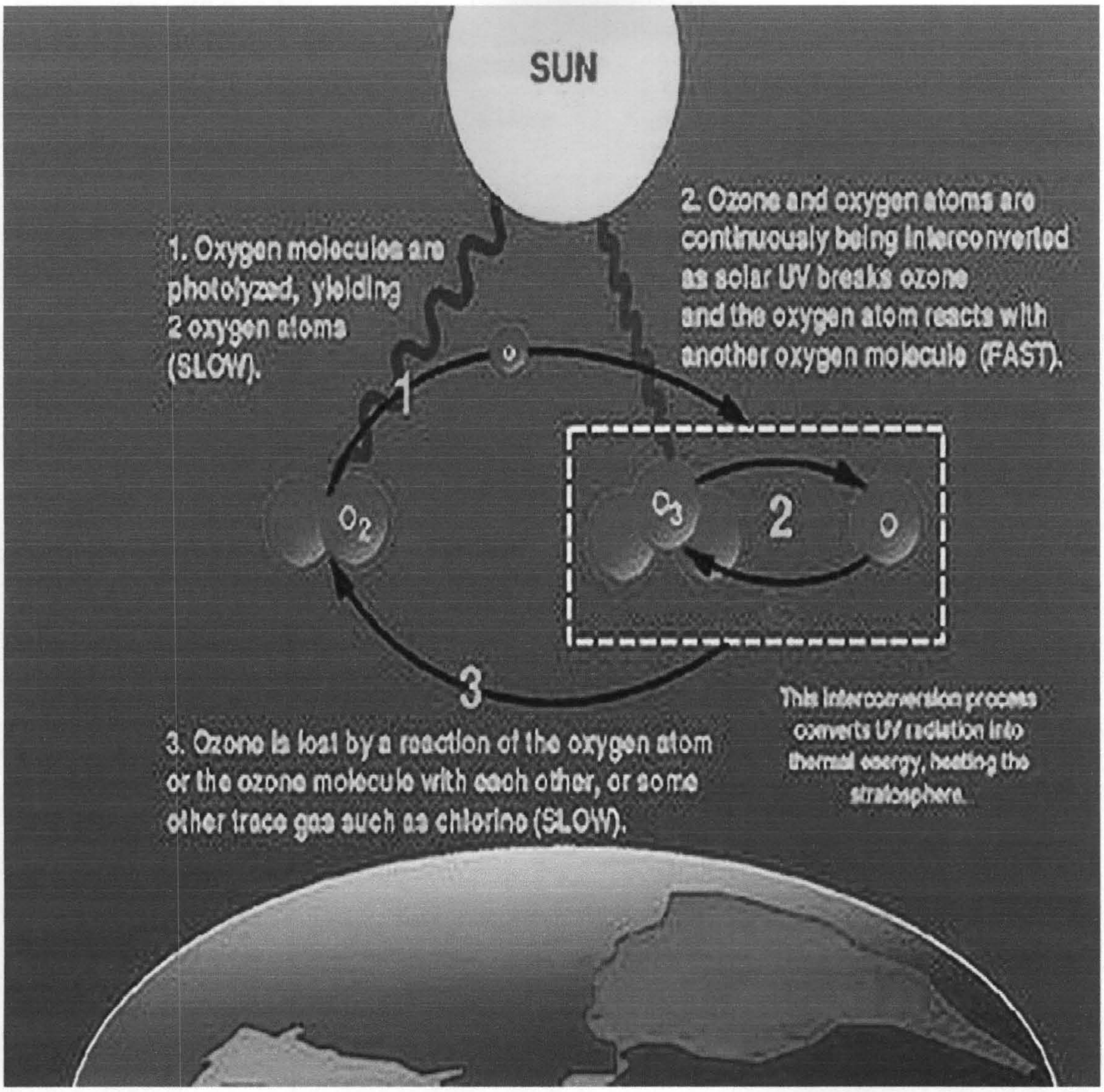


Fig. 2.3 Ozone-oxygen cycle in the ozone layer.

Ozone depletion describes two distinct, but related observations: a slow, steady decline of about 4% per decade in the total volume of ozone in stratosphere, and a much larger but seasonal, decrease in stratospheric ozone over earth's Polar Regions during the same period.

The most pronounced decrease in ozone has been in the lower stratosphere. However, the ozone hole is most usually measured not in terms of ozone concentrations at these levels (which are typically of a few parts per million) but by reduction in the total column ozone, above a point on the Earth's surface, which is normally expressed in Dobson units, abbreviated as "DU". Marked decreases in column ozone in the Antarctic spring and early summer compared to the early 1970s and before have been observed using instruments such as the Total Ozone Mapping Spectrometer (TOMS). (The Ozone Hole Tour: Part II. 2007)

Reductions of up to 70% in the ozone column observed in the austral (southern hemispheric) spring over Antarctica and first reported in 1985 (Farman et al. 1985) are continuing. In middle latitudes it is preferable to speak of ozone depletion rather than holes. In the tropics, there are no significant trends.

2.6.1 Causes of Stratospheric Ozone Depletion

Ozone can be destroyed by a number of free radical catalysts, the most important of which are the hydroxyl radical (OH·), the nitric oxide radical (NO·) and atomic chlorine (Cl·) and bromine (Br·). All of these have both natural and anthropogenic (manmade) sources; at the present time, most of the OH· and NO· in the stratosphere is of natural origin, but human activity has dramatically increased the levels of chlorine and bromine. These elements are found in certain stable organic compounds, especially chlorofluorocarbons (CFCs), which may find their way to the stratosphere without being destroyed in the troposphere due to their low reactivity. Once in the stratosphere, the Cl and Br atoms are liberated from the parent compounds by the action of ultraviolet light.

