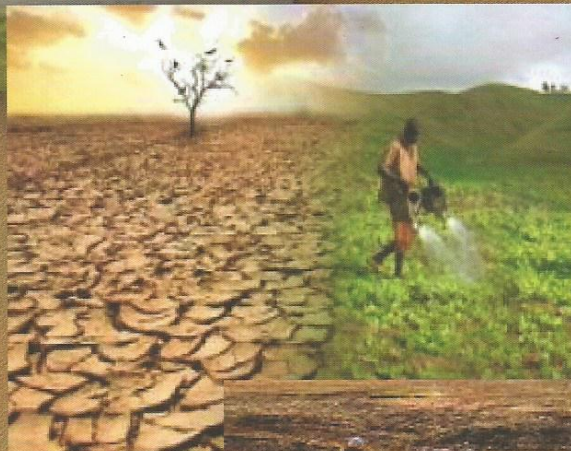


Water, Land and People in Climate Change



S. L. Tilakasiri

WATER, LAND AND PEOPLE IN CLIMATE CHANGE

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Chapter 16

CLIMATIC VARIABILITY AND URBAN AGRICULTURE:

SOME LESSONS FROM NIGERIA

A.M. Tunde, E. A. Adeleke and N. A. Malik

Introduction

Recent research in many African countries has proved that urban agriculture is an important strategy to solving food insecurity problem (Mougeot, 2001; 2005a and 2005b). In most developing countries including Nigeria, urban agriculture is an important source of food and a critical food 'insurance policy' for poor urban households (Mougeot, 2000; Nugent, 2000). The United Nations Development Program (UNDP, 1996a) estimated a decade ago that more than 800 million people were involved in urban agriculture around the globe. This is as a result of increase in the population brought about by migration of people from rural areas among other factors. In Nigeria, rapid increase in population at urban areas for greener pastures necessitated the need for increased food production. The resultant effect of this migration is that when migrants get to the urban centres, most of them are neither able to cope with the high cost of urban living nor are absorbed in the organized economic sector. Invariably, poverty results which make many city migrants to embark on informal enterprises such as farming (Adedayo, 1994).

Climate is a long term average weather conditions of a place which exercises some controls and effects on agricultural produce either directly or indirectly. The implication of this is that climate forms part of the physical environment in which urban agriculture thrives. Past studies have revealed the effects of climatic variables on crop production especially in developing countries including Nigeria (Adefolalu, 2004; Kurukulasuriya and Mendelsohn, 2006; IISD, 2007; Lobell *et al.*, 2008). The International Fund for Agricultural

Development (IFAD) observed climate change as one of the environmental factors affecting urban agricultural production and as one of the challenges it needs to address.

According to Enete and Amusa (2010) climate change is one of the most serious environmental threats facing mankind worldwide. Basically, it affects agriculture in several ways; including its direct impact on food production which has adversely affected agricultural production in Africa (Ziervogel *et al.*, 2006). Factors such as climate, soil, relief and diseases among others influence greatly the growth of crops. For instance, rainfall which is one of the climatic elements greatly affects tropical agriculture since it supplies moisture for crops and grasses for animals. Thus, Ayoade (1983) submits that agriculture largely depends on climate to function.

Supporting this, Olaniran (1981) affirmed that knowledge of climate is a necessary tool in agricultural training because it is an essential environmental factor which greatly determines crop production. Climate change may likely have a serious threat to meeting global food needs than other constraints on agricultural systems in the next 50 years (IPCC, 2007; BNRCC, 2008).

Climate to some extent determines the choice of what to plant, when to plant, how to plant and the overall yield of crops. Climate determines the limit for the agricultural activity in any area or ecological zone of the world. Ayoade (1988) noted that temperature, solar radiation, moisture and other climatic parameters largely determine the global distribution of crops and livestock as well as crop yield and livestock productivity. In a study carried out by Olaniran and Babatunde (1987) in Kabba, Kogi State it was discovered that rainfall distribution and the occurrence of moisture stress condition during vegetative period are critical for the yield of maize crop. In fact, Ayoade (2002) succinctly declares that many of the problems facing agricultural production are climate-related. This is because Nigerian agriculture is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather.

