Economic Implications of Dust Assaults on Humans and Animals exposed to Environmental Hazards due to Air Pollution in the Dry Belt Zone of Nigeria

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ABSTRACT

Daily, humans and animals are exposed to environmental hazards due to air pollution whether indoor or outdoor. The extent, nature or characteristics of such hazards varies from one locality to another. Dust constitutes one of the important air pollutants in the dry belt zone of Nigeria (Sahel Savanna). The zone is generally characterized by scanty rainfall and vegetation cover, summering heat, incessant dust storms and harmattan, droughts and desertification, desiccating wind pattern and sandy soil textures that are prone to droughts and alarming desertification and soil degradation and deterioration brought by both natural and human forces. The open and flat topography of the region allows an uninterrupted incursion of dust particles into the region and this persist for greater part each year. There is heavy dependence on agriculture related activities leading to land degradation and desertification as a result of deforestation and denudation which further exacerbate the environmental problems. Dust storms and harmattan dust are so prevalent in this region and recently are assuming harming rate and proportion, destroying lives and property. This work is hence a review of the economic implication of dust assaults on humans and animals exposed to environmental hazards due to air pollution in the dry belt zone of Nigeria. The study highlights that the sand dunes created by such phenomena bury crops, lands, houses, water, schools, roads and animals, rendering this region almost completely unsuitable for human and animal habitation as well as agricultural activities.

Keywords: *Dust assults, dry belt zone, economy, Nigeria*

INTRODUCTION

Air free from all impurities cannot be completely found anywhere in the world. The air which we breathe is not pure oxygen but is contaminated with dust, smoke and several gases or harmful phosphorus (Sodipo, 2007). Sub-Saharan Africa and Nigeria in particular, faces several environmental challenges from air pollution and desertification ranging from encroachment of the Sahara desert desiccating wind pattern and dust storms in the north and severe air pollution in overcrowded cities, such as Lagos, Ibadan and Port Harcourt in the south, Kano, Maiduguri and Kaduna in the north, and in the Niger Delta areas, environmental challenges from oil spillage, gas flaring and deforestation. Water, food and

soil, air quality are important factors that determines the sustainability of an environment (Ikamaise, Obioh, Ofoezire and Akeredoulu, 2001). Dust constitutes one of the major air pollutants, especially in the dry belt of Nigeria (McTainsh and Walker, 1982; Middleton, 1985). Dust, according to health fact sheet report series of United States Department of Health and Human Services (DHHS, 2008), consists of a mixture of fine or tiny particles usually formed by disintegration or fracture of solid form materials. The United States Mine Safety and Health Administration (US-MSHA, 2008), defines dust as finely divided solids that may become air borne from the original state without any chemical or physical change other than fragmentation.

Dust (also referred to as suspended particulate matter) represents a complex mixture of organic and inorganic substances, solid or liquid substances and mass of inert materials. According to the United Nations Environmental Protection Agency and World Health Organization (UNEP/WHO, 1994) reports on review of methodology of management of particulate matter in ambient air, total suspended particulate matter (TSP) is used to assess air quality. Dust, together with particulate emissions such as automobile and industrial exhaust fumes and other fugitive and combustion emissions is a paradigm of synergic processes in atmospheric air pollution in the Sahel region. The particulate matters are complex heterogeneous mixture of solid particulates and liquid components such as those from power plants and industries, gas flaring, motor vehicles and natural source elements such as dust.

Air borne particulate matter is an example of solid and liquid particulate suspended and dispersed in air (UNEP/WHO, 1994). Air pollutants, especially dusts, permeate all fabric of environment through biogeochemical and anthropogenic routes (Ikamaise, Obioh, Ofoezire and Akeredoulu, 2001). These may constitute serious contaminants or pollutants when present in greater than recommended concentration. The severity of effects and contamination by the pollutants increases with intensity of emissions, sources of strength and atmospheric mixing of the pollutants and some predisposing factors (Obioh, Oluwole and Akeredolu, 1993).