The most defining process is the catalytic destruction of ozone by atomic chlorine and bromine and bromine. The main source of these halogen atoms in the stratosphere is photo dissociation of chlorofluorocarbon (CFC) compounds, commonly called freons, and of bromofluorocarbon compounds known as halons. These compounds are transported into the stratosphere after being emitted at the surface. The ozone depletion mechanisms strengthened as emission of CFC's and halons increased.

Reactions that take place on polar stratospheric clouds (PSCs) play an important role in enhancing ozone depletion (U.S. EPA, 2008). PSCs form more readily in the extreme cold of Antarctic stratosphere. This is why ozone holes first formed, and are deeper, over Antarctica. Early models failed to take PSCs into account and predicted a gradual global depletion, which is why the sudden Antarctic ozone hole was such a surprise to many scientists.

2.6.2 Effects of stratospheric ozone Depletion

Ozone depletion also explains much of the observed reduction in stratospheric and upper tropospheric temperatures. The source of the warmth of the stratosphere is the absorption of UV radiation by ozone, hence reduced ozone leads to cooling. Some stratospheric cooling is also predicted from increases in greenhouse gases such as CO_2; however the ozone-induced cooling appears to be dominant.

The ozone layer prevents most harmful UVB wavelengths (270-315nm) of ultraviolet light (UV light) from passing through the earth's atmosphere. A variety of biological consequences such as increases in skin cancer, damage to plants, and reduction of plankton population populations in the ocean's photic zone may result from the increased UV exposure due to ozone depletion.

2.7 Atmospheric Heat

This is simply the amount of heat in the atmosphere, as measured by the surface temperature.

2.7.1 Sources of Atmospheric Heat

The atmosphere can be heated either directly (pollution) or indirectly (forcing).

2.7.1.1 External Forcing

External forcing is a term used in climate science for processes external to the climate system (though not necessarily external to Earth). Climate responds to several types of external forcing, such as changes in greenhouse gas concentrations, changes in solar luminosity, volcanic eruptions, and variations in Earth's orbit around the Sun.(Hegerl *et al*, 2007) Attribution of recent climate change focuses on the first three types of forcing. Orbital cycles vary slowly over tens of thousands of years and thus are too gradual to have caused the temperature changes observed in the past century.

2.7.1.1.1 Greenhouse Effect

Our planet is warmed by radiant energy from the sun that reaches the surface through the atmosphere. As the surface warms, heat energy reflects back toward space; meanwhile, gases in the atmosphere absorb some of this energy and reradiate it near the surface. This is often called the greenhouse effect, named for the way heat increases inside a glass enclosure. In the greenhouse effect around Earth, the atmosphere can be visualized as a blanket that is made thicker by the action of a small amount of water vapour, carbon dioxide, methane, ozone, nitrous oxide, other gases, and soot; it thus holds in more heat, forcing air temperature higher.

On an average day, this effect is caused by water vapour and clouds (75 percent) and carbon dioxide (20 percent), with the rest of the heating caused by other gases. Relatively small additions of carbon dioxide and methane force more heat, and that heat allows the air to hold more water vapour, creating a feedback loop that magnifies the effect. Although water vapour is naturally prevalent in the atmosphere, it does not trap as much heat per molecule as carbon dioxide and methane. Also, water vapour molecules cycle through the atmosphere in only a few days, a brief period compared to the residence time of CO2,which persists for many decades and creates some warming even after as long as three hundred years. Dust and aerosol chemicals in the air cause some cooling (negative forcing); they are also very short lived. Even though the gases are measured only in parts per million (ppm) or billion (ppb), they have been powerfully, and naturally, influencing the Earth's temperature for millions of years. Without them, instead of an average air temperature of about 58°F (14.5°C), the Earth would be below the freezing point. Life as we know it now would be impossible.

2.7.1.1.2 Radiative Forcing

Earth's temperature is also subject to natural forcing cycles from solar radiation and the movement of the planet around the sun. Scientists think these cycles, which have left a visible signature extending back millions of years, are what led to past ice ages and the warming that ended them. Currently, we are in a period between major ice ages. The last great glaciation, when temperatures were about 10°to 12°F (6°to7°C) cooler than today, began fading away about 18,000 years ago.

2.7.1.2 Heat Pollution

Because most people on earth live in cities, and each city is also substantially hotter than its natural surroundings, urban contributions to Atmospheric pollution are significant. The amount of heat pollution (in watts) each household produces is within a constant factor of the average net amount of electricity it uses (in watts); this is because energy usually ends up being converted into heat (e.g. any type of light bulb, which converts energy into light, which then turns into heat when the light hits something). Other sources of heat pollution include combustion of natural gas and any fossil fuels which contribute heat in exactly a constant factor, as well as body heat, where about 50% of consumed food energy is wasted as heat (the other half being used for body processes or left in the faeces).

2.7.2Effects of Increased Atmospheric Heat

2.7.2.1 Effects of Environmental or Atmospheric Heat on the Human Body

The human body is continually making adjustments to maintain thermal equilibrium. The primary factors that influence thermal regulation are:

- **(a)** Metabolic heat (heat produced within the body as a result of activity that burns energy)
- **(b)** Convection (heat transfer by contact with a moving fluid)
- **(c)** Evaporation (heat loss by loss of body fluids through the skin)

(d) Radiant heat (resulting from electromagnetic non-ionising energy that is transferred through space without the movement of matter within that space.

