Climate Change and Its Effects on Food Security in Africa

John, Wajim

Department of Sociology, Federal University, Wukari, 200 Katsina-Ala Road, P.M.B 1020 Wukari, Nigeria

***Abstract*: - This paper determined climate change and its effects on food security in Africa. Climate change which is the change in average weather condition is one of the environmental drivers interacting with a food system. It will affect not only food production, but also food processing, distribution and consumption. Climate change is also among the most pressing challenges in current environmental policy. Climate change happens in different ways, ranging from increased climate variability and gradual changes in temperature and precipitation, to increased frequency and intensity of extreme events. Climate change will affect: availability of good quality water, habitats and species distribution, timing and length of growing season, distribution of agro-ecological zones, ecosystem stresses erosion by water and wind, acidification, salinization, biological degradation. Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Qualitative secondary sources of data and ecological approach of environmental sociology were used for this scholarly paper. Amongst other recommendations, it is recommended that public awareness campaign should be carried out by government and Non-governmental organizations on the impacts of climate change on humans' lives and food security.**

***Keywords:* Climate change, food security, food production, food consumption, Africa**

I. INTRODUCTION

Climate is the major determinant of agricultural productivity and it is instigated by both anthropogenic and natural sources. It was estimated that by the middle of the 21st century climate change impacts could reduce maize production in West Africa. It was also discovered that only cassava will be less affected by climate change because of its ability to achieve at least some yield in the worst weather years; flooding and cold conditions may substantially hamper food storage. The observed effects of past climate trends on crop production are evident in several regions of the world (Porter *et al.*, 2014), with negative impacts more common than positive ones, including several periods of price spikes following climate extremes in key producing regions. There is evidence that climate change has already negatively affected wheat and maize yields in many regions and also at global level (Lobell, Schlenker and Costa-Roberts, 2011). Climate and food availability is fundamentally interlinked. Considering agricultural systems are managed ecosystems heavily dependent on climatic conditions and given the elemental role of agriculture in human welfare, the single most important concern raised by climate change is its potential impacts on agricultural productivity. This concern has motivated a substantial body of research on possible physical effects of climatic change on agriculture, such as changes in crop and livestock yields, as well as the economic consequences of these potential yield changes. The stability of whole food systems may be at risk under climate change because of short-term variability in supply. However, the potential impact is less clear at regional scales, but it is likely that climate variability and change will exacerbate food insecurity in areas currently vulnerable to hunger and under nutrition. Likewise, it can be anticipated that food access and utilization will be affected indirectly via collateral effects on household and individual incomes, and food utilization could be impaired by loss of access to drinking water and damage to health. The evidence supports the need for considerable investment in adaptation and mitigation actions toward a "climate-smart food security" that is more resilient to climate change influences on food security.

Climate change is already impacting, and will increasingly impact, food security and nutrition. Through effects on agro-ecosystems it impacts agricultural production, the people and countries depending on it and ultimately consumers through increased price volatility. The impacts of climate change on food security and nutrition are the results of climate changes themselves and of the underlying vulnerabilities of food systems. Climate change is now widely recognized as the major environmental problem facing the globe and rightly so, given the gravity of this phenomenon in terms of its predicted adverse effects on human lives and property. Climate change has become one of the leading risks to food security, with droughts, floods and hurricanes expected to result in production and price volatility. The increasing risk from unpredictable weather patterns and the resulting volatility in prices raise the probability of farmers investing less in agricultural production and are also threatening food output levels.

II. CONCEPTUAL CLARIFICATION

Climate Change

Climate simply connotes significant change in the average temperature of the earth surface. It is the only one input factor in a sector that is already under pressure. According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of anthropogenic (that is human) activity. This explanation differs from that of the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Food Security

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). This definition introduces four main "dimensions" of food security:

- Physical availability of food, which addresses the "supply side" of food security and is determined by the level of food production, stock levels and net trade.
- The economic and physical access to food, including incomes and access to markets.
- The food utilization, i.e. the way the body makes the most of various nutrients in the food, which is influenced by people's health status; and
- The stability of food security at all times, which emphasizes the importance of having to reduce the risk of adverse effects on the other three dimensions.

