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Section A: Environmental Science

Review Article

Effect of climate change on food security in Nigeria

J.A. Ayo, M.O. Omosebi. and A. Sulieman

Dept. of Food Science and Technology, Faculty of Agriculture and Life Sciences,

Federal University Wukari, PMB 1020, Wukari, Taraba State, Nigeria.

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Abstract: The work is a review of the climatic effect on food security on developing nation with focus on Nigeria. Climate change could potentially interrupt progress toward a world without hunger. A robust and coherent global pattern is discernible of the impacts of climate change on crop productivity that could have consequences for food availability. Principally effect have been identified to include: reduction of agricultural production, changes in the suitability of land for crop production, changes in precipitation patterns, and increase in temperature could lead to longer growing seasons, CO_2 fertilization could increase yields for those crops with the physiology to benefit from CO_2 enrichment, increased irrigation, planting and harvesting changes, decreased arability, more pest, risk to fisheries, under nutrition(inadequate dietary intake and reduce calorie intake), increase aflatoxin contamination, increased pathogenicity of organisms(by environmental induced mutation), etc. A step change is needed in efforts to create a 'climate-smart food system' that can better withstand whatever climate throws at us. This should include development of drought- and heat-tolerant crops or new tillage techniques that reduce release of carbon from soils, but we need to go further and ensure trade, investment and development policies all have 'climate- smart' food as a central goal.

INTRODUCTION

Climate change could potentially interrupt progress toward a world without hunger. A robust and coherent global pattern is discernible of the impacts of climate change on crop productivity that could have consequences for food availability. 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[1]. Likewise, it can be anticipated that food access and utilization will be affected indirectly via collateral effects on household 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 system" that is more resilient to climate change influences on food security[2].

Food security, like climate change, is a multi-faceted issue. It is affected not only by obvious influences such as climate and weather but also by oil and commodity prices, trade and social policies, global politics, and population growth, to name just a few[2,3]. Bringing the two together to determine how climate change may impact food security is complex.

Climate Change: Climate encompasses the statistics of temperature, humidity, atmospheric pressure, wind precipitation, atmospheric particle count and other metrological elemental measurement in a given region over long periods of time. Climate change is the drastic alteration in natural components of the atmospheric environment with the resultant adverse responses such as the shift in weather variations or patterns involving overall and unprecedented changes in weather patterns which may include unusual rain yield or precipitation temperature, density or cloud look[4].

Climate change is caused by factors that include oceanic processes (such as oceanic circulation), biotic processes, variation in solar radiation received by earth, plate tectonics and volcanic eruptions, and human-induced alteration of the natural world. These latter effects are currently causing global warming (causing defrosting of ice in the arctic and Antarctic regions) and "climate change" is often greatly and mostly caused by human specific impacts.

The public have also been blamed for their contribution to climate change that is affecting Food Security in Nigeria. In the bid to meet our energy needs Nigerians over-depend on the use of fossil fuels which leads to the release of toxic gases like greenhouse gases (GHGs), mainly carbon dioxide (CO_2) and methane into the atmosphere? Fertilizers used in our farms to improve crop yield are also petro-chemical products which also affect the atmosphere negatively. Excess fertilizer escapes from fields as gases into the atmosphere. The use of synthetic nitrogen fertilizer has accelerated the increase in nitrous oxide in the last few decades[2]. Other farming and lumbering activities like tree felling and bush burning lead to deforestation and the resultant emission of CO_2, which saturates the earth's atmosphere and consequently results into thicker cloud layers with adverse consequences on climatic weather conditions[1,2]. When all these occur, the result is increase in temperature and rainfall variation (resulting to drought and desertification in some regions and some parts flooding). All these have been threatening Food Security in Nigeria and needs urgent attention of the Nigerian government and populace.

Global warming-instigated climate change has profound outcomes on disruptions to seasonal circles and instability and predictability of ecosystem with adverse effects on agricultural production in general, but specifically on water need and food production. Changes in rainfall patterns have a disruptive effect on planting seasonal cycles. Late or much early rain has affected farming / planting seasons. These often lead to unusual sequence in crop planting and replanting. Usually, late or delayed rainfall extends period of dry season with delayed planting period. The adverse effect of climate goes beyond the consequence of extreme weather impracticability of rainfall and change in rainfall yields. It goes a long way to affect the availability of wholesome food for the consumption of man and animals. This in turn will make food prices go up, accessibility of food to the poor even more difficult[1,2,4].