The environmental factors that affect heat exchange are: air temperature, air humidity, air movement and radiant temperature.

The effects of atmospheric heat on the human body are: heat stress and heat strain.

2.7.2.1.1 Heat Stress

Heat stress is the net heat load to which one may be exposed from the combined contributions of metabolic effect of work, environmental factors and clothing. A mild of moderate heat stress may cause discomfort, adversely affect performance and safety, but is not harmful to health. As heat stress approaches human tolerance limits, the risk of heat-related disorders increases. Some effects of heat stress are:

(a) **Heat exhaustion:** In this state, the skin becomes clammy and moist while the body temperature is sill normal or higher than normal. Heat exhaustion results from loss through sweating of fluid and salt that are not properly replaced during exertion.

(b) **Heat cramps:** These are muscle cramps that occur when workers exert themselves sufficiently to lose fluids and salt through sweating, but replace only the fluids (water).

(c) **Heat syncope or fainting:** This occurs especially when one is accustomed to working in such an environment.

(d) **Heat rash:** This is prickly rash which occurs in environments where sweat does not evaporate.

2.7.2.1.2 Heat Strain

Heat strain is the overall physiological response resulting from heat stress. The physiological adjustments are dedicated to dissipating excess heat from the body. Heat strain is measured by: body temperature, heart rate and amount of sweat (Goetsch 2008).

2.7.2.2 Effects of Atmospheric Heat on Combustion Engines in Agricultural engineering Practice

Cool air is denser than hot air. This means that per unit volume cool air has more oxygen than hot air. Thus cool air provides more oxygen per cylinder charge than less dense hot air.

Hot air (containing less oxygen) will over work the engine cooling system, increasing the noise emitting from the engine. Insufficient oxygen will promote improper combustion of the fuel. Thus, the engine will produce less power, and release very dangerous gases i.e. volatile organic compounds (VOC's) into the atmosphere, which may lead to photochemical ozone formation (Engineers Edge 2008).

2.8 Noise Pollution

Noise pollution (or environmental noise) is displeasing human or machine created sound that disrupts the activity or balance of human or animal life. Noise pollution is the condition in which noise has characteristics and duration injurious to health and welfare, in the areas affected by the noise.

2.8.1 Sources of Noise Pollution

The source of most noise worldwide is transportation systems, motor vehicle noise, but also including aircraft noise and rail noise. Poor urban planning may give rise to noise pollution, since side-by-side industrial and residential buildings can result in noise pollution in the residential area. Other sources are office equipment, factory machinery, construction work, appliances, power tools, lighting hum and audio entertainment systems.

Table 2.1 Sound Levels /Human Response

Source	Noise Level(dBA)	Response
	0	**Threshold of hearing**
Breathing	**10**	**Just Audible**
Soft Whisper	**30**	**Very Quiet**
Light auto Traffic	**50**	**Quiet**
Normal Speech	**60**	**Audible**
Freeway Traffic	**70**	**Intrusive (conversation is difficult)**
Alarm Clock	**80**	**Annoying**
Light Diesel Engine	**85**	
Food Blender	**90**	
Heavy diesel Engine	**90**	**Hearing Damage (8 hr. Daily Exposure)**
Jet Takeoff(2000 ft)	**110**	
Jet Take off (200ft)	**120**	**Max. Vocal Effect**
Live Rock Music	**130**	**Limits amplified speech**
Carrier Deck, Jet Operation	**140**	**Threshold of pain**

Source: Salvato, 1992

2.8.2 Effects of Noise Pollution on Humans and Animals in Agricultural Engineering Practice

Noise pollution can be dangerous to health, and to the animals in the environment. It would greatly affect farmers and farming practices in the area, especially animal farming. Noise health effects are both health and behavioural in nature. Unwanted sound can damage physiological and psychological health. Noise pollution can cause annoyance and aggression, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects. Furthermore, stress and hypertension are the leading causes to health problems, whereas tinnitus hypertension can lead to forgetfulness, severe depression and at times panic attacks. Chronic exposure to noise may cause noise-induced hearing loss. Older males exposed to significant occupational noise demonstrate significantly reduced hearing sensitivity than their non-exposed peers, though differences in hearing sensitivity decrease with time and the two groups are indistinguishable by age 70.

High noise levels can contribute to cardiovascular effects and exposure to moderately high levels during a single eight hour period causes a statistical rise in blood pressure of five to ten points and an increase in stress and vasoconstriction leading to the increased blood pressure noted above as well as to increased incidence of coronary artery disease. Noise pollution is also a cause of annoyance. Noise can have a detrimental effect on animals by causing stress, increasing risk of mortality by changing the delicate balance in predator/prey detection and avoidance, and by interfering with their use of sounds in communication especially in relation to reproduction and in navigation. Acoustic overexposure can lead to temporary or permanent loss of hearing.

An impact of noise on animal life is the reduction of usable habitat that noisy areas may cause, which in the case of endangered species may be part of the path to extinction. One of the best known cases of damage caused by noise pollution is the death of certain species of beached whales, brought on by the loud sound of military sonar.

Noise also makes species communicate louder, which is called Lombard vocal response. Scientists and researchers have conducted experiments that show whales' song length is longer when submarine-detectors are on. If creatures don't "speak" loud enough, their voice will be masked by anthropogenic sounds. These unheard voices might be warnings, finding of prey, or preparations of net-bubbling. When one species begins speaking louder, it will mask other species' voice, causing the whole ecosystem to eventually speak louder.