III. THEORETICAL BASE

In considering the causes of widespread environmental destruction, two primary approaches stand out: the ecological explanation as embodied in Catton and Dunlap's model of 'competing environmental functions', and the political economy explanation as found in Alan Schnaiberg's concepts of the 'societal-environmental dialectic' and the 'treadmill of production'. As Buttel (1987: 471) has noted, both approaches view social structure and social change as being reciprocally related to the biophysical environment but the nature of this relationship is depicted very differently. Based on the two aforementioned approaches, the ecological approach was adopted for this scholarly paper and elucidated below.

Ecological explanation

The ecological explanation for environmental destruction has its roots in the field of 'human ecology' that remained dominant within urban sociology from the 1920s to the 1960s. This urban ecology model was introduced during the 1920s and 1930s by sociologist Robert Park and colleagues at the University of Chicago. Park was well acquainted with the work of Darwin and his fellow naturalists, drawing on their insights into the interrelation and interdependence of plant and animal species. In his discussion of human ecology, Park (1936 and 1952) begins with an explanation of the 'web of life', citing the familiar nursery rhyme, The House that Jack Built, as the logical prototype of long food chains, each link of which is dependent upon the other. Within the web of life, the active principle is the 'struggle for existence' in which the survivors find their 'niches' in the physical environment and in the division of labour among the different species. If Park had been primarily interested in the natural environment for its own sake, he might have realised that human intervention in the form of urban development and industrial pollution artificially broke this chain, thereby upsetting the 'biotic balance'. In fact, he did acknowledge that commerce, in 'progressively destroying the isolation upon which the ancient order of nature rested', has intensified the struggle for existence over an ever widening area of the habitable world. But he believed that such changes had the capacity to give a new and often superior direction to the future course of events forcing adaptation, change and a new equilibrium. Biological ecology was the primary source from which Park borrowed a series of principles, which he applied to human populations and communities. In doing so, however, he notes that human ecology differs in several important respects from plant and animal ecology. First, humans are not so immediately dependent upon the physical environment, having been emancipated by the division of labour. Second, technology has allowed humans to remake their habitat and their world rather than to be constrained by it. Third, the structure of human communities is more than just the product of biologically determined factors; it is governed by cultural factors, notably an institutional structure rooted in custom and tradition. Human society, then, in contrast to the rest of nature, is organised on two levels: the biotic and the cultural.

The ecological basis of environmental destruction is probably best described in Catton and Dunlap's own 'three competing functions of the environment'. This scheme has been much less widely disseminated than their theory of the 'dominant social paradigm', even though it is, to my mind, more conceptually interesting. Catton and Dunlap's model specifies three general functions that the environment serves for human beings: supply depot, living space and waste repository. Used as a supply depot, the environment is a source of renewable and non-renewable natural resources (air, water, forests, fossil fuels) that are essential for living. Overuse of these resources results in shortages or scarcities. Living space or habitat provides housing, transportation systems and other essentials of daily life. Overuse of this function results in overcrowding, congestion and the destruction of habitats for other species. With the waste repository function, the environment serves as a 'sink' for garbage, sewage, industrial pollution and other by-products. Exceeding the ability of ecosystems to absorb wastes results in health problems from toxic wastes and in ecosystem disruption.

Furthermore, each of these functions competes for space, often impinging upon the others. For example, placing a garbage landfill in a rural location near to a city both makes that site unsuitable as a living space and destroys the ability of the land to function as a supply depot for food. Similarly, urban sprawl reduces the amount of arable land that can be put into production while intensive logging threatens the living space of aboriginal people. In recent years, the overlap, and therefore conflict, among these three competing functions of the environment has grown considerably. Newer problems such as global warming are said to stem from competition among all three functions simultaneously.

IV. EFFECTS OF CLIMATE CHANGE ON FOOD SECURITY

Climate change affects food security through the following dimensions:

Food production and availability

Climate affects food production directly through changes in agro-ecological conditions and indirectly by affecting growth and distribution of incomes and thus demand for agricultural produce. Changes in land suitability, potential yields and production of current cultivars are likely. Shifts in land suitability are likely to lead to increases in suitable cropland in higher latitudes and declines of potential cropland in lower latitudes.

