



## Minimisation of Environmental Damages Caused by Bushfire in Nigeria: Case Study of Northern Nigeria

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*The aim of this seminar is to evaluate and minimize the dangers caused by bushfires on our environment. The environment can be defined as the surroundings and conditions in which people, animals, and plants live. The natural world is a virgin geographical surrounding, a person's physical surrounding is a place he lives comfortably without any damage to equilibrium surrounding conditions and forces such as soil, climate, and other living things. Therefore, we can summarily define environment as a sum of all living and non-living elements and their effects that influence human life while all biotic elements are animals, plants, forests, fisheries, and birds and abiotic like water, land, sunlight, rocks, and air. The method involved the use of questionnaires to gather primary data and the use of secondary data collections like webinars and journals. The findings show that human beings and activities caused enormous effects and dangers on the environment by burning bush. The result suggests some variables that reduce bush burning and dangers to the environment, especially in northern Nigeria. Conclusively, bushfires must be discouraged, and laws shall be enacted to support the abolishment. Public enlightenment must be radically engaged on the dangers of bushfires to the environment, especially in the northern area of Nigeria.*

ABSTRACT



**Keywords:** Bushfire; Environmental Damages; Public Enlightenment; Northern Nigeria

## **Introduction**

Environmental damages caused by bushfires in the northern region of Nigeria were traced to Population explosion, industrialization, urbanization, and intensive damage by agricultural activities. Man's ignorance of the laws of nature and his over-exploitation of natural resources have further aggravated the problem of environmental degradation and damage. Fortunately, during the last few years, the world has started realizing its past mistakes and began to make amendments to prevent further degradation of its environment. Environment means the surroundings in which we live. It is a life-sustaining system in which various living beings like animals, including man, birds, insects, micro-organisms like algae, fungi, protozoa, amoeba, and non-living beings like air, water, and soil are interrelated. The earth is a wonderful planet that has perennial sources of water to quench all thirst. Its atmosphere supplies pure air for him to breathe and has a natural ozone umbrella that protects him from the sun's dangerous ultraviolet rays. It has a green carpet to utilize the carbon dioxide that we exhale to recycle into oxygen essential to sustain life on the planet. The atmosphere, Lithosphere, and Hydrosphere formed the Biosphere in which the life of man, animals, and plants exists. The biosphere is not only a source of life-sustaining elements but a sink into which all waste products are dumped. From time immemorial, the biosphere discharges its duty of recycling waste products to recompensate loss so that every generation finds the biosphere the same as the one before it. Primitive man ate uncooked food available from plants, birds, or animals within his reach. He ate the raw meat. He drank the water from the rivers. He lived in caves or huts made of mud, wood, and leaves of some trees, everything natural, this living never polluted the environment. When Promethean life began, man's travails began and resulted in environmental imbalances and degradation. Man discovered fire not only to cook food but also as a weapon to destroy the neighbor and this led to a series of air pollution and disasters that affect millions all over the world (Bhat, et al, 2001).

Moreover, Man's environment is under constant threat from his activities. Man's expanding population is the biggest challenge to the quality of the environment. The developments in industrial and agricultural sectors to provide food and other basic amenities to the increasing population have further deteriorated the environment. Uncontrolled mechanization, overexploitation of natural resources, deforestation, and extensive use of chemical fertilizers and pesticides have brought about many changes in different components of the environment. On the other hand, nature has been striving hard to compromise with man to bear the onslaught of his activities. Nature gave warning signals to man in the form of droughts, floods, and unbearable hot temperatures in many countries of the world. The human population started increasing beyond the limits that the natural food supply can care for. The development and overactivity in machinery, fertilizers, and pesticides application caused a lot of danger to the environment. Overgrazing, widespread destruction of forests, and intensive wood/firewood harvest (deforestation) denuded the land and converted productive regions to barren areas.

## **Statement of the Problem**

Bushfire is common, especially in most developing nations including Nigeria, commonly noticed during the dry season. As more land, vegetations are natural grasses are being dried up which extremely will give rise to, bush burning which has become a challenging factor in the human environment. Northern Nigeria fell in the tropical belt where extremely hot temperature is common. Global warming due to greenhouse effects recently contribute to more temperature increase.

In many Northern Nigeria areas, the attitude of bush burning (bushfire) becomes a major cause of the depletion of soil nutrients. In northern Nigeria, uncontrolled and indiscriminate bush burning has become a common yearly occurrence during the dry seasons. This is caused by human activities such as farming, hunting, trapping, and seeking fresh fodder for cattle consumption. In this area, indiscriminate bush burning as a norm need to be discouraged. It causes large-scale destruction of the forest and bush life resources. It destroys beneficial crops, animals, microorganisms, insects, birds, reptiles, and mammals. Most of the area burnt experiences many economic losses, pursuing animals away from their place of inhabitation.

## **Aim and Objectives**

This study aims to ascertain how the environmental damage caused by bushfires could be minimized in Northern Nigeria. This aim will be achieved through the following objectives:

- I. Developing socio-economic characteristics of the respondent in northern Nigeria.
- II. Analyzing the causes of bushfires in northern Nigeria.
- III. Developing methods to minimize the damages caused by bushfires in northern Nigeria.
- IV. Assessing the total number of fire outbreaks between 2016-2020 in northern Nigeria.

## **Research Questions**

- I. What is the socio-economic characteristic of the respondents in northern Nigeria?
- II. What are the main causes of bushfires in northern Nigeria?
- III. What are the best ways of minimizing the environmental damages caused by bushfires?
- IV. Analyze the extent of damage caused by bushfires in the region.