Some species become less faithful to their partners when exposed to traffic noise. This could alter a population's evolutionary trajectory by selecting "sexy" traits, sapping resources normally devoted to other activities and thus lead to profound genetic and evolutionary consequences (Wikipedia 2008).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Temperature Measurement

Temperature measurement using modern scientific thermometers and temperature scales goes back at least as far as the early 18th century, when Gabriel Fahrenheit adapted a thermometer (switching to mercury) and a scale both developed by Ole Christensen Røemer. Fahrenheit's scale is still in use, alongside the Celsius scale and the Kelvin scale.

Table 3.1 Temperature Scales

Comment	Kelvin K	Celsius °C	Fahrenheit °F
Absolute zero	0	−273.15	−459.67
Average surface temperature on Earth	288	15	59
Average human body temperature	310.0 ±0.7	36.8 ±0.7	98.2 ±1.3
Highest recorded surface temperature on Earth (Al 'Aziziyah, Libya - 13 September	331	58	136
Gas Flame	1773	1500	2732

Many methods have been developed for measuring temperature. Most of these rely on measuring some physical property of a working material that varies with temperature. Temperature may be measured by:

(a) Expansion of solid, liquid, or gaseous materials

(b) Change in electrical resistance of metals and semi-conductors

(c) Thermoelectric e. m. f. 's which are generated at the junctions of unlike metals

(d) Intensity of radiation from a particular area of the hot material.

Under some conditions it becomes possible to measure temperature by a direct use of the Planck's law of black body radiation. For example, the cosmic microwave background temperature has been measured from the spectrum of photons observed by satellite observations.

3.1.1Thermo-sensors

The practical basis of thermometry is the existence of triple point cells. Triple points are conditions of pressure, volume and temperature such that three phases (matter) are simultaneously present, for example solid, vapour and liquid. For a single component there are no degrees of freedom at a triple point and any change in the three variables results in one or more of the phases vanishing from the cell. Therefore, triple point cells can be used as universal references for temperature and pressure. Temperature Measuring devices include:

(a) Glass Thermometers

(b) Thermocouples

(c) Thermocouples

(d) Thermistors

(e) Resistance Temperature Detector (RTD)

(f) Pyrometers

(g) Langmuir probes (for electron temperature of a plasma)

(h) Infrared Thermosensors.

3.1.1.1 Glass Thermometers

One of the most common devices for measuring temperature is the glass thermometer. This consists of a glass tube filled with mercury or some other liquid, which acts as the working fluid. Temperature increases cause the fluid to expand, so the temperature can be determined by measuring the volume of the fluid. Such thermometers are usually calibrated, so that one can read the temperature, simply by observing the level of the fluid in the thermometer.

The theoretical basis for thermometers is the Zeroth law of thermodynamics which postulates that if you have three bodies, A, B and C, if A and B are at the same temperature, and B and C are at the same temperature then A and C are at the same temperature. B, of course, is the thermometer (Wikipedia, 2009).