The background information revealed that climatic variables undoubtedly are fundamental factors that determine crop cultivation and livestock keeping in the cities. This chapter therefore addresses the issue of climatic variability and its effects on agriculture in the urban areas of Nigeria. Essentially, the chapter is divided into five sections. The first part deals with the introduction, the second aspect examines the concepts of urban agriculture and climatic variability, the third section discusses various climatic elements and their impacts on selected agricultural production found in urban areas, the fourth part is the concluding aspect of the study while the fifth section highlights policy recommendations.

Urban Agriculture

Urban agriculture is a relatively new concept in Nigeria although, farming in the urban environment is not new. Urban agriculture is multidimensional and has been defined in different ways by different scholars and associations. For instance Cai *et al.* (2004) posited

it that the concept of urban agriculture originated from the United States in the 1950s. It is regarded as agricultural activities in and around urban areas making use of the land, natural ecology and environment resources. Urban agriculture is the growing, processing and distribution of food and other agricultural products through intensive plant cultivation and animal husbandry in urban and peri-urban areas. It includes green belts around cities, farming at the city's edge, vegetable plots in community gardens and food production in thousands of vacant inner-city lots (Community Food Security Coalitions of North American Urban Agriculture Committee, 2003:1).

It was further stressed that urban agriculture comprises farm animals at public housing sites, fish farms, municipal compost facilities, school yard, green houses, restaurant-supported salad gardens, backyard orchards, rooftop gardens and beehives, window box garden and much more. In a similar view, Rootpedia (2008) refers to urban agriculture as the production of food within the boundaries of a city. Urban agriculture can be a pot of herbs grown on a rooftop, balcony, backyard gardening, greenhouses, market and community gardens, edible landscaping and even beekeeping.

Madden and Chaplone (1997) defined urban agriculture as the growing of crops and keeping of livestock within the boundaries or the immediate periphery of a city. Choice of what to produce and how to produce it is determined by factors such as rainfall, soil condition, exposure to sun, culture, traditions, market, water supply, climate, plot size and distance from home. Other critical determinants of the type of urban agriculture practiced include family and individual resources, land availability and location. In essence, the broad division of urban agriculture farming systems include: animal husbandry, aquaculture, horticulture, agro-forestry and other farming activities. Urban agriculture is of broad variety. It includes fish and other aquatic products grown in tanks; ponds and fish cage on sewage lagoons; poultry, livestock; orchards including street trees and vine yards, vegetables grown in small hydroponics solution, market garden on vacant city plots; and horticulture and vegetable farming on utilities' right of ways.

Remeniyi (2000) in his own contribution says urban agriculture is the production of food grains, tree crops, raising of fish, horticultural produce and animal products for consumption as well as for sale. It also includes conventional cropping of food grains, kitchen vegetable, herb gardening, nursery activity, dairy production, keeping of poultry, tree crop fruit, nut growing, honey harvesting, flower and shrub growing, mushroom raising, production of soil through composting, gathering of plant material for use in handicrafts, cooking or as a fuel source. Dima and Ogunmokun (2004) defined urban and peri-urban agriculture as the production of agricultural commodities within demarcated urban and edges of urban areas. Urban agriculture has generally been practiced without legal back up, and no technical support by local authorities or the relevant ministries of agriculture.

A review of definitions commissioned by International Development Research Centre (IDRC) led Mougeot (2000:10) to propose that "Urban agriculture is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which

grows and raises, processes and distributes a diversity of food and non food products (re-) using largely human and material resources, products and services found in and around that urban, and in turn supplying human material resources, products and services found in and around that urban area, and in turn supplying human material resources, products and services largely to that urban area". Apart from the fact that urban agriculture is been constrained by socio-cultural and institutional biases, some climatic variables also affect urban agriculture. These variables include rainfall, temperature (maximum and minimum) and relative humidity.

Climatic Variability

The difference from statistical average of climate over a given period of time (such as a specific month, season or year) is what is regarded as climatic variability. Climate variability means the basic characteristic of climate which shows itself very clearly in changes with time. While climate change on the other hand is any change in climate which alters the composition of the global atmosphere which is in addition to natural climate variability observed over comparable time periods. Climate variability and change are caused essentially by natural and anthropogenic activities. The natural activities include interaction of the oceans and the atmosphere, changes in the earth's orbit, changes in the energy received from the sun and volcanic eruptions. Anthropogenic activities include urbanization, population explosion, deforestation, industrialization and the release of greenhouse gases contribute greatly to the depletion of the ozone layer and its associated global warming, climate variability and change. Climate change and animal productions have negative impacts one over the other and the impact is much pronounced in the tropics. Climate change affects animal productions due to the impact of increasing air temperature, feed-grain availability and favoring the diseases (Adams *et al.*, 1990).