## **Literature Review**

### **Conceptual Review**

#### **Environment**

There have been different definitions of the concept of 'environment' preferred by different scholars and organized bodies/agencies. However, from whatever angle one perceives the term 'environment,' it simply depicts what surrounds us. To Bras. and Zootec (2012), environment refers to the "total of all conditions that surround man at any point in time on the earth's surface". According to Amigun (2000), the term 'environment' could be perceived as 'the aggregate of external conditions that influence the life of an individual or population, specifically the life of man and other living organisms on the earth's surface'. The Federal Environmental Protection Agency (FEPA) Act of 1990, under section 38 also gave a clear definition of environment, thus; Environment includes water, air, land, and all plants and human beings and/or animals living there and the interrelationships which exist among these or any of them.

The primitive farmers use fire to clear parcels of farmland, modify the soil by plowing, alter the drainage by irrigation, and introduce or breed new animals and crops. These activities no doubt alter the natural vegetation of the environment. [Bedel et al. \(2013\)](#) pointed that "in recent times, humans have destroyed enormous tracts of natural vegetation, excavated large areas of land, modified the landscape, and even created new lands. The economic importance of vegetation to humanity cannot be underestimated. Apart from the fact that it serves as a primary source of food to man, it provision of the resource base to the building, manufacturing, and pharmaceutical industries, note that in northern Nigeria region, primitively, Fire is used to clear land in preparation for farming (Fischer et al., 2016). The use of fire to clear land either for farming and/or hunting activities produces secondary problems associated with deforestation, which aids erosions by wind, water, and flooding. Continuous and frequent burning often reduces the capability of an area to regenerate itself and to replenish its natural vegetation, exposing also lands and rock to direct sun rays which increases underground poisonous gases release and inflict the atmosphere with severe pollutants, thus endangering life and property as well as threatening the very survival of the environment, ([Murray et al 2013](#) in *Ayia, 2009*). The simple fact is, whatever reason one may adduce for indulging about bushfires, it is submitted that the practice is dangerous to the environment and must be discouraged with all vehemence.

More so, its consequences far outweigh its advantages. This practice is mostly common among rural farmers in the Northern and North-central region of Nigeria. Livestock farming, popularly referred to as domestication of animals which is commonly practiced in the Northern and North-central regions of Nigeria also has a major polluting impact on the land surface. Heavy grazing of cattle leads to trampling and compaction of the soil, thus reducing its capacity to hold water and altering its structure at the same time. This leads to soil erosion by wind and water. Although, grazing may have positive effects on the land because the animals provide feces, a natural fertilizer rich in nitrates

and several other nutrients. These fences are sometimes washed into the streams and rivers during rainy seasons which serve as sources of drinking water for most farmers in the rural areas and thus, constitute health hazards-outbreaks of cholera, etc. Similarly, the rate at which our forest resources are depleting is alarming. This deliberate removal of forest to create new agricultural land and/or for other purposes deprive us of the wealth of diversity and the potential use of many of their unique biological compounds often of great medical value. This act also upsets the nutrient cycles, especially the oxygen and carbon dioxide cycles of which trees form a vital component.

The effect of bushfire leads to deforestation and may increase water flow over the land's surface, as rain will fall directly to the ground, no longer being impeded by the vegetation cover. This practice may lead to an increase in the magnitude and frequency of flooding, soil erosion increased sediment loads in rivers, slope instability, and degradation of adjacent lands. Examples include forest clearing in southern, western, and eastern Nigeria, clearing of tropical rainforest in Colombia, the destruction of rain forest in Madagascar, etc. Bushfire clearing leads to vegetation removal which increases the infertility of land and subsequently desertification (Bhat et al, 2001). Rural farmers sometimes out of ignorance, over-fertilize their farmlands because they are not aware of the nutrient content of the soil upon which they farm. This practice also damages the soil tops and results in poor yields with excess nutrients sinking into ground water. In another development, the indiscriminate use of pesticides and herbicides chemicals against pests, weeds, and mosquitoes by farmers and households has caused serious problems (Ali et al., 2013).

Many pesticides and herbicides move through the air, water, and soil and bioaccumulate or bio concentrate in food chains leading to serious ecological and human health problems. Hunting is also one of the human activities that often result in bush burning and the use of chemicals in our streams, rivers, and seas in search of game and fish. In the most general sense, hunting is the pursuit of a target to kill animals (Ali et al 2013). It is commonly applied to the practice of pursuing animals to capture or kill them for sports, food, or trade in their products. Animals so hunted are referred to as game animals. Hunting is also done to control varmint populations or wildlife management to reduce animal populations that have exceeded the capacity of their range or when individual animals have become a danger to humans. Sometimes they are captured and kept in zoos and wildlife parks for tourist activities and cultural carnivals. Various devices are used to capture and kill the animals. Many hunters use dogs, traps, spears, arrows, guns, knives, etc. Plants, and animals, including fish and birds, are hunted for by man. The methods employed create a lot of negative impacts on the environment (Ali et al 2013). For instance, bushfire depopulates animals, generates smoke for an unhealthy environment which consequently affects human life, and this practice is common in the tropics – hunters gain these advantages and use the avenue to drive animals from their locations. The rural Tiv people of North Central Nigeria use this device to hunt for rats and other animals. The result of this is that sometimes it destroys lives and property, especially when the fire is out of control. Smoke from the fire (bushfire) also contaminates the air, land, and water. The first thought that might cross our minds when talking about a wildfire is the image of destruction, pain, and suffering (Ali et al., 2013).