3.1.2 Measurement of Local Temperature –Distance Distribution around a Gas Flaring Station

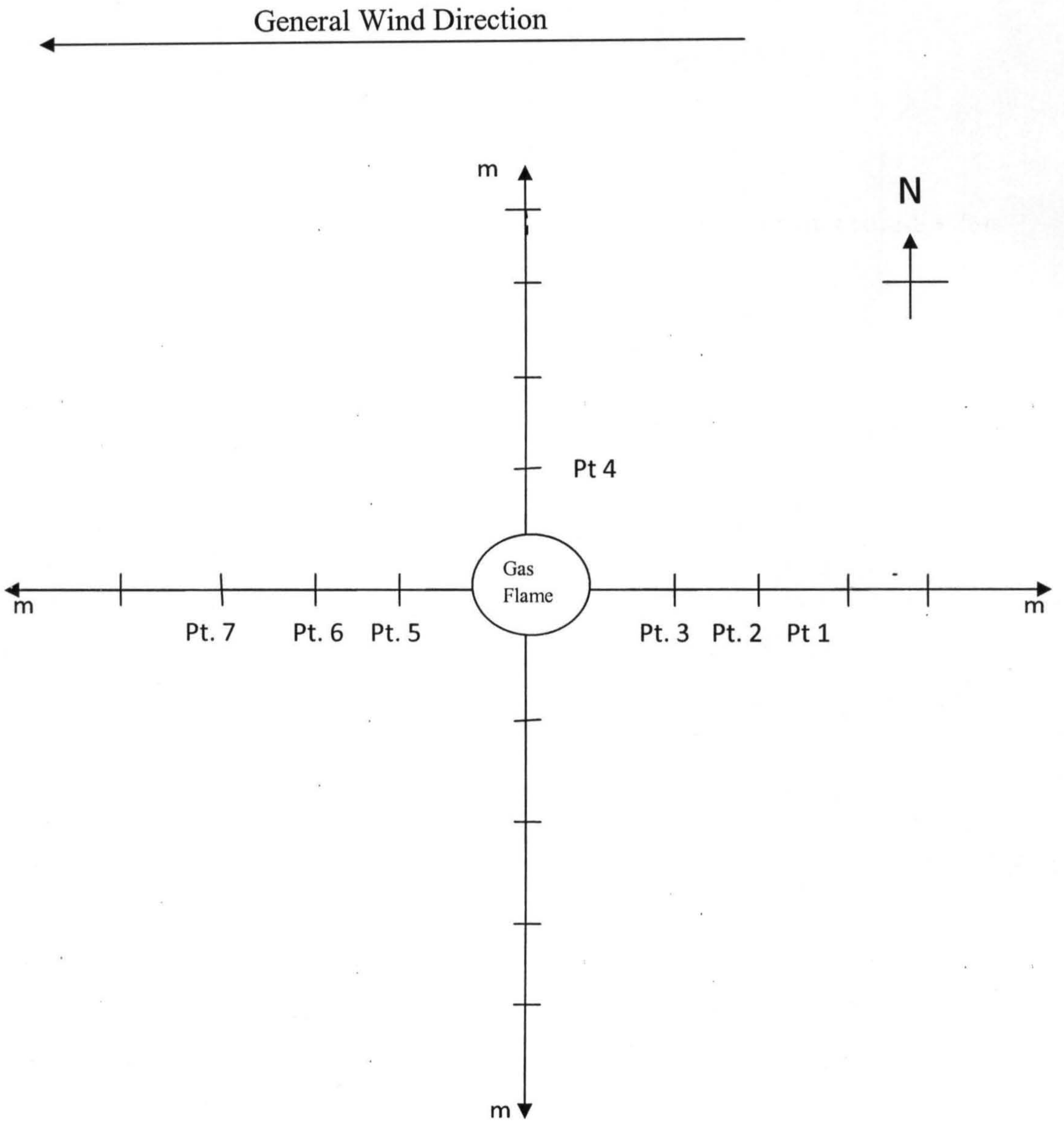


Fig.3.1 Measuring Temperature

Temperature is measured in four cardinal directions from the gas flare at intervals.

3.2 Measurement of Noise

Sound level meters measure sound pressure level and are commonly used in noise pollution studies for the quantification of almost any noise, but especially for industrial, environmental and aircraft noise. However, the reading given by a sound level meter does not correlate well to human-perceived loudness; for this a loudness meter is needed. The current International standard for sound level meter performance is IEC 61672:2003 and this mandates the inclusion of an *A*-frequency-weighting filter and also describes other frequency weightings of *C* and *Z* (zero) frequency weightings. The older *B* and *D* frequency-weightings are now obsolete and are no longer described in the standard.

The standard sound level meter is more correctly called an exponentially averaging sound level meter as the AC signal from the microphone is converted to DC by a root-mean-square (RMS) circuit and thus it must have a time-constant of integration; today referred to as time-weighting. Three of these time-weightings have been standardized, 'S' (1s) originally called Slow, 'F' (125 ms) originally called Fast and 'I' (35 ms) originally called Impulse. I-time-weighting is no longer in the body of the standard because it has little real correlation with the impulsive character of noise events.

Most national regulations also call for the absolute peak value to be measured to protect workers hearing against sudden large pressure peaks, using either 'C' or 'Z' frequency weighting.

Fig. 3.2 An integrating-averaging sound level meter complying with IEC 61672:2003

3.2.1 Sound Level Meters

1. Windshield covering the microphone
2. The microphone preamplifier
3. Instrument body
4. The display
5. INC and DEC keys
6. AC-out and serial interface are located at the side of the instrument body
7. The keyboard

Fig. 3.3 Sound Level Meter Example, the Nor-116

3.2.1.1 Sound Level Meter Design Principles

A sound level meter is an instrument designed to respond to sound in approximately the same way as the human ear and to give objective, reproducible measurements of the sound pressure level. This involves restriction of the frequency range to the audible region; spectral weighting of the sound as well as the application of time constants and calculation of the equivalent continuous level.

The microphone cartridge converts the acoustic pressure variations - the sound - to an equivalent electrical signal, which varies in analogy with the acoustical signal, which is why we talk about analogue signals and analogue signal processing.

In precision sound level meters like the Nor-116 (shown above), the microphone used is of the condenser type, which combines precision with stability and reliability. The output signal from the microphone cartridge is quite small and needs to be converted in the preamplifier before further processing takes place.

The dynamic range of sound - the distance between the lowest and the highest sound pressure levels occurring - is larger than the dynamic range of the sound level meter. In principle, the dynamic range of sound may exceed 140 dB, counting from the threshold of hearing - 0 dB - and up to peak values of 140 dB.

The dynamic range of a practical sound environment is generally not as high as 140 dB. In addition, for assessment of hearing damage potentials there is no need for such large dynamic ranges. The important thing for such measurements is to determine the equivalent level and the maximum level. A level 20 dB below the equivalent level will not contribute significantly to the equivalent level (in fact a level drop of 20 dB corresponds to a drop to 1% of the initial energy).

Nevertheless, to overcome this problem the dynamic range of the instrument can be shifted up and down to be able to accommodate as much of the occurring dynamic range as possible. The shifting is made by means of changing the FSD (full scale deflection) settings (actually the gain of the amplifier is changed). This is done with the INC and DEC keys of the Nor-116.

The Nor-116 calculates the A- and C-weighted Peak and RMS values simultaneously. For this it needs one C-weighting and one A-weighting network as well as one Peak and one RMS detector.

After detection of the RMS and Peak values, the signals are digitised in the analogue-to-digital converter. The level signals are now represented by digital signals, which do not vary in an analogue manner any more. They can now be processesed by the microcomputer which also controls the display, converts the values to decibels and calculates such things as the L_{eq} and the C-A value. The time constant is also superimposed on the signals by the microcomputer.