Food Security: It is generally accepted that the term 'food security' means, in simplest terms, "access to nutritious food." Food Security refers to the availability of Food and one's access to it. A household is considered Food-Secure when its occupants do not live in hunger or the fear of starvation[1]. It is a measure of resilience to future disruption or unavailability of critical food supply due to various risk factors.

The world Health Organization (WHO) describes three facet of food security as: food availability, food access, and food use[1,2].

- Food availability is having sufficient quantities of food on a consistent basis.
- Food access is having sufficient resources both economic and physical, to obtain appropriate foods for a nutritious diet
- Food use is the appropriate use based on knowledge of basic nutrition and care as well as adequate water and sanitation. According to their research around 925 million people in the world are chronically hungry due to poverty while many families and countries lack food security intermittently due to varying degrees of poverty.

Table 1: Effect of Climatic Change on Food Security[1,2,3]

FOOD SECURITY DIMENSION	CONSEQUENCES OF CLIMATE CHANGE
AVAILABILITY *(sufficient quantity of food for consumption)*	• Reduced agricultural production in some areas locally (especially at tropical latitudes) • Changes in the suitability of land for crop production • Changes in precipitation patterns could affect the sustainability of rain-fed agriculture in some areas • Increases in temperature could lead to longer growing seasons in temperate regions and reduced frost damage • CO_2 fertilisation could increase yields for those crops with the physiology to benefit from CO_2 enrichment
ACCESS *(ability to obtain food regularly through own production or purchase)*	• Lower yields in some areas could result in higher food prices • Loss of income due to the potential increase in damage to agricultural production
STABILITY *(risk of losing access to resources required to consume food)*	• Instability of food supplies due to an increase in extreme events • Instability of incomes from agriculture
UTILISATION *(quality and safety of food, including nutrition aspects)*	• Food security and health impacts include increased malnutrition • Ability to utilise food might decrease where changes in climate increase disease • Impact on food safety due to changes in pests and water pollution

Overall Effects of Climate Change on Food Security: Food insecurity is the single greatest danger of climate change to vulnerable human populations and indeed to all humanity[2]. Understanding the specific impacts of climate change on food security is challenging because vulnerabilities are unevenly spread across the world and ultimately depend on the ability of communities and countries to cope with risks. In the context of food security, some regions of the world might experience gains under climate change, but developing countries are likely to be negatively affected. That is because there are multiple adverse impacts of global warming and climate disruption on agriculture and all of these impacts will increase as the global temperature increases. Climate-related threats to global food production include risks to grain, vegetable, and fruit crops, livestock, and fisheries[4,5].

Reduced yields: The productivity of crops and livestock, including milk yields, may decline because of high temperatures and drought- related stress.

Increased irrigation: Regions of the world that now depend on rain-fed agriculture may require irrigation, bringing higher costs and conflict over access to water.

Planting and harvesting changes: Shifting seasonal rainfall patterns and more severe precipitation events— and related flooding—may delay planting and harvesting.

Decreased arability: Prime growing temperatures may shift to higher latitudes, where soil and nutrients may not be as suitable for producing crops, leaving lower- latitude areas less productive.

More pests: Insect and plant pests may survive or even reproduce more often each year if cold winters no longer keep them in check. New pests may also invade each region as temperature and humidity conditions change. Lower-latitude pests may move to higher latitudes, for example.

Risks to fisheries: Shifts in the abundance and types of fish and other seafood may hurt commercial fisheries, while warmer waters may pose threats to human consumption, such as increasing the risk of infectious diseases. Extreme ocean temperatures and ocean acidification place coral reefs, the foundations of many of the world's fisheries at risk.

As with health risks, nations and individuals do not bear threats to the global food supply equally. Nations that lose arable land and critical fisheries may not have the resources or climate to pursue reasonable-cost options for maintaining food security. Some nations are also more vulnerable to unfavorable international trade agreements and regional strife that may interrupt food distribution.

Impact on Crops: Trying to understand the overall effect of climate change on our food supply can be difficult. Increases in temperature and carbon dioxide (CO_2) can be beneficial for some crops in some places. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. Changes in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers[1,2].

In some areas, warming may benefit the types of crops that are typically planted there. However, if warming exceeds a crop's optimum temperature, yields can decline.

Higher CO2 levels can increase yields. The yields for some crops, like wheat and soybeans, could increase by 30% or more under a doubling of CO_2 concentrations[4].