Climate change will adversely affect the ability of individuals to use food effectively by altering the conditions for food safety and changing the disease pressure from vector, water and food-borne diseases. Climate change may initiate a vicious circle where infectious diseases cause or compound hunger, which, in turn, makes the affected population more susceptible to those diseases.

The effects of climate change will be through both the channels of availability and accessibility. On the one hand, it will affect long-term as well as short term food security, through the dimension of food availability, while long-term effects will be driven by shrinking of yield rates and arable land, supply shocks owing to natural calamities will set short-term effects in motion. To the contrary, negative impacts of climate change on food security induced through lack of accessibility may result with or without the occurrence of non-availability. Decrease in production and supply of food items puts inflationary pressure on markets even when such decrease is not large enough to cause non-availability or the incidence of per capita availability of food falling below per capita sufficiency. Food inflation severely affects the affordability of vulnerable population (the poor) and, in turn, their accessibility to food markets.

Climate change effects on major crop yields is probably the food security-related issue on which there are the most studies, with two decades of work since the global assessment of Rosenzweig and Parry (1994), including major studies by Parry, Rosenzweig and Livermore (2005), Cline (2007), the IBRD/WB (2010) and Rosenzweig *et al*. (2014). Projections vary according to the scenario used, the model and time scale. There is, however, consistency on the main orientations: yields are more impacted in tropical regions than at higher latitudes and impacts are more severe with increased warming. Importantly, many of the areas where crop yields are expected to decrease are also areas that are already experiencing food insecurity. There are important limitations to these studies. There are risks that are difficult to factor in such projections, like single weather events and impacts of pests. Moreover, they are limited to major crops and the effects of climate change on many important productions are much less known. Availability of aquatic foods will vary, positively and negatively, through changes in habitats, stocks and species distribution (Barange and Perry, 2009). Marine fish availability in the tropical belt and along coastal regions across the globe is predicted to decrease substantially (Cheung *et al.*, 2010). Global temperatures of four degrees or more, combined with increased food demand, would pose large risks to food security globally and regionally (Porter *et al.*, 2014). They are generally greater in low latitude areas.

Stability of food supplies

Instability in crop yields and local food supplies will adversely affect the stability of food supplies. Climatic instability will be most pronounced in semi-arid and sub-humid regions and are likely to reduce crop yields and livestock numbers and productivity. As these areas are mostly in Sub-Saharan Africa and South Asia, the poorest regions with the highest levels of chronic undernourishment will be exposed to the highest degree of instability.

Increased climate variability, increased frequency and intensity of extreme events, as well as slow ongoing changes, will affect the stability of food supply, access and utilization. Stability of food supply will be impacted by changes in seasonality, increased variance of ecosystem productivity, increased supply risks and reduced supply predictability issues that may also have large impacts on supply chain costs and retail prices (FAO, 2008). For instance, the UK-US Taskforce on Extreme Weather and Global Food System Resilience Report (Global Food Security Programme, 2015) indicates that severe "production shocks" caused by extreme weather – whereby global food production is seriously disrupted – of a scale likely to occur once in a century under past conditions, may occur as frequently as once every 30 years as the world's climate and global food supply systems change in the coming decades.

Irregularity of income of people depending on agriculture for their livelihoods as well as food price increases and volatility will threaten economic access to food. This will be compounded in some regions, particularly in landlocked countries and small island states with reduced physical access, further aggravated in the case of extreme events. Forest foods, including bush meat and forest plants, are sources of protein and micronutrients that are crucial for peoples' nutrition in many places. These are particularly important in times of food shortage. Dependence on "famine foods" from forests may well increase where climate change negatively impacts the production of crops and livestock. In addition to the impacts on nutrition through the pathways mentioned above, droughts and floods severely impact reliability of drinkable water supply.