3.2.2 Measurement of the Noise-Distance distribution around the Gas Flaring Station

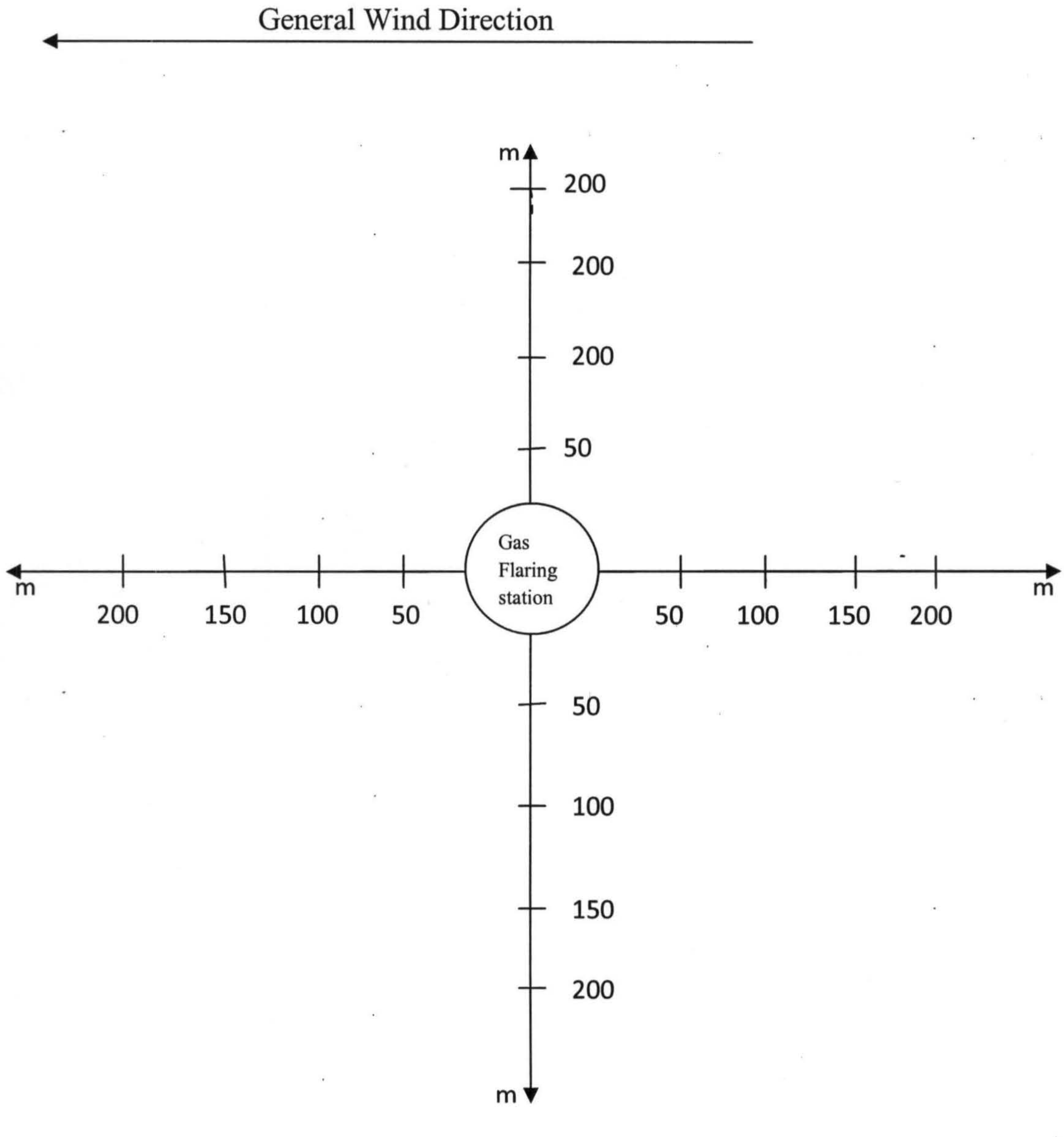


Fig.3.4 Measuring Noise

Noise is measured in four cardinal directions equidistant from the gas flare at 50-metre intervals.

3.5 Instruments Used

Plate 3.1 3-in1 Thermometer, Barometer and Hygrometer

Plate 3.2 Sound Level Meter

This instrument uses satellite technology to read the position and saves the corresponding co-ordinates