### **Bushfire**

Bushfire is a fire that spreads over a minimum area of one hectare, where one or more types of vegetation are concerned. Several terms were used across the globe to describe vegetation fires in areas outside the urban environment ([Murray et al \(2013\)](#)). In the United States, bushland fire defines as “any non-structure fire that occurs in the bushland and includes bushfire, bushland fire use, and prescribed fire.” In Australia, the term bushfire with even bushfire is being used to describe any vegetation fire, whereas the generic term bushfire describes “any unplanned vegetation fire, including grass fires, forest fires and scrub fires (Ali et al 2013).” The term bushfire is currently used by the European Commission Joint Research Centre Institute for Environment and Sustainability, already found in their annual report on fires in European countries. In Canada, forest fires and bushfires are defined by the Canadian Interagency Bush Fire Center. According to them, bushfire is “any fire or prescribed fire that is burning in bush areas, grass, or alpine/tundra vegetation,” while bushfire means “an unplanned or unwanted natural or planned/human-caused fire, as contrasted with a prescribed fire.” In this review, we considered and discussed all these described fires except for the prescribed fire ([Murray et al, 2013](#)).

Bushfires occur worldwide, but in the United States alone there are an estimated 60,000–80,000 wildfires per year according to the National Interagency Fire Center (NIFC) in 2015. Worldwide bush areas are presenting a fluctuating trend over the years. Before the Industrial Revolution (1760–1840), almost half of the terrestrial surfaces were covered with bush (i.e., 5.9 billion hectares). In 2000, while a further decline was expected, it was found that bush areas increased from 2.5 to 4.08 billion hectares. It was the consequence of major reforestation efforts. Anyhow, in 2010, these areas decreased by 50 million hectares which shows an increase in bush burning decline and afforestation ([Murray et al., 2013](#)).

Currently, several countries are researching fire management systems, such as Canada, South America, Mexico, and South Africa. On a global scale, different systems are present to map and forecast near real-time event information (e.g., Global Fire Monitoring Center (GFMC), Experimental Climate Prediction Center (ECPC), Global Fire Information Management System (GFIMS), Global Early Warning System for bushland Fires, etc.). Their purpose is to reduce the bushfire risk. Fire and forest management institutions should enlighten local communities that the best way to stop a bushfire is to make sure it never starts ([Murray et al., 2013](#)). For the reasons outlined above, an identification of the causes behind the ignition of the bushfire is crucial to protect and save the forest. The bushfire likelihood, commonly confused with the bushfire hazard, has been determined via different types of factors and methodologies. In this report, we discussed the diverse approaches used in the literature worldwide (Historical). Then, we pinpointed each factor found throughout the collected references. It is important to note that ignition factors, defining the probability of ignition or burning, are required ([Murray et al., 2013](#)).

## Factors for Fire Ignition in Nigeria

### Climate in Nigeria

**Precipitation:** Precipitation is one of the elements of weather used to predict fire occurrences because of its direct relationship with fuel moisture content within plant ecosystems. In Nigeria, there is a well-defined dry season, which is a period of low or no precipitation. The length of the dry season varies with different vegetation types in the country. The dry season periods extend from 7 - 8 months in the northern part of the country to only about one month in the wet coastal areas of the country. The length of the growing season (rainy season) is usually short in the Tropical-savanna region of the country. The number of rainless periods is long and is recently increasing with hot temperatures. The decrease in the number of rainy days has been increasing to drought and storms (floods); drought because of the reduction of the growing season of plants due to lack of rainfall and storms because of the spread of the total annual rainfall has been shortened resulting in higher rainfall per day (Abdulkarim and Maikano, 2015). The dry season starts in August in some parts of northern Nigeria before spreading to the rainforest zone in November.

### Temperature

The study of temperature characteristics in northern Nigeria during the dry season. The mean dry season temperature in parts of northern Nigeria is normally about 36 °C. At Kaima (rainforest reserve) a mean maximum temperature of 38.1 °C was obtained in the 2009/018 dry season which was the highest since 2000 (Nigeria Weather Meteorology Agency). Temperature affects the drying factor of plants, soils, and animals. It affects the evapotranspiration process, it also speeds up the rate at which dry combustible plant matter is made available for ignition (Ani 2014).

### Relative Humidity

Relative humidity follows the rainfall pattern: it is high during the rainy season and low during the dry period. Humidity as low as 20% was obtained in the derived tropical-savanna zone of Yobe State-Portiskum, and the high savannah zone of Machina bush life had humidity as low as 22%. Relative humidity has commonly been used in temperate countries to give a quick assessment of the degree of fire danger. Air relative humidity influences the state of dryness of combustible plant matter. Increased human activity in the zone in the past few years particularly massive clearance (for farming and other activities) has increased and adversely affected the microclimate of the area (Arnold, 2006). The zone now has a ready-fire climate and has been seriously predisposed to bushfires. On the other hand, burning is impeded by the moisture content of vegetation at the time of burn (Arnold, et al 2006) and by the relative humidity of the surrounding air. Burning across the Northern Nigeria region is enhanced by the drying

up of vegetation by dust-laden, dry-seasonal north-east surface winds (Harmattan) that render vegetation vulnerable to burn in the dry season.