Ayoade (2004) considered Climate change as a long-term shift or change in the type of climate which prevail over specific location, region or the entire planet. Change is an inherent attribute of climate which is caused by both human activities (anthropogenic), and natural processes (Biogeographically) climate change causes floods, landslides, drought and famine.

Climate Change and Rainfall System in Nigeria

There is increasing evidence that precipitation patterns have changed worldwide as a result of atmospheric responses to climate change (UNEP, 2007). As climate changes, several direct influences alter precipitation amount, intensity, frequency and type (IPCC, 2007). Precipitation has increased by about 1 to 2 per cent over the world's continent in the last century. This change is statistically significant but neither spatially nor temporally uniform (UNEP, 2007). For high and mid-latitude regions, there has been a 2 to 4 per cent

increase in the frequency of heavy precipitation events over the second half of the 20th Century (Dore, 2005; IPCC, 2001). Global warming due to climate change accelerates land surface drying and increases the potential incidence and severity of droughts (IPCC, 2007). The decreasing rainfall and devastating droughts in the Sahel since the 1970s are among the least disputed and largest recent climate changes by the global climate research community (IPCC, 2007). It is likely that rainfall has increased by 0.2 to 0.3 per cent per decade over the tropical (10°N to 10°S) land areas. Increases in the tropics are not evident over the past few decades. It is also likely that rainfall has decreased over much of the Northern hemisphere sub-tropical (10°N to 30°N) land areas during the 20th Century by 0.3 per cent per decade (IPCC, 2001). IPCC (2007) also estimates that due to climate change, wet areas will get wetter and dry areas drier.

Meteorological data have shown that rainfall pattern and trends in Nigeria has changed in the past decades. Oladipo (1995) reported that the decline in rainfall in Nigeria started at the beginning of the 1960s when a decade of relatively wet years ended. According to him, the persistence of below-mean rainfall in the last decades in Nigeria is an indication of an abrupt change in climate. The portion of Lake Chad in Nigeria as completely dried up, forcing the Fulani grazers and other people earning their livelihood around the lake basin to migrate south. Drought is becoming an annual event in states within the Sahelian and Sudan climatic zones of the country (Larry and Regina, 2009). Previous time-series studies of rainfall characteristics in Nigeria have been examined for dominant trend on various spatial and temporal scales by Olaniran (1990; 1992; 1995). His results showed a progressive early retreat of rainfall over the whole country spanning up to a half century. He found significant decline of rainfall frequency (rain-days). Olaniran (1991) found evidence of climate change in the heavy and moderate rainfall series in the Sahelian zone and the heavy rainfall series in the Sudan savanna belt.

Climatic Variables and Urban Agricultural Production

The various urban agricultural production examined in this study includes vegetables, crops, poultry and fish raising, while climatic variables examined include rainfall, temperature and relative humidity. Scientists have been predicting the consequences of climate change since 1980s. They noted that the average temperature of the earth has increased by 0.74 degrees Celsius over the past 100 years. And if nothing is done, there is going to be more rise in the earth's temperature to the extent that it will be difficult to cope with it. This statement buttresses more the seriousness of the threat pose by climate change to countries that depend mostly on climate overall development. Eboh (2009) stated that developing countries are likely to suffer the most because of their geographical location, low incomes, low institutional capacity as well as their greater reliance on climate agriculture. The effects of climate change on food security in Nigeria can be discussed as follows:

Agricultural Effect

Climate change has a cumulative effect on natural resources and food production (Edame *et al.*, 2011). Rough estimates suggests that for the next 50 years or more, climate change may likely have a serious threat to meeting global food needs than other constraints on agricultural systems (IPCC, 2007; BNRCC, 2008). If climate change adversely affects agriculture, effects on human are likely to be more severe in a poorer world. Orindi *et al.* (2006) worry that rising demand for food over the next century, due to population and real income growth, will lead to increasing global food scarcity, and a worsening of hunger and malnutrition problems particularly in developing countries. Consequently, the effects of climate change on food demand and production as well as its effects on population increase in Nigeria cannot be over emphasized. The global production and distribution of food is inadequate in relation to rapidly expanding global population of 5.8 billion people under present and foreseeable economic systems.