The yields for other crops, such as corn, exhibit a much smaller response (less than 10% increase) [1,2,3]. However, some factors may counteract these potential increases in yield. For example, if temperature exceeds a crop's optimal level or if sufficient water and nutrients are not available, yield increases may be reduced or reversed. More extreme temperature and precipitation can prevent crops from growing. Extreme events, especially floods and droughts, can harm crops and reduce yields **Figs.1-4).**

Fig 1 : Flood affected newly transplanted rice farm

Fig. 2: Flooded Rice farm

Fig. 3: Drought affected Corn farm

Fig. 4 : Drougt Affected Gunea corn farm

Many weeds, pests and fungi thrive under warmer temperatures, wetter climates, and increased CO_2 levels. Currently, farmers spend more than $11 billion per year to fight weeds in the United States [4]. The ranges of weeds and pests are likely to expand northward. This would cause new problems for farmers' crops previously unexposed to these species. Moreover, increased use of pesticides and fungicides may negatively affect human health[1,4].

Fig. 5: Drought affected land

Fig. 8: Flooded settlements

Impact on Livestock: Changes in climate could affect animals both directly and indirectly. Heat waves, which are projected to increase with climate change, could directly threaten livestock. A number of states have each reported losses of more than 5,000 animals from just one heat wave[4]. Heat stress affects animals both directly and indirectly. Over time, heat stress can increase vulnerability to disease, reduce fertility, and reduce milk production. Drought may threaten pasture and feed supplies. Drought reduces the amount of quality forage available to grazing livestock. Some areas could experience longer, more intense droughts, resulting from higher summer temperatures and reduced precipitation. For animals that rely on grain, changes in crop production due to drought could also become a problem. Climate change may increase the prevalence of parasites and diseases that affect livestock. The earlier onset of spring and warmer winters could allow some parasites and pathogens to survive more easily. In areas with increased rainfall, moisture-reliant pathogens could thrive[1-3].

Increases in carbon dioxide (CO_2) may increase the productivity of pastures, but may also decrease their quality. Increases in atmospheric CO_2 can increase the productivity of plants on which livestock feed. However, studies indicate that the quality of some of the forage found in pasturelands decreases with higher CO_2. As a result, cattle would need to eat more to get the same nutritional benefits. Flood in most cases has been find to reduce the grazing land and hence the quantity of grass for the cattle **(Fig.9)**

Fig. 9: Flooded Cattle Ranch

Impacts on Fisheries: Many fisheries already face multiple stresses, including overfishing and water pollution. Climate change may worsen these stresses. In particular, temperature changes could lead to significant impacts. Shifts in the abundance and types of fish and other seafood may hurt commercial fisheries, while warmer waters may pose threats to human consumption, such as increasing the risk of infectious diseases. Extreme ocean temperatures and ocean acidification place coral reefs, the foundations of many of the world's fisheries at risk[5,7].

The ranges of many fish and shellfish species may change. Many marine species have certain temperature ranges at which they can survive. For example, cod in the North Atlantic require water temperatures below 54°F. Even sea- bottom temperatures above 47°F can reduce their ability to reproduce and for young cod to survive. In this century, temperatures in the region will likely exceed both thresholds[4].

Many aquatic species can find colder areas of streams and lakes or move northward along the coast or in the ocean. However, moving into new areas may put these species into competition with other species over food and other resources, as explained on the Ecosystems Impacts page.

Some diseases that affect aquatic life may become more prevalent in warm water. For example, in southern New England, lobster catches have declined dramatically. A temperature-sensitive bacterial shell disease likely caused the large die-off events that led to the decline[4].

Changes in temperature and seasons could affect the timing of reproduction and migration. Many steps within an aquatic animal's lifecycle are controlled by temperature and the changing of the seasons. For example, in the Northwest warmer water temperatures may affect the lifecycle of salmon and increase the likelihood of disease. Combined with other climate impacts, these effects are projected to lead to large declines in salmon populations [1, 3,5].

In addition to warming, the world's oceans are gradually becoming more acidic due to increases in atmospheric carbon dioxide (CO_2). Increasing acidity could harm shellfish by weakening their shells, which are created from calcium and are vulnerable to increasing acidity[4]. Acidification may also threaten the structures of sensitive ecosystems upon which some fish and shellfish rely [1,3].

International Impacts: Internationally, the effects of climate change on agriculture and food supply are likely to be similar to those seen in the United States. However, other stressors such as population growth may magnify their effects. For example, in developing countries, adaptation options like changes in crop-management or ranching practices or improvements to irrigation are more limited than in the United States and other industrialized nations[1].