Pollution caused by smoke, particulate matter, and gaseous emissions is detrimental to human health (Schmerbeck and Kraus 2015). During annual vegetation burns, substantial amounts of carbon dioxide (CO<sub>2</sub>) and other greenhouse gases are emitted into the atmosphere. These greenhouse gases absorb and re-emit radiation (within the thermal infrared region) from the earth's surface, a process that results in the warming up of the earth's atmosphere thereby affecting the global climate (Schmerbeck and Kraus, 2015). Each greenhouse gas has a different warming potential. For instance, a unit mass of N<sub>2</sub>O has 310 times the global warming potential (GWP) of a unit mass of CO<sub>2</sub>, while CH<sub>4</sub> has about 21 times for a time horizon of 100 years (Montiel and San-Miguel 2009). The higher the quantity of atmospheric greenhouse gases, the stronger the warming of the global climate. Since vegetation removes CO<sub>2</sub> from the atmosphere during the process of photosynthesis, plant destruction during annual fires also results in the removal of the natural consumption for CO<sub>2</sub> capture from the atmosphere and subsequent assimilation into plant tissues.

The consistent annual bush-fire carbon-sink removal through burns and the related direct carbon and greenhouse gas emissions into the atmosphere, therefore, contribute to the observed changes in the global climate. Agricultural losses due to bushfires are diverse (Andersson et al., 2004). Fire results in the abrupt physical destruction of vegetation and its related ecosystem function (Andersson et al., 2006), and it results in the direct loss of plant and animal life. Bush burning also results in the direct loss of essential plant nutrients (N, P, K, Ca, Mg, Na) (Andersson et al. 2004). In the northern region of Nigeria, bush fire has been suggested to be a reason for the observed decline in soil fertility (White et al., 2011). Nutrient-rich ash that remains after vegetation burning may be transported from the burned sites to other areas through surface erosion losses, it may be leached to lower horizons beyond plant root zones (Stark, 20003) or may be carried along by runoff and wind to different sites, resulting in a local loss of plant nutrients.

Temporal loss of plant nutrients manifests in reduced plant growth, degraded soils and environment, and unsecured future food production. The demerits of annual fires far outweigh their merits (White et al. 2011). Across the tropical areas of northern Nigeria, only a few studies exist relating plant nutrient losses due to bushfires to their consequences for soil degradation and the foreseeable impact on food security. The available studies often omit some aspects of the loss quantification parameters and are not complete. For example, very serious dry-season bush burning across the northern region of Nigeria is observed between November and March of each year, Wilkinson and Boulding (2003) estimated net annual bushfire losses for N, P, and K in the northern region of Nigeria to be about 10-22 kg N/ hec , 1-7 kg P/ hec and 2- 12 kg K/ hec, based only on a 2-month estimation (December and February). Annual nutrient loss based on two months of data serves as a proxy for predicting the annual. If data on nutrient losses during a wildfire in November and January could add as above, therefore a clearer picture of the seasonal variations in fire-induced elemental losses is crucial. Bushfire nutrient losses need to be quantified for the entire period when the fire occurs to project the potential depletion of the soil nutrients resource against the background of the expected increase in food demand for the ever-increasing human population. The temporal cumulative effect of annual vegetation burns and the related plant nutrient losses should have detrimental effects on current and future soil productivity parameters across the region.

### **An Ecological Perspective of Change and Development**

The tropical-savanna areas of Northern Nigeria were identified as the region with the highest occurrence of wildfires around Nigeria. Bush burning is known to take place during the dry season (November to March), and large areas of natural vegetation are annually burned in the process. The fires have both natural and anthropogenic causes (Sheuyange et al 2005). They are affected by environmental, seasonal climate, and geophysical conditions such as moisture, relative humidity, wind speed, and ambient temperature. Ignition by lightning is the main natural cause of bushfires. Anthropogenic activities such as seasonal land clearing for farming and hunting (Sheuyange 2002) are reported to be the main cause of bush burning across northern Nigeria. Farmers burn vegetation covers during land preparation, for weed control, to rid the land of crop debris, and to remove rubbish. Arsonists may set vegetation on fire indiscriminately, while nonchalant smoking cigarettes discarded irresponsibly initiate fires across the region.



Van Stroppiana et al. (2000) reported that the anthropogenic source of vegetation fire accounts for over 70% of all fires across northern Nigeria.

**Reasons for Bushfires:** When drought causes dryness, after every bushfire, if investigation from technical and organizational institutions properly carried out will reveal the reasons and consequences of the bushfires.

Forests can be divided into 3 categories by the types of their trees and undergrowth:

- i. deciduous forest (oak, beech, poplar trees).
- ii. coniferous forest (pine trees, juniper bushes).
- iii. mixed forest (mixture of deciduous and coniferous species).

Bushfires' ignition and spreading parameters of various forests are different. The undergrowth of a deciduous forest has more humidity, so it does not catch fire easily. But there is a high resin content in the leaves and trunks of coniferous trees causing easier kindling and burning, this bush is dryer. Approximately 75% of forest fires happen in pine woods and only 25% in deciduous forests. Concerning the reasons and consequences of bush fires the following categories can be investigated in detail: abiotic factors; biotic factors; economic factors; human factors; amount of daily sunlight; atmospheric conditions; prevailing wind speed and wind direction

**Abiotic Factors:** The amount of precipitation and temperature are the key components in the development of bushfires. Relief forms on the surface are also important because fires in general can rapidly spread from lower terrains uphill. Also, ragged surfaces with rifts, rocks, or watercourses can stop vegetation fires. Biotic factors: Populations of species and interactions among the individuals are the key aspects during forestation to select proper tree species. It is especially important in our country to handle coniferous species with care, because they are affected by fires the most, and influence the range and seriousness of forest fires. The age of forests, quality and quantity of undergrowth, and thickness of dead fallen leaves are also important biotic factors.

**Economic factors:** The neatness of the bush, and the clearness of bush passages, tracts, and trenches are important because the bush becomes more open and transparent this way. Woodcutting and burning also affect bushfires.