Plate 3.3 Global Positioning System

CHAPTER FOUR

4.0 RESULTS AND ANALYSIS OF RESILTS

4.1 RESULTS

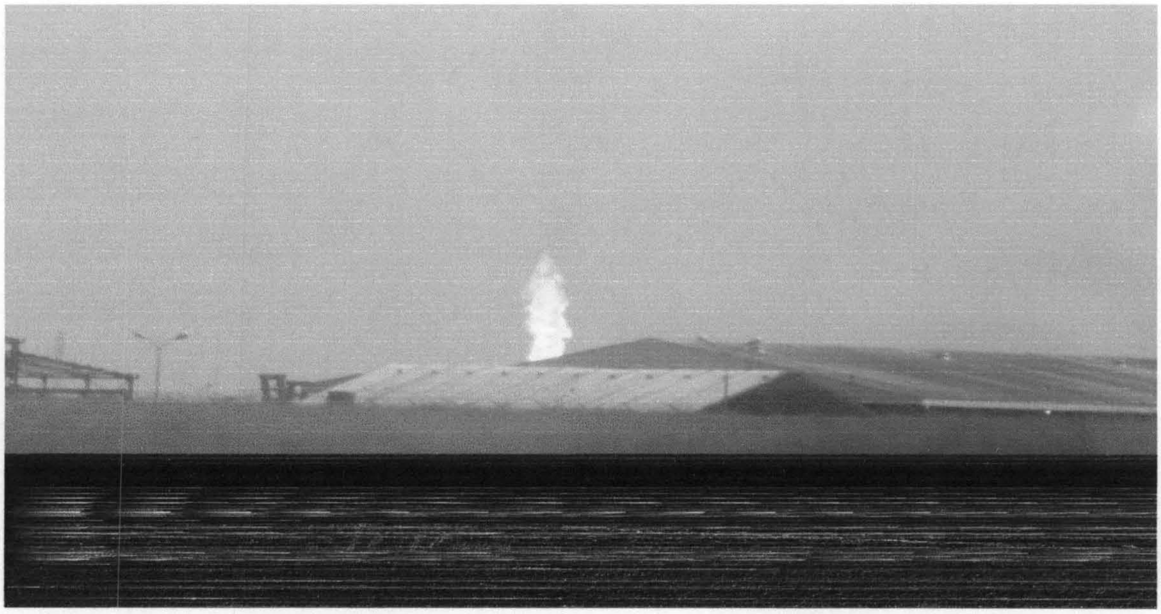


Plate 4.1 Gas Flaring in Ibeno, Akwa Ibom State

Plate 4.2 Taking Field Measurements

Plate 4.3 Satellite map of Qua Iboe Terminal (QIT), Ibeno

DATE OF MEASUREMENT: 31-12-09

Positions 1 to 7 were taken in the gas flare area while position 8 was taken in a residential area. The temperatures did not vary according to the distance. The altitude and the relative humidity are the factors responsible for the difference in atmospheric temperature at different points. The maximum readings however, were observed in the general wind direction away from the gas flare, namely positions 6 and 7.

The noise was also accompanied with deep vibrations from the gas flare stack. This became even more unbearable than the noise itself with continued exposure, of about 2 hours.

As seen from the map in Plate 4.3, position 1 is closer to the bush, so animal sounds contributed to the ambience noise. Position 4 is closest to the gas flare. The readings are relatively low. A possible explanation is that the emissions are concentrated at the top of the gas flaring stack which is about three storeys high. Transmission of the heat and noise is minimal, as dispersion by wind and diffusion is yet to intensify.

Position 6 is the highest recorded value. This point is in the direction of wind flow. The wind is a major agent of dispersion. The vibration is also minimal due to damping. Position 7 is on the road intersection the temperature is unchanged but the noise level is influenced by passing cars contributing to the ambience.

Position 8 is on a beach house in a residential area. Domestic noise, occasional moving cars and the ocean contribute to the ambience noise.

Table 4.1 Field measurements

POSITION	TEMPERATURE(°C)	SPL_{max}(dBA)
1	**27.0**	**81.0**
2	**26.5**	**79.0**
3	**26.0**	**81.5**
4	**25.0**	**74.7**
5	**27.0**	**81.1**
6	**28.0**	**86.6**
7	**28**	**82.1**
8	**27**	**79.9**