Food and Water Resources

Climate change affects food and water resources that are critical for livelihood in Africa where much of the population especially the poor, rely on local supply system that are sensitive to climate variation. Disruptions of existing food and water systems will have devastating impact on development and livelihood. These are expected to add to the challenges climate change already poses for poverty eradication (De Wit and Stankiewicz, 2006). Agricultural production in Nigeria like in other developing countries is highly vulnerable with inverse or direct effect on the performance of food crops. According to Obioha (2009) the sustainability of the environment to provide all life support systems and the materials for fulfilling all developmental aspirations of man and animal is dependent on the suitability of the climate which is undergoing constant changes. The effect of these changes is posing threat to food security in Nigeria. More productive and resilient agriculture requires certain resources (e.g. land, water, soil nutrients, and genetic resources) and higher efficiency in the use of these resources and inputs for production. Transitioning to such systems could also generate significant mitigation benefits by increasing carbon sinks, as well as reducing emissions per unit of agricultural products (Edame *et al.*, 2011).

Food Security in Nigeria

Food security and safety begin with the planning of your garden and extends to storage and food preparation, since contamination can occur at any step along the way. The primary sources of pathogens are poor-quality water, manure, pets, wild animals and poor personal hygiene. By following a few common sense practices, you can keep the risk of contamination to a minimum. Climatic changes already have varying, mostly adverse effects on agriculture and, therefore, food security. Higher temperatures result in decreased

agricultural productivity and production, high evaporation rates and reduced soil moisture, lowering of the groundwater table and shrinking of surface water. Heat stress reduces human labour use on farms, lowers labour productivity and leads to rapid deterioration and wastage of farm produce. Changes in the amount of rain, increased rainfall intensity and changes in rainfall patterns lead to decreased resource productivity and production. Changing and erratic rainfall patterns make it difficult for farmers to plan their operations, may reduce the cropping season and can lead to low germination, reduced yield and crop failure. Erratic weather interferes with processing of produce (such as sun-drying of crops and smoking of fish). Increased frequency of major storms causes damage to farm land, crops and livestock. Major storms can also cause road wash-outs, which make it difficult to access farms and to market products.

Climate change may affect food systems in several ways ranging from direct effects on crop production, changes in rainfall leading to flooding and drought, warmer or cooler temperature which leads to changes in the length of season, changes in food prices and food supply in the market (Ikyase and Iloh, 2014).

Urban Vegetable Production

Climatic conditions are major factors that explain what can be grown in urban areas and at what times of year can one engage in such farming. There are optimum temperature ranges for all crops. Crops may be heat sensitive while others are cold sensitive and may be affected by frosts. Germination of seed of some crops is temperature dependant (agriculture.vic.gov.au, 2009). It is increasingly important to take into account the impact of potential climate change on vegetable production in Nigeria. For vegetable production, the major impact is in relation to increased climate variability which may mean that there is an increased risk of crops running to seed or failing to set normal heads due to unseasonal conditions or being damaged by severe weather events. This increase in seasonal variability should be taken into account when planning planting schedules and choosing varieties. When establishing a new property one may want to consider the long term outlook of the area. It is likely that most parts of the area will become hotter and drier in the future.

Rainfall and Vegetable

Rainfall plays significant role in urban vegetable production. Rainfall amount and regularity vary with location and climate types of different cities in Nigeria. These amounts have greater effect on the production of different types of vegetable in urban cities because the growth and development of vegetables depend mainly on availability of water. Excessive rainfall can lead to flooding which easily wash away vegetables. Also inadequate rainfall may lead to loss of vegetables since water is needed for plants to manufacture their food.

Temperature and Vegetable

Vegetables can be classified according to the temperature requirements of their optimum air temperature range. Climate and climatic variability are critical factors in vegetable production and is largely beyond ones control, unless you plan to establish protected cropping such as glasshouse or shade-house production. Climate will determine what vegetable can be grown and at what time of the year. Some crops will be frost sensitive; others will have a heat requirement or a minimum soil temperature for germination of seed (Henderson and Dimsey, 2009).