**Human factors:** One of the common reasons for bushfires is inappropriate and uncontrolled human activities. Most of bushfires start because of human faults and carelessness. Characteristics of bushfires and their Impact on the Environment AARMS (2016) said fire can only occur when three basic elements like oil/gas, air, and ignition occur, which means fire cannot occur even in the absence of one of these factors. Some of the most common human activities causing bushfires include: forbidden or irregular firing; growing tourism by car or motorcycle; smoking in the bush; burning of agricultural waste or burning during clearing for farming. Some Categories of bushfires are based on tree and other vegetation species, they are: underground burning, peat fire; fire in the undergrowth or dead fallen leaves; fire in seedlings and saplings; fire in trunks and shrouds.

**Underground Burning** occur where peat layers can be found beneath. In most cases under-composed organic material enriched in the upper layers of soil burns without flames. These types of fires are rare, but when they happen, they can last long and can spread onto large territories. Their spreading speed is slow, some centimeters or a maximum of a few meters per day. Flames spread directly on the surface vegetation (dry grass, dead fallen leaves, twigs, etc.) burning the lower parts of the trunks and roots above the surface.

**Undergrowth fire** can be divided into 3 categories based on their spreading speed ( $V_t$ ) and flame height ( $H_f$ ): (1) weak, if  $V_t \leq 1$  m/min and  $H_f \leq 0.5$  m; (2) moderate, if  $V_t \leq 1-3$  m/min and  $H_f \leq 0.5-1.5$  m; (3) strong, if  $V_t > 3$  m/min and  $H_f > 1.5$  m. The spreading speed depends on wind speed and wind direction. Spreading in the wind direction is 6-10 times quicker than in a headwind. Based on their duration we can distinguish running fires and persistent fires. Running fires burn down the dry vegetation close to the surface. Plants with higher water content and deeper, humid soil layers are not affected. Running fires can be formed by high wind speeds and spread rapidly. Persistent fires in undergrowth spread slowly because of a low wind speed and not only surfaces are burned, but fires also spread in the upper mold layers with glow and dense smoke. Fire on Seedlings and Sapling: In case of persistent fires in the undergrowth, additionally smaller trees, and bushes can catch fire. In sapling areas of forests in the presence of

heavy winds spreading speeds can reach 500 meters per hour. In most cases spreading has an irregular form; the burnt area grows radially.

**Fire on Trunks and Shrouds:** During dry or drought periods, fires in undergrowth can grow to fires on trunks and even on shrouds. Their common feature is that fire spreads not only on the ground, but on trunks, leaves, and shrouds of bushes and trees, with the burning of leaves, twigs, and bigger arms of the trees. Consequently, trees die in most cases. Additional fire in undergrowth can be formed during fires in shrouds, this time the burning of undergrowth is part of the shroud fire. Three categories can be described based on the horizontal speed of fire spreading ( $V_t$ ): (i) weak, if  $V_t < 3$  m/min; (ii) moderate, if  $3 \leq V_t \leq 10$  m/min; (iii) strong, if  $V_t > 10$  m/min. Based on their behaviour in time it can be also divided into two groups: running and persistent shroud fires. A running shroud fire can be formed in case of heavy, stormy wind. Spreading of fire happens with “jumps” among shrouds this way being far ahead of the accompanying undergrowth fire. In general, the fire starts within the undergrowth, then lower parts of the shrouds heat up, begin to burn, and the fire spreads in the shrouds with the help of the wind.

In case of persistent shroud fires, they spread among the shrouds, but the ground surface burns down, too. They can be formed with weak winds. After this kind of fire trees are heavily burned, charred, and can fall. When grouping forest fires, we must make differences based on the types of affected territories. Because of their unique features, we can talk about forest fires on plains and in mountain areas. Forest fires in mountains are extremely dangerous, because of the high resin content of coniferous trees the speed of spreading can be 2–3 times quicker than in deciduous forests. Fighting against forest fires in mountains can be more difficult because of the rough terrain and rare water sources. Size of Forest Fires Forest fires can also be categorized by their sizes, based on the affected areas.

#### **Effects of Bush Fires on the Environment**

Effects of Bush Fires on the Movements of Air Differences in air pressures between geographical points are equalized by significant and continuous movements of air. Shuwani, (2009) This movement shows a form of unperturbed flow in the absence of external effects. A bush is an obstacle, so the moving air changes its direction and form after a collision. It can be observed on the windward side of the forest that the wind blows through the fringe of the forest depending on the wind speed, the density of the forest, and the surface relief. If the wind direction is perpendicular to the fringe of the forest, it always blows through a larger area. On the opposite side of the forest, a shadow zone can be observed, where the air movement is less intense. Its size depends on many factors, in general, 6–10 times larger than the affected forest area. Wind speed beyond the shadow zone is equal to its speed in front of the forest.

Abijahi (2000) In addition to the above-mentioned effects, surface relief, large objects on the ground, vegetation, effects of large fires, and other factors can disturb the unperturbed wind flow resulting in whirling movements. This is the so-called “turbulence” that has significant effects on the use of fire-fighting aircraft in low altitudes in case of forest fires and the spreading of smoke. Mechanical turbulence. Unevenness in the shroud level of the forest, cuttings, clearings, and the fringe of the forest together force the disturbed air into a whirly movement with the horizontal axis. These mechanical turbulences in low altitudes can cause danger to the fire-fighting aircraft, but their predictable presence and moderate airflows allow the pilots to handle them securely. Aini (2008) The harmful effects of forest fires on different elements of the environment promptly. Whether the fire is natural or synthetic; it can disturb and strongly change the structures and functional processes of forest ecosystems. The consequences of fires are hard to describe in general because they are functions of their characteristics. Some of these are the frequency of their repetition in time, the volume of fires, and their intensity (fire on dead fallen leaves, on shrubs, or treetops).