The Federal Environmental Protection Agency of Nigeria (FEPA, 1991) maximum total suspended particulate air quality standard limit is 250µg/m^3. The dry belt zone of Nigeria, which is generally known as the Sahel, is defined as the area that receives between 200mm and 800mm of rainfall per year (IIED, 1989), and occupies about 65% of her total land mass, and is located within the co-ordinates of latitude 10^0 to 14^0N and longitude 3^0 to 14^0 E. Dust constitutes one of the major air pollutants (McTainsh and Walker, 1982; Middleton, 1985; Gadzama, 1991, 1995). In the Sahel region, harmattan dust and hot dry dust storm and desiccating winds, characterizes the major part of the year, usually extending from December to June (Rayar, 1996; Middleton, 1985). The dust particles are mechanically produced by the breakup of larger solid particles (US-EPA, 1996), and may include windblown dust from the Sahara desert, dust from agricultural activities, uncovered soils, unpaved roads or mineral operations, among others (Moses, 2007). As soon as the dust has been raised by wind and lifted up in the atmosphere, the coarse particles begin to be removed from the atmosphere by gravitational forces. Relatively big particles with radii

of more than 100µm will have atmospheric residence time of the order of minutes to hours, while particles of radii of 1µm or less, might remain in the atmosphere for up to weeks and transported several thousands of kilometers from the site of origin (Christer, 1998). The annual dust storm frequency as well as the magnitude in the Sahel region is on the increase at an alarming rate (Gadzama ,1991; Rayar , 1996). The zone is generally characterized by scanty rainfall and vegetation cover, summering heat, incessant dust storms and harmattan, droughts and desertification, desiccating wind pattern and sandy soil textures that are prone to droughts and alarming desertification and soil degradation and deterioration, brought by both natural and human forces. The open and flat topography of the region allows an uninterrupted incursion of dust particles into the region and this persist for the greater part each year (Dajab 2006; Gadzama, 1991, 1995; Rayar, 1996).

In Nigeria, particularly in the north, the Harmattan , dry dust-laden atmosphere, occurs from November to June each year as experienced in some other parts of West Africa (Dajab 2006; He *et al*., 2007; Gadzama, 1995; Rayar 1996). The Harmattan is known to rise in the Sahara desert and is carried southwest by winds from that area (Harris, 1967). Harmattan dust is the product of an Aeolian system of continental scale which originates in the southern Sahara and across West Africa and the Atlantic (McTainsh, 1980). Storm activities in the Bilma and FayaLargeau area in the Chad Basin were reported to raise large amounts of dust into the atmosphere, which is carried southwest by the predominant winds (Alfeti and Resch, 2000). Fugitive dust and automobile emissions result from the complex interplay between wind and anthropogenic activities that generates dust or particulate matter (PM) which is suspended in the atmosphere.

Anthropogenic activities generate dust which emanates primarily from soil that has been disturbed by wind or human activities, such as earth movement and vehicular traffic on both paved and unpaved surfaces. Generally, the entity, air particulate or dust is a mixture of particles in which differentiation exists only in source, size, composition, and properties (USEPA, 2004a, IDEQ, 2008). Movement of soil dust, comprising mineral dust and product of chemical or organic processes, depends on a variety of factors, which can be divided into two categories: firstly, movement resulting from the surface and presence of wind being strong enough to lift the soil particles into the air. The amount of dust mobilized at a given location over any given period will therefore depend on the frequency, intensity and duration of wind events in which the magnitude of the surface velocity exceeds a certain threshold value at that location (Akeredolu, 1989).

Secondly, the degree of dust mobilization occurring at a given location as a result of particular combination of climatic factors will depend on the susceptibility deflation of the soil at that location (Moses, 2007). The particular mix and concentrations of air pollutants may vary considerably from location to location, and from day to day. Particles suspended in the atmosphere may have long atmospheric resident times; these may be transported by vertical and horizontal wind currents, frequently to a great distance (McCartney, 1976). The incidences of harmattan dust and dust storms in the dry belt of Nigeria have become a recurring phenomenon and recently are assuming alarming rate and proportion, destroying lives and properties (Moses, 2007; Rayar, 1996). In general, all the regions that are situated

above 10^0N are bathed by simmering heat experiences, endless occurrence of incessant droughts, harmattan and dust storm of monumental proportions, which are brought about by an alarming rate of desertification, and thereby putting tremendous pressure on the already crippled agriculture and economy, resulting in a continued declined in the living standard of the people (Dajab, 2006; Gadzama, 1995; Rayar, 1996). This region, characterized by arid and semi arid climate pattern, consists of vegetation zones of Northern Guinea, Sudan and Sahel Savannas. In general, the arid and semi arid zones of Africa are a mixture of varying magnitude of deserts and dry lands, coupled with difficult and fragile environment that is fast becoming inhabitable (Gadzama, 1991, 1995; Rayar, 1996).