Relative Humidity and Vegetable

The opening and closing of the stomata which regulates loss of water from the plant through transpiration as well as photosynthesis is affected by relative humidity. In the urban areas, when air is moist especially in the morning, vegetable plants absorb enough water and bring forth tender leaves when compare to the afternoon hours with dry air. High amount of relative humidity will lead to increase in atmospheric pressure.

Urban Crop Production

The common crops grown within the urban cities of Nigeria include the staple crops such as maize, guinea corn and melon. Climatic variables such as rainfall, temperature and relative humidity affect most of these crops.

Rainfall and Crops

Rainfall contributes significantly to crop production in Nigeria. It is guided by some important factors in relation to crop and these include number of rainy days, time of fall, total amount of fall and the type of soil. Rainfall usually determines the type of agricultural system to be practiced in different parts of the country and the type of crop to be grown in different environment. According to Olaoye (1999), the capability of increased crop production has been reduced Nigeria due to regular occurrence of drought caused by erratic rainfall distribution and/or cessation of rain during the growing season.

Bello (1998) also noted that dry spells and droughts which are related to rainfall and occur annually in Nigeria are injurious to crops leading to crop failure. The early and late cessations also destroy the late crops. Furthermore, Omotesho (2002) asserts that most critical weather and climate dependent sectors of any West African and particularly Nigerian economy are agriculture and water resources.

Ojonigu (2009) also pointed out that where rainfall is optimum, crop yield is high; if low, low crop yield and if too high, poor yield partly due to flooding. In general therefore, optimum rainfall which is well distributed throughout the growing season is required for a good harvest, abundant food crops and availability of raw materials for the few agro – allied industries as well as to guarantee food security.

Temperature and Crops

For most crops the optimum functional efficiency occurs mostly between 55 and 75°F (12°C and 24°C). Crops that originated in temperate climates usually require low temperature, while those that originate in the tropical climates require warm temperature. Temperature affects crop production by controlling the rate of physio-chemical reaction and rate of evaporation of water from crops and soil surface (Ismaila *et al.*, 2010). Studies have revealed that productivity in rice and other tropical crops will decrease with increase in temperatures as a result of global warming. For instance high temperature for just 1 to 2 hours at anthesis (about 9 days before and at heading) cause large percentage of grain sterility in rice (Nguyen, 2006). The resultant effects of heat stress on rice include reduced tiling, reduced height, reduced spikelet number, sterility and reduced grain filling (Nguyen, 2006). For most crops the optimum functional efficiency occurs mostly between 55 °F and 75°F (12 °C and 24°C). Most crops (and especially vegetables) can be classified according to the temperature requirements of their optimum air temperature range.

Relative Humidity and Crops

Plant development depends on high atmospheric humidity in the sense that many plants have the ability to directly absorb moisture from unsaturated air of high humidity. Humidity may again affect the photosynthesis of plant leaves. High humidity at night is beneficial to some plants. Relative humidity is greater over the ocean than over the continental areas. This reflects the high rate of evaporation due to the fact that the supply of water is unlimited at the ocean surface while over many land areas; water is an important limiting factor of evaporation because it is scarce. Also relative humidity is high throughout in very humid climates and low in arid and semi-arid climates. In seasonally humid areas, relative humidity is higher during the rainy season than during the dry season.

The vapour pressure distributions have similar characteristics with relative humidity over the oceans and the very humid areas of the world. For instance, vapour pressures are almost at high saturation level with humidity in humid environment. In the arid and semi-arid areas, vapour pressures are low, causing the saturation deficit of evaporability of air to be high. When vapour is continuously added to the atmosphere and the limit is reached, the air is said to be saturated. The resulting vapour pressure of the upper limit of water holding capacity is termed saturation vapour pressure.

Moderately low air humidity is favourable for seed set in many crops, provided soil moisture supply is adequate. For example, seed set in wheat is high at 60 per cent relative humidity compared to 80 per cent when water availability in the soil was not limiting. Elijah and Adedapo (2006) reported in their study that high rainfall and relative humidity provides a conducive environment for breeding of parasites that causes outbreak of diseases which invariably reduces egg production. They further reported that temperature reduces the feed intake of poultry birds because more energy is needed to conserve the heat caused by high temperature, hence, a decreased in the rate of feed intake.