Access to food

The falling of real prices for food and rising of real incomes over the past number of decades have led to substantial improvements in access to food in many developing countries. Possible food price increases and declining rates of income growth resulting from climate change may reverse this trend. There are relatively few models that look at the impacts of climate change on the global number of hungry and malnourished. The Fourth Assessment report of the IPCC (2007) estimated that depending on the climate change scenario 200 million to 600 million more people could suffer from hunger by 2080 (Yohe *et al.*, 2007). Nelson *et al.* (2009) developed 15 scenarios for climate change based on three economic development and five climate change scenarios and found that up to 2050 economic growth has a much greater effect on global food security than climate change, although climate change does augment negative impacts. They project increases in the number of malnourished children due to changes in per capita calorie availability driven by varying economic growth and climate change scenarios. They found increases ranging from 8.5 to 10.3 percent over the baseline scenario. Their findings also indicate that, up to 2050, changes in global food trade patterns can mitigate negative effects of climate change. Hertel, Burke and Lobell (2010) use a computable general equilibrium model to analyse food security impacts of climate change, focusing on the tails of the distribution of projected climate change impacts on yields up to 2030. The results highlight the importance of income source in determining food security impacts: scenarios with high impacts on yields also generated increases in food prices, which benefitted net exporters/sellers. Conversely, high productivity growth scenarios lead to reductions in food prices, which had differential impacts on sellers and buyers.

The risks of climate change are not just to the production capacity of food security but also to the potential growth in incomes and ability to purchase food of poor people, the risk of market disruptions, effects on supply and storage systems, and effects on stability of agricultural and rural incomes as well as nutritional content. The people at greatest risk are those that are dependent on agriculture and natural resources for livelihoods, especially those most vulnerable, and who depend on systems that are the most impacted, and poor people.

World Bank, (2015) revealed that there are still 836 million people in the world living in extreme poverty (less than USD1.25/day). In view of IFAD, at least 70 percent of the very poor live in rural areas, most of them depending partly (or completely) on agriculture for their livelihoods. It is estimated that 500 million smallholder farms in the developing world are supporting almost 2 billion people, and in Asia and sub-Saharan Africa these small farms produce about 80 percent of the food consumed. Rural poor often depend partly on forests for their livelihoods (World Bank, 2002). It is estimated that between 660 and 820 million people (workers and their families) depend totally or partly on fisheries, aquaculture and related industries as a source of income and support (HLPE, 2014).

Forest-based employment and sale of forest products – including timber, fuel wood and non-wood forest products collected from forests or produced on-farm – provide a main or supplemental source of income that may be used by the rural household to purchase food. The poor tend to have a higher dependence on forest products. A study of the miombo woodlands in Southern Africa cites several studies that record high dependence on the woodlands, including forest income from different sites in Zambia ranging from 10–50 percent and in put at high risk indigenous peoples, who depend on the environment and its biodiversity for their food security and nutrition – specifically those living in areas where significant climate change impacts are expected such as mountain regions, the Pacific islands, coastal and other low-lying areas, and in the Arctic (IPCC, 2014b). Access to aquatic foods will be affected by changes in livelihoods and catching or culture opportunities combined with transferred impacts from other sectors (i.e. increased prices of substitute foods), competition for supply and information asymmetries. Impacts may also arise from rigid management measures that control temporal and spatial access to resources. Climate change also has remote impacts on the food security of people distant from the initial shock, particularly through food price increases and volatility. Without considering effects of CO2, changes in temperature and precipitation will contribute to increase global food prices by 2050 (Nelson *et al.*, 2014).

Food utilization

Climate change will impact livelihoods and income of small-scale food producers and also, through food price increases and volatility, the livelihoods of poor net food buyers, constraining these populations to reduce their food consumption in quantity and quality. They are also likely to reduce health expenditures with potential effects on nutrition. Using the results of Nelson *et al.* (2009) on undernourishment, Lloyd, Kovats and Chalabi (2011) projected a relative increase in moderate stunting from 1 to 29 percent in 2050, with severe stunting increasing from 23 percent (Central Africa) to 62 percent (South Asia).