## **Theoretical Framework**

### **An Ecological Perspective of Change and Development Theory**

An ecological perspective of change and development: The theory is concerned with issues of change and development in contemporary societies, especially as they relate to environmental changes and ecologically related trends of population growth and the need to devise and sort out techniques for tackling development problems. The theory states that, as the population of a society increases in size, individual members of the society exert more pressure on scarce available resources such as land and other natural endowments for survival. Human activities directly or indirectly pollute the environment and further cause harm (degradation) to the environment. For instance, as the population of a society outgrows the available resources, especially in northern Nigeria, people are forced to migrate to urban cities in search of job opportunities. Some sell their labor, whereas some engage in several other commercial and agricultural investments such as livestock; some still carry out some technical and entrepreneurial businesses – all for survival.

The urban and city dwellers establish and carry out industrial activities that equally pollute society, all these activities pollute the environment with its attendant consequences on biodiversity. In northern Nigeria, there are reported cases of wildfires dotted across the region resulting in the loss of agricultural lands and forestry (Danthu et al., 2003). The lack of capacity in predicting and forecasting fire outbreaks in the region is quite consequential, leading to loss of lives and property. A lot, therefore, must be done to improve the situation, especially in the areas of record keeping and adoption of early warning signals. Therefore, this research compiled active wildfires produced by using satellite imagery between late 2016 to 2018 for countries in West Africa and compared this with northern Nigeria's efforts in reducing the menace of wildfire outbreaks in the region.

Wildfire occurrence is a combination of evaporation and transpiration. Higher evapotranspiration increases the likelihood of a wildfire. A steeper slope means that fire burns not only at high speed but more vigorously. In addition, heat transfers by convection are encouraged. More importantly, a slope can change the soil infiltration properties by reducing the amount of interception material that protects the soil against the impact of raindrops and slow runoff. Various aspects result in different vegetation covers, temperatures, and illumination times. The likelihood of a wildfire could be affected by the extent of various aspects. South and southwest aspects are the regions with the highest probability of wildfire occurrence. As elevation increases, both precipitation and humidity increase while temperature decreases, and the vegetation cover becomes sparse. The likelihood of a wildfire is low. Fuels constitute the organic matter needed for the ignition of a fire. They represent one of the factors that are included in forest fires assessment and a factor that humans can control (Jabiler, 2008).

### **Methodology**

A survey research design was adopted for the study. A primary source of data was adopted for the study. Data were collected through questionnaires, observation, and oral interviews. The study was conducted in Kwara state North Central Nigeria. The method of questioning used is the semantic differential type such as: Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. The population of this study consisted of eight (8) local Government areas (Asa, Baruten, Edu, Ekiti, Ifelodun, Ilorin, Ilorin-East, Ilorin-South). It consists of 201 management and top senior staff of the eight LGA and a total of eighty (80) samples size are selected from the (8) local Governments. The sample size was determined using Yamane (1973) a standard statistical formula. The data were analyzed using Pearson Product Moment Correlation Coefficient (rs) used to analyze the hypotheses with the aid of a statistical package for social sciences (SPSS 20.0).

### **Socio-economic Characteristics of Respondents in the Study Area**

This sub-section discussed the findings of research under the following headings: gender, age, fire experience, and occupation as shown in Table 1 above.

**Table 1:** Socio-economic Characteristics of Respondents in the Study Area

<b>Variables</b>	<b>No. of people</b>	<b>No. of respondents</b>
<b>Gender</b>		
Male	110	100
Female	90	84
<b>Age:</b>		
<30	15	13
31-40	110	104
41-50	50	45
Above 50	25	22
<b>OCCUPATION</b>		
Farmers	93	93
Hunters/Business	92	91
<b>Fire Experience</b>		
Male	110	100
Female	90	84

**Source:** Field survey 2022

Table 1 shows that the majority 50% of the respondents who admitted that bushfire caused a lot of damage were male, about 42 percent of them were female, while others of the total sample size did not respond.

### Age

Table 1 shows the number of years that the respondents had spent witnessing/experiencing bushfires in the study area ranging between 31 to 40 years predominance with 56.5 percent. Also, 24.4 percent of the respondents ranging between 41 to 50 years old while only 12 percent were above 50 years old and about 7.4 percent of them indicated less or equal to 30 years old. It was observed that age has a significant and positive effect on the respondents to give a detailed and historical account of bushfire outbreaks and damage in the study. Thus, aged people 30-40 years had more experience and historical records of bushfire occurrence in the study than the young ones. This finding also deduced that the majority of respondents in the study are aged and are within the age bracket that had useful information about the bushfire in the Northern area.

### Fire Experience

In terms of fire experience, a sizable number of 92% of the respondents of age between 30-50 years had bushfire outbreak experience, and 7-8 percent of 30 years and below have bushfire experience. This indicates that most of these respondents are well-grounded in the knowledge and history of bushfires in Northern Nigeria.

### Occupation

Table 1 shows that 50.3 percent of the respondents are farmers while 49.2 percent of the respondents are Hunters/businesses as gathered in this work. This finding conforms with Jhariya, (2011) who noted that the majority of the respondents engage in hunting, and Farming (bush clearing/bush burning) is more and caused earth damage, especially during the dry season. However, the activities of herders possess much threat in preserving bushes as they prefer setting their animals to eat up all farm products or even st the whole land on fire in various bushes to pave way for regeneration of fresh grasses to feed their cows, Ena (2010).