At high relative humidity pollen may not be dispersed from the anthers. The incidence of insect pests and diseases is high under high humidity conditions. High relative humidity favours easy germination of fungal spores on plant leaves. For example, the blight diseases of potato and tea spread more rapidly under humid conditions. Several insects such as aphids and jassids thrive better under moist conditions. Chemical reaction rates increase with higher temperature, increased concentration of reactants and increased pressure. Water is a reactant in many decay processes. Increased relative humidity increases the concentration of water (Alten, 1999).

Urban Poultry Production

Poultry are birds such as domestic fowl, turkey, duck, goose, ostrich, guinea fowl, etc. that contribute significantly to human food as a primary supplier of animal protein, raw materials to industries (feathers, waste products), source of income and employment to people compared to other domestic animals (Demeke, 2004). Climate change affects natural resources, biodiversity and livestock health (Thornton, 2010). The environmental conditions such as temperature, relative humidity, sunshine prevailing at a given time, light, housing system and ventilation affect the performance and health productivity of a chicken.

Rainfall and Poultry

The rate of intensity and average amount of rainfall over a particular area affect the amount of water availability in the area. Rainfall is important source of water to meet poultry birds need and reduction of heat. Poultry diseases are seasonal, for instance, high moisture of rainy season provides comfortable atmosphere for breeding of disease parasites. According to Obayelu and Adeniyi (2006), climate variables (temperature, rainfall, wind-speed and relative humidity) in Ilorin contributes about 81 per cent, 96 per cent and 43 per cent to the variance in poultry egg production, feed intake and outbreak of disease of poultry production respectively.

Temperature and Poultry

According to Indian Council for Agricultural Research (ICAR) (2010), temperature has significant effect on birds because as the ambient temperature increased to 34°C the mortality due to heat will be significantly high in meat type chickens by 8.4 per cent, the feed consumption of the chickens decreases from 108.3g/bird/day at 31.6°C to 68.9g/bird/day at 37.9°C, the egg production also decreased by 6.4 per cent as compared to the standard egg production. Temperature reduces the feed intake of poultry birds because more energy is needed to conserve the heat caused by high temperature, hence, a decreased in the rate of feed intake which can lead to mortality and reduction in meat production.

Temperature is the most climatic element that best explain the physiological comfort of chicken due to its positive and negative effects on poultry production and mortality rate of the poultry birds in the tropical environment. High temperature is said to be observed in a situation whereby the degree of hotness is higher than the normal temperature. Positively, the rises in temperature can reduce the cost of setting up the poultry. In condition of higher temperature, ventilation is needed more so that fresh air will be allowed to enter into the poultry house. As a result of climate change effect, increasing temperature has been a contributing factor to the death of chicken.

Poultry production is highly affected by high temperature, and as a result, the poultry birds are unable to feed well, thereby reducing their body weight and their growth rate in many parts of tropical environment. Therefore, temperature is an important bio-climatic factor affecting the physiological function of layer chickens. The effect of temperature is more evident at old age when birds are exposed to a cold climate. When temperature falls below the thermo-neutral zone of below 12.8°C (which is rarely experienced in the tropics), egg production becomes uneconomically difference. According to Charles (1980), feed intake of a laying hen decreased by 1.5g per day for every degree centigrade rise in temperature above 30°C. Meanwhile, there is a decrease in egg production by about one egg per bird a year for every degree rise in temperature above 25°C-30°C.

The depressive effect of environmental temperature by heat stress significantly increase the level of water consumption of birds, reduces egg production, egg weight, shell weight, shell thickness and generally reduces economic gains from poultry production. High temperature and humidity has some negative effect such as an increase in poultry body temperature, a decrease on feed consumption and feed efficiency (Barua and Howlader, 1990). High temperature also results to a reduction in poultry live weight, growth speed and high mortality which decreases the production and quality of eggs (Arjona *et al.*, 1988).