Warmer temperatures, changes in rainfall patterns and more extreme weather under climate change are expected to affect food and fodder production, change patterns of pest and diseases of crops and animals and impact on food supplies. Countries where these impacts are expected to be negative are also those where hunger is most prevalent now. Extreme weather, such as floods, drought and heat waves, contributes to short term food price spikes and longer term climate change is likely to be an important factor in future price trends[1,2]. Volatile food prices are a particular concern to the poor, who often spend a high proportion of their income on food.

Professor Joachim von Braun, from Bonn University's Center for Development Research in Germany said: "Human suffering due to the climate change impacts on food security is increasing. And the costs of short term food crises mitigation will grow, if meaningful investments for more resilient food systems are further delayed."[1]

A broad set of risks to food security needs to be considered, of which climate change is an increasingly important one. Climate change can increase food market volatility by affecting both supply and demand. These risks can ripple out to destabilize food systems, resulting in high and volatile food prices that temporarily limit poor people's food consumption, financial and economic shocks that lead to job loss and credit constraints, and political disruption[2,4]. This complex system of risks can assume a variety of patterns that could potentially collide in catastrophic combinations.

Studies reviewed included one that found an average of 17% drop in yields of wheat in Africa by 2050 and a 16% drop in maize yields in South Asia under climate change [6].

Importantly, the impacts of climate change on food go much further than the direct effects of weather on crop harvests. For example, a loss of access to drinking water can cause diarrhoea and so reduce the goodness derived from food. Relatively little research has been done on such indirect effects of climate change on food security, and this review calls for more to be done on these broader aspects of food security.

What Does Climate Change Mean For Food Security At The Urban-Scale?

At the urban-scale, reduced food production especially of staple food crops means reduced (or unstable) food supplies and food unavailability. While imports (other distribution mechanisms and safety nets) can potentially and partially cover such food gaps, evidence from across the country abounds on the ineptitude of some governments in instituting such interventions on time, if at all. Against that reality, exchange entitlement-driven urban food markets which are highly volatile to unstable, erratic food supplies will predictably respond through prices rises[3]. Increased prices will make food unaffordable, especially by most working class and urban poor. The destruction of road networks**(Fig.6 and 7)** has in no little way contribute to non-uniform distribution of food and in most cases resulted into food wastage as they could not be transported to the processing plants[2].

Fig. 6: Flooded road from Farm to market

Fig.7: Road networks destroyed by flood

Thus, there is a real and increased risk of climate change-induced urban food riots occurring in the future. Inevitably, food price increases will also lead to an alteration of food consumption patterns, either through changing dietary habits (eating fewer meals per day) or eating unbalanced diets of less nutritious foods.

Such dietary adaptation strategies will have direct negative effects on human nutrition and health. For those who afford, expenditure on food will increase in proportion to price increases with accompanying erosion of disposable income for other household necessities. Furthermore, (from an indirect sense), a reduction in food production suggests direct impacts on jobs (agriculture linked) and associated incomes thereby curtailing such groups ability to access food and other basics[11].

Another dimension relates to how climate change linked high and rising temperatures will impact food utilization in urban settings. High temperatures will require food storage and safety techniques that can withstand adverse radiation[1,2]. Current refrigeration systems are an obvious storage option, but, how many urban poor and working class in villages own refrigerators? Their food storage and safety techniques are pressurized by current temperatures; hence increased temperatures can only worsen their plight. High temperatures will also mean perishable food products will have a short shelf life, thus requiring immediate consumption[3]. This will affect food preservation and conservation strategies at household level since emergency rations will be eaten sooner than previously planned. Inevitably, such haphazard consumption patterns will affect household financial budgets. The effects of rising temperatures in conjunction with reduced food production will also mean preferred food products will not be ordinarily available in urban food markets[4]. With limited choice in the urban food system, consumption of undesirable foods will be widespread.

And running the risk of sounding alarmist evidence based predictions clearly suggest that urban food availability, access and utilization in Africa will be affected by climate change. Climate science scenario projections are pointing that direction[6]. With that knowledge, it is upon responsible governments in partnership with local communities, development agencies and climate science experts to begin to map out intervention and adaptation strategies. The time for those actions is now.

Impact on Nutrition and Health: Nutrition is also likely to be affected by climate change through related impacts on food security, care practices and health. The implications of climate change on hunger or food insecurity depend critically on how sources of income and other aspects of health are affected by climate" that unintended consequences could have huge impacts; for example, "climate-induced changes in the incidence of diarrheal and other diseases [could] inhibit food security by reducing utilization of nutrients in food"[2,4].