The zone is generally characterized by short rainfall, receives between 200mm and 800mm of rainfall per year (IIED, 1989), scanty vegetation cover, summering heat, incessant dust storms and harmattan, droughts and desertification, desiccating wind pattern and sandy soil textures that are prone to droughts and alarming desertification and soil degradation and deterioration, brought by both natural and human forces. Nonetheless, a short cold spell usually known as harmattan cold blows from December to February. The temperature during this period is relatively lower; thus enabling the cultivation of wheat and other vegetable crops under irrigation.

The open and flat topography of the region allows an uninterrupted incursion of dust particles into the region and this persists for the greater part each year. The scanty vegetation dictated by insufficient rainfall and anthropogenic activities and demand for wood for construction, building, fuel and other uses, removal of trees, shrubs, herbaceous plants and grass cover from the fragile land of the Sahel continue to accelerate the degradation of the soil to desert like condition, predisposes the soil to various destructive forces of nature, thus leading to its degradation of varying magnitude, thereby reducing sustainable agricultural production and ensuring the perpetuation of drought syndrome (Dajab , 2006; Gadzama, 1995; Rayar, 1996). Together with seemingly limited and erratic distributions of rainfall lingering each year, the ravaging effect of drought and desertification becomes exceedingly intensive and warrants systematic monitoring of the climatic pattern and changes so as to institute deliberate and appropriate measures to stop this ugly trend. It is presently estimated that Nigeria has lost some 351,000 square km to desertification representing 38% of its total landmass which corresponds to the eight (8) desert –threatened front line States of the country (Table 1).

Table 1: Sudano-Sahelian West Africa

Country	Population (millions - 1983)	Total Land (Area 000/sq. km)	Total Dry lands (000/sq. km)	As % of total
Benin	3.8	113	50.7	45
Burkina Faso	6.7	274	243.9	89
Cameroun	9.6	474	123.6	26
Cape Verde	0.3	4	3.5	87
Chad	4.7	1,284	1,1686	91
Gambia	0.7	11	9.6	90
Ghana	12.5	239	66.8	28
Guinea	5.8	246	2.5	1

Guinea-Bissau	0.9	36	1.1	3
Mali	7.3	1,240	1,202.5	97
Mauritania	1.6	1,031	1,031.0	100
Niger	6.1	1,267	1,267.0	100
Nigeria	93.6	924	351.0	38
Senegal	6.2	196	171.1	87
Togo	2.8	57	14.0	25
Total	168.8	7,397	5,706.9	77.1

Source: United Nation Sudano-Sahelian Office (UNSO) (1989)

Maiduguri, the capital of Borno State for example, is located in the semi arid region of the dry belt zone of Nigeria, and it has a close proximity to the Sahara desert. The open and flat topography of the region allows an uninterrupted incursion of dust particles into Maiduguri and its environs. Suspended particulate matter or dust is prevalent in this region and mostly accrues from dust storms from the harmattan winds, which blows across the Sahara desert (Gadzama, 1991, 1995; Rayar, 1996). Maiduguri dust storm in particular, which occurred on 30th May, 1988, is of grave concern to every inhabitant of this region and indeed, the entire nation (Rayar, 1996). This unsurpassed sand storm lasted for about 30 minutes, thereby causing total darkness at about 3.30pm.