4.2 Discussion of Results

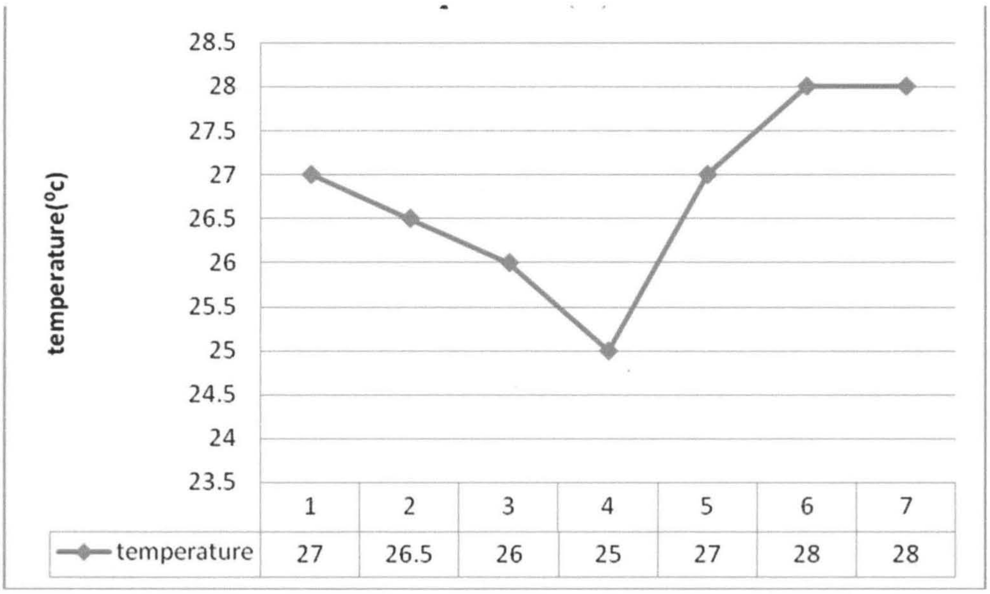


Fig 4.1 Temperature Distribution Chart

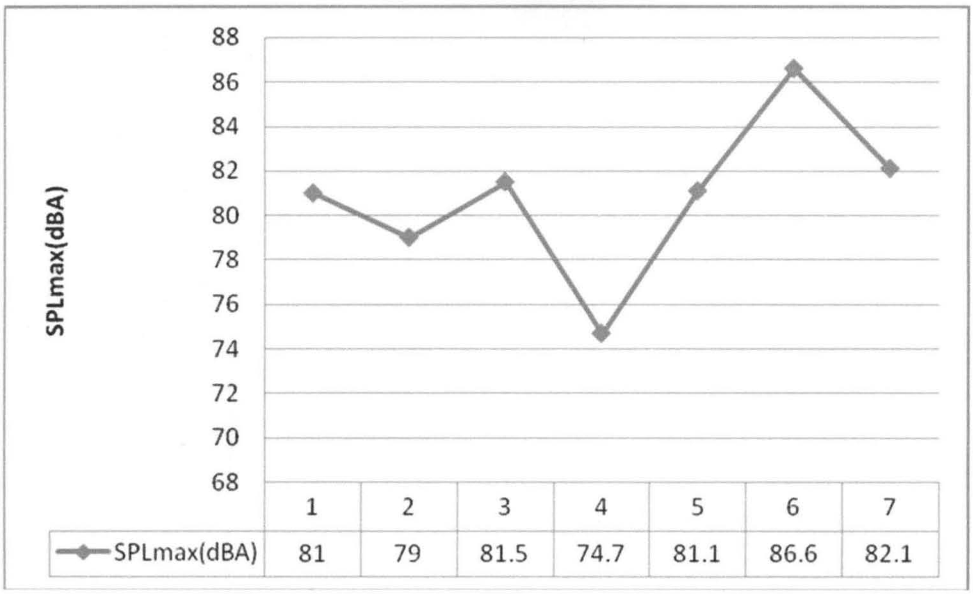


Fig 4.2 Noise level Distribution Chart

4.3 Analysis of results

4.3.1 Noise measurements

From Fig. 4.2

The maximum noise level = 86.6dBA

The Federal Ministry of Environment (FMENV) safety standard = 90dBA

The noise level although high is still within boundaries.

4.3.2 Temperature Measurement

The following table shows the monthly average readings of nine previous years in the same area.

YEARS	MONTHLY AVERAGE PER YEAR												YEARLY
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	AVE °c
2000	27.2	27.3	28.0	27.1	27.2	25.8	25.3	24.9	24.6	25.5	27.0	26.5	26.4
2001	26.8	27.4	27.3	27.1	27.0	25.8	25.2	24.5	24.9	25.9	26.2	27.6	26.4
2002	25.8	27.8	27.6	27.7	27.3	25.9	25.4	25	25.3	25.6	26.8	26.6	26.4
2003	25.9	28.2	28.2	27.2	27.2	25.6	25.4	25.3	25.4	26.3	27	26.7	26.5
2004	26.9	28.1	28.5	27.4	26.7	25.9	25.2	25.3	25.6	26.2	26.8	26.5	26.6
2005	25.8	28.5	27.6	28	27	26.1	25.2	25.3	25.6	25.5	27.1	27	26.6
2006	27.4	27.4	27.7	27.4	26.5	26.2	25.4	25.1	24.9	26.2	26.8	26.7	26.5
2007	25.7	28.2	27.8	27.1	27	26.1	25.6	25	25.2	25.6	26.4	27	26.4
2008	25.1	27.7	27.5	27.2	27.2	25.8	25.4	25.2	25.7	26.4	26.9	27	26.4
MEAN	**26.3**	**27.8**	**27.8**	**27.4**	**27.0**	**25.9**	**25.3**	**25.1**	**25.2**	**25.9**	**26.8**	**26.8**	**26.5**

Source: QIT Station, Exxonmobil Nigeria Ltd , Ibeno,2008

Table 4.2 Mean Annual Temperature at Ibeno in °C [2000-2008]

From Table 4.2,

The Average December temperature = 26.8°C

The maximum December Temperature (2001) = 27.6°C

2007 December average = 27°C

2008 December average =27°C

From Figure 4.2,

The maximum recorded temperature is = 28°C

The residential area temperature (Pt. 8) = 27°C

There maximum temperature is higher than previous December average values.

Plate 4.4 An Exxonmobil Staff in Safety Clothing

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1CONCLUSION

The noise level at the gas Flaring Station is within the safety standard. There is an increase in atmospheric temperature, indicating climatic variation. However, considering the contribution of gas flaring to greenhouse gas emissions, it could eventually result in climate change in the region.

5.2 RECOMMENDATIONS

5.2.1 Air Pollution Control

Air pollution should be controlled at the Federal, State and Local Government levels. The following measures should therefore be applied:

i) Public Information and Education

ii) Source Regulation

iii) Plan review and construction operation approval

iv) Set Emission Standards

v) Monitoring and surveillance

vi) Technical assistance and training

vii) Inspection and compliance follow up

viii) Conference and administration hearing

ix) Suspension of operating permit

x) Legal action –fine, imprisonment etc.

5.2.2 Noise Control Measures

i) Noise control should be done in planning a new plant or modifying the existing one

ii) The effects of the noise of machinery on workers, office personel and nearby residents should be minimised by controlling the:

   a) emission of noise (installing filters and vibration isolators)

   b) transmission of noise (town planning, plant and traffic engineering)

   c) reception of noise (safety gear and clothing)

iii) The public should be informed of the harmful effects of noise and ways of reducing noise to acceptable levels.

5.2.3 Development projects

a) A Remote Sensing and Geographic Information System -based Environmental Management Information System. This will serve as a decision support system for policy makers in the state. The system will help the ministry to among other things monitor/map changes in vegetation and land use, urban growth and development, monitor deforestation etc.

b) Geography gardens in primary and post primary schools in view of the importance of weather information on agricultural and infrastructure development.

c) Policy on tree planting and preservation of green belts within our urban areas. Also, there is need for policy to check deforestation especially within our forest reserves.

d) Policy on poverty alleviation to reduce deforestation in the coastal areas of the state

e) Policy on carbon trade to reduce gas flaring in line with Kyoto protocol

f) Improvement in public transport system to reduce the number of cars on the roads

g) Policy on efficient public power supply to reduce the use of generators.

h) In view of the awareness on environmental sustainability, there is need to exploit renewable sources of energy like biofuels among others. The Agricultural and Bio resources Engineer is well equipped for this task.

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