Relative Humidity and Poultry

High relative humidity level above 75 and 80 per cent will cause a reduction in egg laying and induced the outbreak of diseases in poultry through the creation of conducive

breeding environment for disease pathogens (Obayelu and Adeniyi 2006). Relative humidity is important in all seasons because it causes dampness and cold stress on poultry birds. Poultry birds consume more food in order to meet up their body response to cold and water consumption would reduce and in several cases, infectious catarrh and bronchitis may occur (Obeng, 1979). High relative humidity in the chicken pens is an important cause of death of young poultry during rainy season (Smith, 2001). The effect of relative humidity with its connection with temperature is long encompassing, affecting hatchability and development of embryos of eggs and influences the growth of chickens. Relative humidity should be kept between 50 and 70 per cent because lower relative humidity will tend to result in a dusty house and high heating costs while higher relative humidity can lead to wet litter and high ammonia concentrations. The close relationship among ammonia, carbon dioxide and relative humidity tends to be strongest with older birds and weakest within a week or two of the flock. This is due to substantial amount of carbon dioxide produces by most heating systems and the use of litter treatments which can result in a situation where the relative humidity is low and carbon dioxide high or the relative humidity is high and ammonia concentrations are low.

Urban Fish Production

Fish production is an important aspect of urban agriculture that is very common in most urban areas of Nigeria these days. Fish production is influenced by some climatic variables such as rainfall, temperature and relative humidity.

Rainfall and Fish

Rainfall is a climate parameter that affects every facet of the ecological system, flora and fauna inclusive (Obot and Onyeukwu, 2010). Rainfall varies from year to year. And over decades, changes in amount, intensity, and frequency affect the environment and society. There is increasing evidence that human-induced climate is changing the rainfall and hydrological cycle, especially the extremes (Trenberth, 2005). Both decreasing and increasing rainfall trends have culminating effects of drought and flood respectively. Although irrigation farming exists in the Northern regions, low-productive rain-fed agriculture is dominant in both the North and South; consequently, the importance of the timing and amount of rainfall that occurs cannot be overstated.

It is generally known that agriculture employs a large number of people in these regions. The reliance on agriculture is even more acute in rural areas. Given such a heavy dependence on rainfall, it should come as no surprise that climate extremes such as drought and flood could pose significant economic, social and health threats to these regions. FAO, (2005) estimated that by 2080, an increase in drought may lead to 11percent decrease in land suitable for rain-fed agriculture. Even if crops do not fail, the vagaries can still cause variation in yield (Olaniran, 2002).

Apart from the impact on agriculture, other natural hazards such as mudslides, landslides and gullies may also ensue from climate change induced by change in rainfall trend. It is therefore crucial to understand trends and variability in rainfall, the relationship with climate change and the possible impacts on environmental, economic and social aspects, as well as identifying adaptation measures to minimize potential hazards on a regional scale.

Temperature and Fish

Increased temperatures can have important consequences for stream organisms. Bioenergetic studies indicate a strong positive relationship between feeding rates and metabolism with temperature for both fish and insect communities (Wotton, 1995). Increased metabolic rate carries with it a need for increased levels of food quantity or quality in order to maintain growth and survival rates (Wotton, 1994). Also, temperatures must not exceed the biological preferences of typical cold-stenotherms (i.e. 20°C) if cold-water fauna are to prosper downstream (Allan, 1995; Giller and Malmqvist, 1998).

Habitat influences the species and numbers of fish found in a waterway. If the habitat meets a fish's needs, it can survive there. If the habitat doesn't meet the fish's needs, it won't be found there. One very important habitat factor is water temperature. The temperature of a waterway is determined by many variables. Water temperature is influenced by the time of year, the amount of sunlight reaching the water, the amount and speed of the water (flowing water and currents), the source of the water (springs or runoff), and the amount of material suspended in the water (Smart, 2016).

Each fish species has a specific range of water temperatures in which it can live. If the water is outside that range, it can't survive. Within that range is a narrower range of temperatures. This is called a fish's "preferred temperature." Fish can live, grow and reproduce when they are within their preferred temperature range. The preferred temperatures are ideal for the fish's survival. Biologists group fish with similar temperature preferences into three groups: Cold, cool and warm. Fish in a group often have other similar habitat needs (Smart, 2016). Higher temperatures increased final weight and length, overall specific growth factor and feeds of fishes. Temperatures have a secondary effect in terms of increasing oxygen consumption at high temperatures (Hallaraker *et al.*, 1995; Jonassen *et al.*, 2000b), and causes energy costs to decrease at continuous light and at lower temperatures (Imsland and Jonassen, 2001).

Relative Humidity and Fish

Ayoade (2004) considered humidity as the amount of water vapour content of the air and the capacity of air to hold water vapour is primarily a function of temperature because warmer air has a greater capacity for water vapour whereas cooler air has a lesser capacity.