It has been estimated that the magnitude of dust accumulations in an enclosed house hold yard during this storm was 45 tons per hectare (45t/ha) (Rayar, 1996). The extent of deaths, and damage or injury to human and animal health as well as damage to the environment by this single unsurpassed episode of dust storm has not yet been officially documented, but surely the consequences must be grievous. Similar episode of almost exact magnitude occurred on 30th May, 2012, exactly 24 years after. This dust storm also occurred the same time, at 3.30pm, and lasted for the same duration of time, i.e. about 30 minutes. This is of particular interest for researchers and all concern citizens of Nigeria and calls for keen and systematic scientific observation and continuous monitoring of such a natural phenomenon. It can be inferred that such a horrible dust phenomenon will probably occur again in the next 24 years, presumably on 30th May, 2036, around 3.00pm local time, and will last for about 30 minutes.

Similar episodes of dust storm of less magnitude occur on daily basis, especially between the months of January and June (Gadzama, 1995; Rayar, 1996). The sand dunes created by such phenomena destroy crops lands, houses water, schools, roads, animals, and rendering this region almost completely unsuitable for human and animal habitation and agricultural activities. Famine, diseases, poverty and hunger are amongst myriads of consequences of this catastrophe. This presents continuous prevalence of hostile and inhospitable environment to crop and animal production as well as human habitation (Gadzama, 1995; Rayar, 1996). Incidences of disease out breaks resulting directly or indirectly from such catastrophe are common in this region. Adverse health effects of dust or particulate matter (PM) are greatly associated with its size and weight (USEPA, 2004b; Nku Peters, Eshit, Oku and Osim, 2005). When such pollutants are inhaled, the coarse particles (2.5-10μm) are deposited in the upper respiratory tract and bronchi, whereas the fine particles (<2.5μm) may reach terminal bronchioles and alveoli and remain there. This

contributes to respiratory illness. The adverse effects of these dust particle deposits include acute respiratory morbidity, pneumonia, asthma, lung damage, decreased lung functions and increased mortality and premature death in sensitive individuals (USEPA, 2004b). Man breathes between $10cm^3$ and $25cm^3$ of air daily and any toxins present are also inhaled (Radojevic and Bashkin, 2006). Of main concern are the small size dust particles ranging from 0.1-3.0µm unit density sphere. These usually have high percentage passing rate through selector device and are normally deposited in the respiratory system upon inhalation, and present 60%-80% extraction efficiency into biological system (Patterson and Schroeder, 1971). Due to the complexity and varying sizes of dust and other particulate matters, a number of terms are used to describe them (Patterson and Schroeder, 1971; OSHA, 2008). Suspended particles vary in size, composition and origin. It is convenient to classify particles by their aerodynamic properties because these govern the transport and removal of the particles from the air and subsequent deposition in the respiratory system (OSHA, 2008; Patterson and Schroeder, 1971). The transport and removal of dust and other particulates in the respiratory system are also governed by their deposition rate within the respiratory system and are associated with the chemical composition and sources of particles (OSHA, 2008; Patterson and Schroeder, 1971).

The aerodynamic diameter is the size of a unit-density sphere with the same aerodynamic characteristic. Dust, therefore, in general can be differentiated or classified on the basis of composition, or with respect to size (OSHA, 2008). Dust can be classified by size into three (3) primary categories: respirable dusts, inhalable dusts, and total dusts (OSHA, 2008). Respirable dust refers to those dust particles that are small (<2.5µm) enough to penetrate the nose and upper respiratory systems and deep into the lungs. Particles that penetrate deep into the respiratory systems are generally trapped by body's natural clearance mechanism of cilia and mucus, and are more likely to be retained. The U.S. Mine Safety and Health Administration (US-MSHA, 2008) defines respirable dust as the fraction of air borne dust that passes a size selecting device, having the following characteristics (table 2).

Table 2: Aerodynamic diameter and percent passing selector of respirable dust

Aerodynamic diameter (µm)	Percent passing selector (%)
2.0	90
2.5	75
3.5	50
5.0	25
10.0	0

Source: US-MSHA (2008)