Decreased water availability and quality in some areas could result in increased health and sanitation problems such as diarrheal disease which, together with changes in vector-borne disease patterns, has the potential to increase malnutrition, and negatively affect food utilization[7]. Healthcare professionals are well positioned to keep reminding the global community about the importance of integrated risk assessment when modelling the impacts of climate change on food security.

Projections suggest that the number of people at risk of hunger will increase by 10–20% by 2050 due to climate change, with 65% of this population in Sub-Saharan Africa. The number of malnourished children could increase by up to 21% (24 million children), with the majority being in Africa[7,8,]

Under nutrition is the consequence of inadequate dietary intake and disease, which in turn result from household food insecurity, inadequate care, an unhealthy environment and lack of health services. These three underlying causes of under nutrition are determined by environmental, economic, and socio-political contextual factors, with poverty having a central role.

Climate change can exacerbate under nutrition. For example, reduced calorie intake due to lower food availability could affect nutrition outcomes. Inadequate care practices could be exacerbated due to difficulty in accessing clean drinking water. Finally, health will be impacted through changing disease patterns as a result of climate change.

KEY FIGURES ON UNDERNUTRITION

• Maternal and child under nutrition is the underlying cause of 3.5 million deaths each year and 35% of the disease burden in children younger than 5 years;

• For all developing countries, nearly one-third or 178 million children younger than 5 years are stunted (low 'height-for-weight');

• There are 55 million acutely malnourished children globally (10%) and 19 million children severely acutely malnourished (3.5%)[9].

Climate change could also have an impact on food security by affecting calorie consumption: recent empirical evidence suggests that climate-related shocks (particularly droughts) impact dietary diversity and reduce overall food consumption with long-term detrimental effects on stunting[10,11,12].

In a simulation of calorie intake under climate change by the International Food Policy Research Institute (IFPRI), it is suggested that the number of malnourished children could fall by over 45% between 2010 and 2050 mostly due to socioeconomic development[1,3]. More pessimistic scenarios which include adverse climate-change impacts, however, indicate that the number would only decrease by 2%. The benefits are greatest in middle‑income developing countries which have the largest share of the world's population (projections suggest that the number of malnourished children could fall 10–50%). However, for low-income developing countries, the benefits are significantly smaller with a decline in malnourishment of 37% in the optimistic scenario and an *increase* of more than 18% in the pessimistic scenario [13].

FOOD SAFETY AND PESTS

Rising temperatures might also impact indirectly on food security through effects on pests, although the interactions between climate and pest incidence are not fully quantified. As the climate warms, it is expected that the range of agricultural pests may expand, as the ability of pest populations to survive the winter and attack susceptible crops increases. Studies suggest that pests, such as aphids [14] and weevil larvae [15] respond positively to higher carbon dioxide concentrations. Increased temperatures in winter also reduce the mortality of aphids enabling earlier and potentially larger dispersion [16].

In Sub-Saharan Africa, evidential research shows that migration patterns of locusts may be influenced by rainfall patterns; therefore, climate change may impact the distribution of this pest [17]. The risk of increased aflatoxin contamination in some areas due to changing rainfall patterns, too, may restrict the area over which certain crops like maize can be grown. Maize is a staple for millions of people in Africa, Asia and the Americas, but it is susceptible to climate influences as exemplified by recent experiences with aflatoxins in Kenya [18,19].

Pathogens and diseases affecting crops may also be affected by climate change. This may be through impacts of unexpected warming, of prolonged drought on the resistance of crops to specific diseases and through increased pathogenicity of organisms by environmentally‑induced mutations[20]. Over the next 10–

20 years, disease affecting oilseed rape could increase in severity and might spread to regions where it is currently not observed [21].

Where do the food insecure live?

The most food insecure people live in the poorest and most marginal areas of Asia, Africa and Latin America, where environmental degradation and climate change are likely to exacerbate current threats to food security. The majority of food insecure people live in Asia, where high poverty rates and high disaster magnitudes affect food security[2,4].

In Sub-Saharan Africa, the most food insecure communities live in highly degraded environments where climate change could increase degradation rates. In Latin America, the most food insecure generally live in poor urban and rural settings where climate-related disasters affect poverty and food insecurity trends. Initial analysis by the United Nations World Food Programme and the UK Met Office Hadley Centre shows that current climate risks and food insecurity intersect in the most vulnerable areas of the world: West Africa, East Africa, Southern Africa, and South Asia. This is due to a combination of exposure to climate risks such as floods, droughts and storms, as well as high poverty rates and high sensitivity to climate change[14].