Relative humidity is the most popularly used measure of air humidity because it is easily understood and computed using wet and dry thermometers. Besides, it indicates the degree of the saturation of the air which in turn affects precipitation, a major source of water to the marine environment. In Nigeria for instance, increase in the level of acidity of water in the ponds, streams and major rivers affect the growth and development of fishes. At this period, farmers introduce artificial fresh water into their ponds to reduce the level of acidity. Increase in rainfall amount and duration often assist farmers to reduce the rate of acidity in the ponds. This is because when relative humidity increases in the air, there is a high tendency of air to saturate which leads to precipitation. Smith (2001b) was of the opinion that the effect of relative humidity of the air is very much interrelated to the ambient temperature and that high relative humidity causes dampness and cold, which in turn affects the water temperature.

Increase in temperature brings about a decrease in the amount of relative humidity in the air at the same environment. Rising temperatures reduce levels of dissolved oxygen and increase metabolic rates of fish, leading to increases in fish death, declines in production or increase in feed requirements. Temperature and relative humidity however cause the activity levels of fish to increase or decrease, make fish to move into areas while avoiding others and influences feeding and productive activity. Fluctuation in relative humidity in Nigeria especially in the hinterland could be attributed to unpredictable weather condition and impact of climate change.

Climate change affects the survival, growth, reproduction, and distribution of fish globally. The climate-related drivers include temperature, relative humidity, salinity, windfields, oxygen, water acidity, and the density structure of the water column. The examples range in scale from experimental studies on individual fish, through a combination of experimental and field studies, to modeling and observation of whole ecosystems and large sea areas (Morgan, 2001). It was observed that mild winters with strong westerly winds, above-normal rainfall, and reduced frequency of inflows have prevailed since the mid-1980s, probably because of climate-related changes in atmospheric pressure fields and have resulted in freshening of the Baltic. Experiments show that at salinities less than 11, cod spermatozoa cease to be active and the eggs sink because their density is greater than that of the water. The eggs cannot survive anoxic conditions in the deeper layers. Biological interactions with other fish and with planktonic prey also influence the dynamics of cod in the Baltic, but the system is ultimately governed by changes in large-scale climatic conditions. Rising ocean temperature and ocean acidity are radically altering aquatic ecosystems. Climate change is modifying fish production and distribution of marine and fresh water species (Sarwa, 2005). If other environmental factors are favorable to the production of fish, a little change in the trend of relative humidity will bring a change to the growth, reproduction and distribution of fish in the country.

Conclusion

This study has been able to establish the fact that climatic variability affects agricultural production in the urban areas of Nigeria. The impact of climate change that is evidenced in many respects such as flooding, increasing rate of pest and diseases, desertification, drought among others has reduced agricultural yields in many urban cities in Nigeria. Increase in climate extremes also implies more variability in climate and hence increases the risk of urban agriculture failure in the country. It can therefore be concluded that for increased agricultural production in the urban cities of the country, climatic variables such as rainfall, temperature and relative humidity must be taken into considerations. If this is done, urban agriculture would be an important strategy for solving food insecurity problem in the country.

Policy Recommendations and Implication for Planning

Climate must be taken into account in the planning of agricultural development, especially in the urban areas of Nigeria, given the fact that there are spatio-temporal variations in the pattern of climatic variables in the country because of distance of some areas to Atlantic Ocean. Majority of crops that are growing in the country depend majorly on climatic condition. Different crops have the climatic threshold at which they grow and produce maximum yield. The growing season, heat content in the air and onset of rain among others are very important factors to be put into consideration in the planning of urban agriculture in Nigeria. This is because of the impact of urban heat island that affects the agricultural output in major Nigeria cities. During excessive heat, most of the plants in urban areas bring out flowers whereas this is not the case in the adjacent areas of the cities. Knowledge of the microclimate of crops will assist in creating a better environment for the growth of crops in urban cities through the application of irrigation water in the right amount at the right time to the crops. Proper farming techniques also are needed to enhance maximum production and reduce cost of crop production because pest and diseases would be brought to control. Urban soil temperature and moisture must be properly monitored in order to reduce the rate of transpiration and loss of stored crops. Also, introduction of crop improvement methods can be adopted to increase productivity.

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