The United States Environmental Protection Agency (US-EPA, 1996) describes inhalable dust as that dust particle, which enters the body, but is trapped in the nose, throat, and upper respiratory tract. The median aerodynamic diameter of this dust is about 10 µm. Total Dust includes all dust or air borne particles, regardless of their size or composition. Dust can also be classified with respect to composition. As dust represents a complex

mixture of organic and inorganic substances, solid or liquid substances and mass of inert materials, dust composition can be chemical, mineralogical or organic in composition or source, among which may be hydrocarbons, nitrogenous compounds, sulphur compounds or other metals. The fibrogenic dust consists of fibrogenic materials, such as free crystalline silica or asbestos, which are biologically toxic. Nuisance (or inert) gas consists of mass of inert materials such as clay, silt and many more, and usually consists of dusts that contain less than 1% quartz (OSHA, 2008). Extensive research has been conducted on composition of dusts in the Sahel, including the elemental contents particularly, in Nigeria (McTainsh, 1980; Adepetu, Asubiojo, Iskander and Bauer, 1987; Adedokun, Emofurieta and Adedeji, 1989; Ayodele and Gimba, 2002; Dimari, Hatis, Waziri and Maitera, 2008) and in neighboring West African countries (Oduro-Afriyie and Anderson, 1996; Breuning-Madsen and Awadzi, 2005).

Dimari, Hatis, Waziri and Maitera (2008); Ogugbuaja and Barsisa (2001); Moses (2007), have determined monthly disposition rates and elemental contents of suspended particulate matter or dusts from Maiduguri Metropolis and environs on an annual basis with elemental enrichment factors**.** The highest mean deposition rate of 34.7/g/m^2 was recorded in April and the least deposition rates of 24.20 g/m^2 in September. The elemental analysis revealed the presence of elements such as Copper (Cu), Iron (Fe), Lead (Pb), Cadmium (Cd), Aluminum (Al), Nickel (Ni), Selenium (Se), Zinc (Zn), Arsenic (Ar) and Cobalt (Co) in varying concentrations. Also found were silt, clay, organic matters or hydrocarbons in varying proportions. These elements or the organic matters when absorbed may be toxic to the body systems (Rob, 1996).

Economic Implications Of Dust Assaults On Human And Animals

Prolonged exposure to dust or suspended particulate matter in the atmosphere has series of deleterious effects on humans, animals, as well as the ecosystem in general. Dust pollution leads to at least 500,000 premature deaths and chronic bronchitis annually in West Africa (Aukernman, 1996; Middleton, 1985). This leads to loss in productivity, huge economic losses as hundreds of work hours are lost daily due to sicknesses associated with dust exposure (Aukernman, 1996). Respiratory infections are mostly transmitted through dust in air pollution, and diarrhoea through contaminated water. This also leads to loss in productivity and huge economic losses as well as unfavourable environmental situation.

The unfavourable environmental situation does not only cause direct havoc to human and animal lives, but also causes huge damage to the general ecosystem and marine life and structures. Farmers depend on animals for their livelihood. Animals, apart from supplementing the food needs of man generate income and play a significant role in maintaining a strong agricultural economy, maintain soil fertility and soil and water conservation. In addition, animals provide an array of other useful products, such as leather, fur, essential enzymes, such as rennin, needed in manufacturing cheese and insulin used in pharmaceuticals and provides companionship, sports and entertainment. The effects of dust on animals translate to man as he eats meat and milk of diseased animals. These have incalculable economic consequences on the inhabitants of this region.

The formation and movement of sand dunes caused by the frequent harmattan dusts and dust storms engulf huge areas of arable land and rivers, destroying water ways and marine environment. The sand dunes created by such phenomena destroy crops, lands, houses and water, causing large scale water pollutions rendering it unfit for both human and animal consumption. Recently, the rapid attack of tetraoxosulphate(vi)acid (H_2SO_4) on marble buildings is known as "icstone leprosy" (Air pollution, 2007). Particulates such as dust, soot, deposit on plants leaves block the stomata of plant leaves inhibiting rate of transpiration from the soil. Water contamination especially by dust, is one of the frequent causes of diarrhoea in both humans and animals. Diarrhoea is considered to be one of the major public health problems caused by unsafe water (UNICEF, 2005. According to UNICEF (2005) report, there are approximately 4 billion cases of diarrhoea each year in Africa, causing 1.8 million deaths annually. Hence, lack of adequate safe water supply, together with poor sanitation presents severe public health, environment and economic implications in both rural and urban areas, in this region, hindering both social and economic developments (table 3).