Limitations: Even in the most highly mechanized agricultural systems, food production is very dependent on weather. Concern about the potential impacts of climate change on food production, and associated effects on food prices and hunger, have existed since the earliest days of climate change research. Although there is still much to learn, several important findings have emerged from over three decades of research.

Studies often do not estimate impacts without adaptation, making it difficult to gauge assumptions. The costs of adaptation are also not considered in these studies, or reflected in price changes. Most assessments have not adequately quantified sources of uncertainty. Although different climate scenarios are often tested, processes related to crop yield changes and economic adjustments are often implicitly assumed to be perfectly known. An additional source of uncertainty is potential competition with bio-energy crops for suitable land, which could limit the ability of croplands to expand in temperate regions as simulated by most trade models[12].

Coping with Climate Change: "Lack of action on climate change threatens to make the world our children inherit a completely different world than we are living in today. Climate change is one of the single biggest challenges facing development, and we need to assume the moral responsibility to take action on behalf of future generations, especially the poorest."[10,11]

Because of the multiple socio-economic and bio-physical factors affecting food systems and hence food security, the capacity to adapt food systems to reduce their vulnerability to climate change is not uniform.

Improved systems of food production, food distribution and economic access may all contribute to food systems adapted to cope with climate change, but in adopting such changes it will be important to ensure that they contribute to sustainability. Agriculture is a major contributor of the greenhouse gases methane (CH_4) and nitrous oxide (N_2O), so that regionally derived policies promoting adapted food systems need to mitigate further climate change [20,21].

Improvements in agricultural technologies, such as more productive and climate- resilient crop varieties, are important to counter this threat, but are unlikely to be sufficient on their own. Wider changes in food trade and stocks, and nutrition and social policy options are also critical. The last few decades have witnessed a substantial decline in the number of hungry people worldwide. However, since 2007, progress has slowed and world food supply and demand have been precariously balanced - climate change threatens to tip this balance, most dramatically in the poorer areas of the world [19,3].

Professor Tim Wheeler, from the University of Reading's Walker Institute for Climate System Research said: "The food price spike of 2008 highlights the increasing vulnerability of the global food system to shocks, such as extreme weather and economic volatility. A step change is needed in efforts to create a 'climate-smart food system' that can better withstand whatever climate throws at us. This should include development of drought- and heat-tolerant crops or new tillage techniques that reduce release of carbon from soils, but we need to go further and ensure trade, investment and development policies all have 'climate- smart' food as a central goal." [11,3]

CONCLUSION

There is an emerging consensus that changes in temperature and precipitation can have detrimental impacts on the food security of the most vulnerable people, in the absence of adaptation. However, the aggregate impact of climate change on food security is not fully understood. In particular, several of the impacts are difficult to quantify and depend on a range of assumptions. The available quantitative studies suggest that climate change will negatively affect food security at the global level in the long run. The research suggests that, at the global level, climate change will reduce crop yields and the land suitable for agricultural production with the greatest impacts in tropical latitudes where the greatest food security challenges persist.

Several quantitative assessments also suggest that food prices will increase as a result of climate change, thereby affecting the ability of poor farmers to purchase food. The impact of these food price rises will ultimately depend on the level of socioeconomic development: in the shorter term, it is expected that the greatest gains in food access will be in South Asia and Latin America with marginal gains in Sub-Saharan Africa.

Although the conceptual links between climate change and food stability and utilization are well understood, less is known about the quantitative impacts.

For example, climate variability and climate extremes are likely to pose greater challenges for food stability. Climate impacts on pest and disease patterns will also affect the ability of the body to absorb and utilize nutrients[18].

Climate change could also increase the numbers of malnourished children, especially in the least developed countries. Some impacts may arise from remote changes in climate, due to dependence on rivers fed by precipitation, snowmelt and glacial melt occurring elsewhere. The evidence suggests that the impacts of climate change on food security will be spread unevenly, affecting the populations that are currently most at risk of hunger[1,2]. Ultimately, how strongly the impacts of climate change are felt will depend on the ability to adapt to these changes. Development of hybrid plants (Fig. 10) could to some extent reduce the effect

Fig. 10: Hybrid fruits available in local markets

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***Corresponding Author: J.A. Ayo;**
Dept. of Food Science and Technology, Faculty of Agriculture and Life Sciences,
Federal University Wukari, Wukari, Taraba State, Nigeria.
E-mail:jeromeayo@yahoo.com,jeromeayo@gmail.com