**Main Causes of Bushfire In this Study**

**Table 2:** Percentage distribution of respondents according to the main cause of bushfire in this work as referred to ministry of forestry and reserved 2012, Kwara state out of ninety-nine cases when visited.

Activity	Frequency	Percentage
Industrial fault	8	8.1
Herders	12	12.1
Bush clearing by burning	11	18.2
Farming activity	40	40.4
Hunting (Local)	21	21.1
Volcanic eruption	0	0

Source: Field survey 2022

Table 2 shows that bushfire incident caused by separate ways, the most is 40.4% dominant among farming, followed by local hunting 21.1% and bush clearing by burning is 18.2%. This is like the findings by Kittur and Jhariya (2012) who noted that bush clearing by burning done by farmers and human error could generate an uncontrollable bushfire and it normally happens during the harmattan period or dry season. Hunting is done by local hunters to hunt game for their consumption. Many times, hunters set fire in the bush to put animals in a confined condition for easy trapping. This activity is common in many parts of the villages in Northern Nigeria.

On the other hand, industrial fault, volcanic eruption, and herdere had recorded low score with the corresponding percentage of 8.1%, 0% and 12.1% respectively. It could be that these activities seldom occur except recently with the emergence of Fulani herdere in this area.

**Ways of minimizing the environmental damage caused by wildfire**

The data show ways of minimizing the environmental damage caused by bushfires and were analyzed using the Logit Regression Model. Several variables were hypothesized to determine the damage caused by bushfires in northern Nigeria.

**Logit Regression:**

This is Logistic regression, and it is a statistical method used to predict binary outcomes such as Yes or No, based on prior observations of a data set. It works as a tool to predict a dependent data variable by analyzing the relationship between one or more existing independent variables i.e., can variables of bush bushfire minimize the damage if applied to mitigate bushfire? Logistics regression is a predictive modelling algorithm used when the Y variable is binomial in the category, that is, it can take only two values 1 or 0, yes or no. The goal is determined mathematically with an equation that can be used to predict the probability of 0 -1. Once the equation is formed, Y can be predicted as Xs are known.

$$Z_i = \ln (P_i/1-P_i) = \alpha + \beta_1X_i + \dots + \beta_nX_n \text{ ----- (3)}$$

$$P_i = E (y = 1/X_i) = \frac{e^{\alpha + \beta_1X_i}}{1 + e^{\alpha + \beta_1X_i}} \text{ ----- (4)}$$

The result of the Logit Model analysis is presented in Table 3 below.

**Table 3:** The factors and ways to minimize environmental damages caused by bushfires using LRM Delaware firehouse system software

<i>Variables</i>	<i>Coefficient</i>	<i>Significance p (y) Level</i>
<i>Intercept</i>		0.00
<i>Awareness Campaign</i>	0.01	0.07
<i>Law against bush</i>		
<i>Burning</i>	0.5	0.04
<i>Bush clearing</i>	0.1	0.04
<i>Regular Farming</i>	0.3	0.03
<i>Recruitment of firefighters</i>	0.2	0.05
<i>Discouraging</i>		
<i>Deforestation</i>	0.3	0.03

Number of observations 6

$$\text{Chi-square } \chi^2 = \sum (O_i - E_i)^2 / E_i$$

Where:  $\chi^2$  = Chi-Square

$O_i$  = observed value

$E_i$  = Expected value

The model provided an acceptable fit to the data. The 6 observations variables have a probability below 1 and greater than 0. This means the factors contribute to minimizing environmental dangers caused by bush fire as indicated in table 3.

**Awareness Campaign( $X_1$ ):** The coefficient of the awareness campaign was a positive sign as well as statistically medium significant at level 0.01 which is  $< 1$ . This result is in line with a prior expectation of the study. It implies that environmental damages caused by bushfires could be minimized through awareness campaigns by the government.

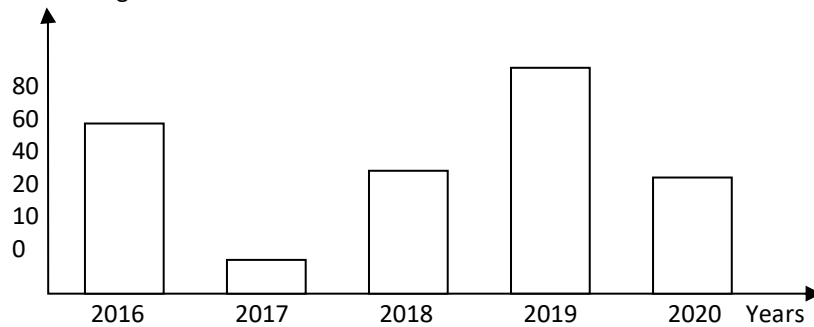
**The law against bush burning ( $X_2$ ):** The coefficient bore positive and statistically highly significant at 0.04 probability levels. This implies that the law against bush burning is one of the most highly effective ways of minimizing environmental damages caused by bushfires. According to the survey carried out 64% of respondents sampled had revealed their terrible experience in bushfires and supported control of bushfires, therefore effective laws should be enacted.

**Bush clearing ( $X_3$ ):** The coefficient of the variable was positively significant as well as statistically significant at 0.04 level. This result conforms to a prior expectation and implies that bushfire incident could be controlled through regular clearing of bushes. Expectedly, other bush clearing rather than burning minimizes the chances of the bushfire spreading within the environment.

**Regular farming ( $X_4$ ):** The variables had less significant effect on the environment if activities are not aid by bush burning, but statistically significant with 0.03 level. Most times in northern Nigeria this variable lead to increase in bushfire outbreak as continuous farming brings about regular bush burning, thereby causing much harm, to wildlife and vegetation. This result reported that an increase in farming activities encourages bush burning and endangers wildlife in northern Nigeria.