Water contamination can basically be divided into two categories: biological and chemical. Microbial contaminations usually arise from the contamination of water with human or animal faeces carried in the dust. Chemical contaminations on the other hand are usually as a result of organic chemicals, such as Arsenic, Fluoride, Lead, Nickel, which are found to be constituents of the typical Sahel dust. These are naturally occurring elements that can be transported by wind along with dust to contaminate water, rendering it unsafe for both animal and human consumption. The dust contaminated water is unsafe for the marine animal species. Consumption of such sea foods will result in detrimental effect on health. Apart from direct adverse health effects of air pollution by dust, the dust and dust storms can also cause damage to natural environment. This includes, widespread deterioration of the ecosystem, destruction of biological potentials of the land, both plants and animals, causing substantial economic losses and social consequences, ranging from added cost of medical care and building restoration to reduced agricultural output, wide spread forest damage, huge economic consequences and generalized lower quality of life (OECD, 1984).

Table 3: Some aspects of health/social services indicators in selected countries

% of population using improved drinking water sources				% of population using adequate sanitation facilities			
Country	Total	Urban	rural	Country	Total	urban	Rural
Nigeria	60	72	49	Nigeria	38	48	30
Kingdom of Saudi Arabia	95	100	64	Kingdom of Saudi Arabia	100	100	100
Cuba	91	95	78	Cuba	98	99	95
Sweden	100	100	100	Sweden	100	100	100

Source: UNICEF (2008)

Destruction of an ecosystem changes the composition of the species and general biological potentials of the region. The dry belt zone of Nigeria, which is generally known as the Sahel, is considered one of the most sensitive and delicately unbalanced ecological systems in the world (Gadzama, 1995). Globally, desertification is now recognized in the arid and semi arid zones of the world as the major threat to ecological productive systems. The most conspicuous effects of desertification is soil degradation and deterioration mainly

by wind and water, and removal of vegetation cover through over grazing and deforestation. The cost of erosion by wind and water is estimated to be over $444billion annually worldwide due to direct damage to agricultural lands and ecosystem and indirect damage to water ways, infrastructure, and fauna and flora, humans and animals (UNEP, 1991). This impact must be of a higher proportion in sub Saharan Africa and Nigeria in particular. The intricacies and ramification of desertification leading to extensive soil degradation are well documented. In Africa alone 37% of the population is affected by desertification. In Nigeria alone, 75% of the area is in the semi arid region (Ryan, 1974) and it is estimated that more than 30 million people, representing 32% of the total population of the country lived under hardship of desertification (UNSO, 1989) (tables 4 and 5).

Table 4: Areas and Number of People affected by at Least Moderate Desertification by Region

Region	Affected (1,000km^2)	%	Affected population (millions)	% Total
Africa	7,409	37	108.00	38
Asia	7,480	37	123.00	44
Australia	1,123	6	0.23	0.00
Med. Europe	296	1	16.50	6
N. America	2,080	10	4.50	2
S. America & Mexico	1,620	8	29.00	10
Total	20,008	100*	281.23	100

*Owing to rounding, the sum of these percentages is not 100. Source: Mebutt (1984)

With the increasing pressure of desertification, exacerbated by a period of prolonged drought and human activities, it has become increasingly difficult to maintain sustainable development in the fragile lands of this region. The prolonged drought led to severe crop failure, famine and wide spread devastation of the environment. In general, the arid and semi arid zones of Nigeria are a mix of varying magnitude of deserts and dry lands, coupled with a difficult and fragile environment that is fast becoming inhabitable (Rayar, 1996, Gadzama, 1995). The arid and semi arid regions witness a short rainfall followed by a prolonged, dry spell ranging from 6-9 months, that is further punctuated with a very high temperature regime and desiccating winds pattern (Rayar, 1996; Gadzama, 1991). Nonetheless, a short cold spell, usually known as harmattan, blows from December to February. The temperature during this period is relatively lower, thus enabling the cultivation of wheat and other vegetable crops under irrigation.