There could be a reduction of production and consumption of some foods that play a critical role in the diets of vulnerable rural and indigenous populations, such as fish, fruits and vegetables and wild foods. The impacts of climate change on many of those are not well known. To date, studies mostly focus on cereals. There is a need to better capture all the nutritional consequences of the effects of climate change on other foods and vegetables and wild foods, all of which have an important role in balanced diets and which are at risk (HLPE, 2012a; Barucha and Pretty, 2010). For instance, today capture fisheries and aquaculture provide 3 billion people with at least 20 percent of their average per capita intake of animal proteins, and a further 1.3 billion people with at least 15 percent of their per capita intake. Utilization of aquatic products and the nutritional benefits produced will be impacted by: changes in range and quality of supply; market chain disruptions; greater food safety issues; and reduced opportunities to consume preferred products. This is particularly critical for countries with high per capita fish consumption, like small island states (FAO, 2008).

Studies also point to changes in the nutritional quality of foods (reduced concentration in proteins and in some minerals like zinc and iron), due to elevated CO2, particularly for flour from grain cereals and cassava (Porter *et al.*, 2014). This effect does not necessarily translate into impacts on nutrition, as it is generally combined with increased yields which themselves can increase food intake, often the main concern (Porter *et al.*, 2014). However, some authors (Myers *et al.*, 2014) note that in some countries populations receive 70 percent of iron or zinc from C3 grains or legumes and that, in countries where proteins are mainly of plant origin, a decrease of protein content could have serious health consequences. Climate change is expected to reduce water quality, posing risks to drinking water quality even with conventional treatment (Jimenez *et al.*, 2014). This is likely to exacerbate risks of water-related diseases reducing food absorption. WHO (2014) asserted that climate change is projected to increase diarrhoeal diseases, impacting mainly low-income populations.

Climate change also has an impact on food safety, particularly on the incidence and prevalence of food-borne diseases. Mycotoxins and pesticide residues have been identified as important issues for climate change effects in Europe (Miraglia *et al.*, 2009). Tirado *et al*. (2010) reviewed the potential impacts on food contamination at various stages of the food chain and described adaptation strategies and research priorities to address food safety implications of climate change. Continuously rising temperatures also support the spreading of the organism responsible for producing the toxin that causes ciguatera fish poisoning (CFP), which occurs in tropical regions and is the most common non-bacterial food-borne illness associated with the consumption of fish (IPCC, 2013). Rising rates of CFP have already been observed in the Lesser Antilles (Tester *et al.*, 2010) and in the Pacific in Tokelau, Tuvalu, Kiribati, the Cook Islands and Vanuatu (Chan *et al.*, 2011). The Food Research International journal recently published a special issue on climate change impacts on food safety (Uyttendaele and Hofstra, 2015), which tackled this topic from various perspectives. Overall, the reviews conclude that climate change could reduce food safety and that more research is required to get a better understanding of the problems and to set up adaptation strategies.

V. CONCLUSION

An International Food Policy Research Institute (IFPRI) climate change impact study on crop yields in Africa (Thomas and Rosegrant, 2015) shows significant geographical variation of impacts, indicating that, while most direct climate change impacts will be negative, there will be positive impacts on yields in some areas with projected increases in precipitation, and in some elevated areas that will be able to be cultivated due to warmer temperatures. Studies also show a large negative sensitivity of crop yields to extreme daytime temperatures around 30 °C to 34 °C depending on the crop and region. The effect of climate change on crop yield will depend on many parameters: temperature, precipitation patterns and atmospheric carbondioxide increase given the stimulatory effect of elevated atmospheric carbondioxide on plant growth. Recent results also confirm the damaging effects of elevated tropospheric ozone on crop yields, with estimates of losses for soybean, wheat and maize in 2000 ranging from 8.5 to 14 percent, 4 to 15 percent, 2.2 to 5.5 percent, respectively (Porter *et al.*, 2014). The increased frequency of unusually hot nights in most regions is also damaging for most crops with observed impacts on rice yields and quality.

VI. RECOMMENDATIONS

Having discovered the effects of climate change on food security, there is need for:

- Public awareness campaign should be carried out by governments and Non-governmental organizations on the impacts of climate change on humans' lives and food security.
- Effective policies for the protection of natural resources for sustainable development should be developed and properly implemented in order to curtail environmental discrimination.
- Work with vulnerable communities at the local level, taking a bottom-top approach in respect to mitigation and adaption.
- The policy of population control should be enacted and implemented so that the three provisions of environment which includes supply deposit, living space, and waste repository will not be overstressed in order to curtail food scarcity and damage to humans lives.

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