**Recruitment of firefighters ( $X_5$ ):** The relationship between the ways of minimizing the environmental damage by bushfires and the recruitment of firefighters confirms the prior expectation of the study with a 0.05 level. That is, the regular recruitment of firefighters helps to checkmate according to Lamda, (2011) fire outbreaks both in the forest and the environment. The variable was statistically significant at a 0.05 level of probability.

**Forest Guard ( $X_6$ ):** The co-efficient was discovered to be positive and statistically significant with a 0.03 level. An increase in the variable is expected to lead to an increase in better ways of minimizing environmental damage in the study area. This is in line with a prior expectation of the study. Therefore, the recruitment of forest guards minimizes indiscriminate fire outbreaks in the bush. This will help to safeguard the animals, farms, and vegetation in the forest (Nwana, 2004).

**Table 3:** Estimating the Total Fire Outbreak Between 2016-2020**Figure 1:** Percentage distribution of respondents according to the estimates of total fire outbreaks between 2016 to 2020 using a bar chart**Affected by Bush Fire(ha)****Affected Bush Fire (Ha) Area Versus Years of Occurrence**

The area affected by fires in the Northern part of Nigeria in the year 2019 is higher. Most of the fire incident occurred in the populated cities in the study area. The study shows the number of fire incident (2016 – 2020) in the Northern Nigeria. From the year 2016 – 2018, the Northern parts, recorded about the same number of incidents; in the year 2019, however, the most populated local government in the North took the lead followed by people living in grassland savanna. As of January 2019, almost 1,500 bushfires had started in some parts of Northern Nigeria like Kwara and Nasarawa State, the number of acres burned in these bushfires far exceeds the latest trends, Kulkarni et al (2013). From the bar chart, over 3 million areas have burned in bushfires so far in 2020 and would be brought under control by federal and state fire service men.

**Conclusion**

The environment is a comfortable place where man confines himself. Man and animals feel uncomfortable when our environment is contaminated through pollution, smoke, and release of explosives, and the destruction of vegetation by any means. These elements contribute negatively to the deterioration of the environment, especially the depletion of ozone layers which is the recent cause of global warming we are experiencing universally. This can be minimized through effective awareness (information), policy, and necessary machinery to be in place and public enlightenment, especially to the people in this northern Nigeria. Fire service and national disaster management, the Ministry of Agriculture and rural / forestry management, and non-governmental organizations should embark on an intensive education and enlightenment campaign among the entire region concerning fire prevention and safety measure.

**Recommendation**

Based on these research findings, the following recommendation is made.

- I. The relevant government agency should work in hand with the rural residents and report anybody found setting fire to the bush.
- II. There is a need to reduce environmental pollution by burning bushes.
- III. Federal/State Environmental Protection Agency (FEPA) should enforce laws that could hinder the indiscriminate setting of bushes on fire.
- IV. The relevant authorities should discourage environmental degradation, environmental pollution, and deforestation

## References

- Ali I. Naibbi and Healey, R. G. (2013). *Northern Nigeria's Dependence on Fuel wood: an alternative? Technological Forecasting and Social Change*, 68:73-193.
- Abdulkarim B. I. and Maikano H. (2015) *Refining of fossil fuel derivatives produce from fossil fuel* p. 1-15, 2001.
- Amigun B., Sigamoney R., von Blottnitz H., (2008) *Commercialization of fossil fuel industry in Africa: A review and Sustainable Energy Reviews* 12, 690-711.
- Arnold, M., Kohlin, G., Persson, R., & Shepherd, G. (2006). *Fuelwood revisited*. What has changed in the last decade? Center for International Forestry Research Occasional Paper, No. 39.
- Ani Nina Chioma (2014) Air quality and Fossil fuel emissions technology [www.avenamlinks.com](http://www.avenamlinks.com).
- Bhat P. R., Chanakya H. N and Ravindranath H. N (2001) *Fossil fuel dissemination: success story of Sirsi, India, Energy for Sustainable Development* 1, 39-46.
- Bras. R. and Zootec (2012). *Potential of biogas and methane production from anaerobic digestion of poultry slaughterhouse effluent*.
- Montiel and San-Miguel-Ayaz (2009) Suppression fire counter fire, back, fire, and burn out, and prescriptions
- Bedel, A. P., Mote, T. L., & Goodrick, S. L. (2013). Climate change and associated fire potential for the south-eastern United States in the 21st century. *International Journal of Wildland Fire*, 22(8), 1034. <https://doi.org/10.1071/wf13018>
- Gazzard, R., McMorrow, J., & Ayles, J. (2016). Wildfire policy and management in England: an evolving response from Fire and Rescue Services, forestry and cross-sector groups. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371(1696), 20150341. <https://doi.org/10.1098/rstb.2015.0341>
- Lourenço, L. (2007). Riscos naturais, antrópicos e mistos. *Territorium*, 109–113. [https://doi.org/10.14195/1647-7723\\_14\\_11](https://doi.org/10.14195/1647-7723_14_11)
- Murray, J. (2013). The Factors that Influence Mathematics Achievement at the Berbice Campus. *International Journal of Business and Social Science*, 4(10), 150–164.
- Schmerbeck, J., & Kraus, D. (2015, January 1). *Chapter 9 - Wildfires in India: Tools and Hazards* (J. F. Shroder & D. Paton, Eds.). ScienceDirect; Elsevier. <https://www.sciencedirect.com/science/article/abs/pii/B9780124104341000099?via%3Dihub>