Table 5: Estimated Area and Population of some of the Semi-arid Tropical Countries in Africa

Country	Portion of country SAT	Semi-arid area (1,000km^2)	Population SAT (million)	% Total SAT Population
Sudan	60	1,491	15	3
Nigeria	75	693	42	8
Tanzania	60	752	10	2
Zambia	100	753	4	1
Mali	60	721	5	1
Niger	40	507	4	1
Chad	40	514	3	0.5
Botswana	100	569	1	0.2

SAT = Semi Arid Tropics. Source: Extracted from Ryan (1974).

The scanty vegetation dictated by insufficient rainfall, predisposes the soil to various destructive forces of nature, thus leading to degradation of varying magnitude, thereby ensuring the perpetuation of drought syndrome (Rayar, 1996). Together with seemingly limited and erratic distribution of rainfall lingering each year, the ravaging effects of drought

and desertification become exceedingly intensive and warrants systematic monitoring of the climate pattern and changes. An urgent need is required to institute deliberate and appropriate measures to stop the ugly trend. Natural sources of air pollution may result from sand or dust storms, harmattan winds, hurricanes or as direct consequences of soil or wind erosion (Gadzama, 1995). The dust particles are mechanically produced by the breakup of larger solid particles (US-EPA, 1996), and may include windblown dust from agricultural processes, uncovered soils, unpaved roads or mineral operations, among others (Moses, 2007). The open and flat topography of the region allows an uninterrupted incursion of dust particles into the region and this persist for a greater part each year.

Annual dust storm frequency and magnitude in the Sahel is on the increase at an alarming rate (Gadzama ,1991; Rayar ,1995) . The incidence of dust and dust storms in the Sahel region of Nigeria are so prevalent in this region and recently are assuming an alarming rate and proportion, destroying lives and properties thereby putting tremendous pressure on the already crippled agriculture and economy, resulting in a continued decline in the living standard of the people (Rayar, 1996). One of the formidable and debilitating factors that threaten the survival of people in Northern Nigeria is the formation and movement of sand dunes that engulf huge areas of arable land every year (Rayar, 1996). The occurrence and reoccurrence of such natural calamities, which are rather intensified by human and animal forces, could perhaps be explained on the premise that loose and unprotected soil particles are lifted up by the convection current of the gusty winds, and carried away to far away locations, resulting in loss of incalculable quantities of top soil and plant nutrient (Rayar, 1996, Gadzama, 1995). This unusual phenomenon has actually propelled the researchers to think seriously how catastrophic it would be, if our soils are left without adequate vegetative cover.

CONCLUDING REMARKS

In the dry belt zone of Nigeria, the main air pollutants are derived from the incessant perennial harmattan dust and dust storms. This is further exacerbated by alarming desertification and soil degradation and deterioration, brought by both natural and human forces, leading to huge economic losses and colossal damages to precious monuments and the ecosystem. Historically, land degradation has been responsible for the fall of great civilizations, because the environmental quality is part of our natural wealth (Daily, 1995), and therefore this merits serious attention to save this life-sustaining natural resources. Incidences of disease out breaks resulting directly or indirectly from such catastrophes are common in this region leading to colossal loss of lives, heavy economic loss and hundreds of work hours. People in this part of the country are in a state of total despair because of the emotionally draining episodes of environmental havoc. The unfolding cumulative effects are constant decrease in real per capita income, declined nutritional improvement and reduced longevity, high mortality, constant dwindling of economic and educational status and continuous destruction of social welfare amenities. Apart from inflicting diseases on humans and animals, dust storm and harmattan dusts also destroy precious monument and other valuables like clothing, paints, electrical contacts, textiles, computers and other

electronics, chemicals and reagents, automobiles or vehicles. It also has adverse effects on atmospheric properties, solar radiation and temperature alteration and reduces visibility, resulting in aircraft and automobile accidents. These and many other effects of dust present continuous prevalence of hostile and inhospitable environment to human existence as well as crop and animal productions. The economic and social stability of any nation or community hinges to a greater extent on the economic as well as environmental and sustainable soil productivity and agriculture on a long term basis (Rayar, 1955). Thus, the possibility of raising the living standard and productivity of the inhabitants of this region is becoming increasingly bleak (Primental *et al*, 1995). Hence, the urgent need to institute deliberate and appropriate measures to stop this ugly trend.

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