ISSN: 2754-477X

Journal of Food Technology & Nutrition Sciences

Review Article

Open Access

Implications of Climate Change on Agricultural Productivity: A Review

Salisu Audu Baba[1]* and Idris A Adamu[2]

[1]Agricultural Education Department, School of Undergraduate, College of Education Zing, Taraba State, Nigeria

[2]Agricultural Education Department, College of Education Zing, Taraba State, Nigeria

ABSTRACT

Global warning and thus climate change is a global issue and its consequences are being felt at varying degrees in different parts of the world. The developing countries are more vulnerable to its effects because of their poor economic status and political instability. In recent times, experiences of more flooding, erosion, drought, storms, rise in sea level and other extreme weather conditions resulting in poverty, degraded environment and low agricultural productivity. It's devastating impact on various dimension of human endeavours and socio-economic income of nations and individual cannot be over emphasized. Climatologically, has an extremely variable rainfall distribution, which will be exacerbated by climate change. This will inevitably impact on agriculture and the availability of water to sustain human activities. These future climate change impacts are likely to aggravate the harmful effects of poor land use; practices, especially deforestation, soil degradation and water pollution. Communities that have been made vulnerable by economic hardship and disease will find it even harder to cope. Climate change is perhaps the most serious environmental threat to the fight against hunger, malnutrition, diseases and poverty in sub-Saharan Africa mainly through its impact on agricultural productivity.

***Corresponding author**

Salisu Audu Baba, Agricultural education department, School of undergraduate, College of education zing, Taraba state, Nigeria. Tel: 08035291244, 08036785922; E-Mail: salisubaba50@yahoo.com; salisubaba50@gmail.com

Received: October 23, 2021; **Accepted:** November 05, 2021; **Published:** November 10, 2021

Keywords: Climate change, Agricultural productivity, Global warming, Environment

Introduction

Climate change describes changes and fluctuations in the variability or average state of the atmosphere over time periods ranging from decades to millions of years. It means any change in climate over time whether due to natural variability or as a result of human activity and is widely recognized as the most serious environmental threat facing the world today [1]. The changes in climate are attributed directly or indirectly to human activities which alter the composition of the Global atmosphere over comparable and different time periods. These changes occur due to veriations in different climate parameters, such as cloud over, precipitation, maximum and minimum temperatures, average daily temperatures and vapour pressure and so on. The abnormal changes in temperature and rainfall and increase frequency and intensity of drought and floods which have long term implication for viability and productivity of world agro-edosy terms especially agricultural productivity [23], [1].

Climate change refers to the statistically significant variation in climate that persists for an extended period within typical decades or longer. It is a complex biophysical process that involved a long-time change in the statistical distribution of weather over periods from decades to millions of years. Global warning on the other hand can be defined as the increase of the average temperature on earth which causes climate change. Warner global temperatures in the atmosphere and oceans leads to climate change affecting rainfall patterns, storm and droughts, growing seasons, humidity and sea level. Global warming is planet-wide while climate change refers to change at the global, continental, regional and local levels. Even though a warming trend is global, different area around the world will experience different specific changes of their climates which will have unique impacts on their local plants, animals and peoples [2]. The United Nations office for the coordination of Humanitarian Affairs (OCHA) and the International Displacement Monitoring Centre (IDMC) at the 2008 data suggested that at least 360 million people were displaced by sudden onset natural disasters of whom more than 20 million were displaced owing to the sudden onset of weather- related disasters. The high number of weather-related natural catastrophes as a record of high temperature both globally and in different regions of the world. It is no longer contestable that the earth is warming due to changing in the climate. Recent floods, droughts, erosion, rise in sea levels and shrinking of lake in some parts of the world and particularly Nigeria attest to the effect of climate change. Disappearance of coral reefs in riverine or coastal areas like Lagos and Port Harcourt are practical evidences of climate change.

Causes of Climate Change

Scientist earlier noted that the rapid warming in the last several decades is due to largely to human induced changes to the atmosphere on top of some natural variation. Human beings are to be blamed because of the changes in the character of the earth's surface due to man's socio-economic activities such as deforestation, cropping, irrigation, damming of rivers to creates artificial lakes, farm animals and the destruction of carbon rich soil [1]. Human being are also blamed because they add energy to the atmosphere through combustion of fossil fuels such as petrol, diesel, and coal. The changes in the composition of the earth's atmosphere by man's socio-economic activities such as gas flaming, brush burning, manufacture of cement from limestone and emission of gases by automobile exhaust are also attributed to man, so which in turn affect agricultural activities and productivity negatively.

There are many factors responsible for climate change. Some of them are discussed below:-

- Natural variability: Each day, the sun emits rays of light to the Earth's surface, the earth absorbs part of the heat, reflects some into the atmosphere and the remaining as form of infra-red rays. These rays are cushioned by the clouds and water vapour, which stabilizes the earth's temperature. This tends to increase the average temperature on the earth surface.
- Green House Gases (GHG): GHGs are gaseous constituent of the atmosphere. They include carbon (iv) oxide (CO_2), water vapour, methane (CH_4), Nitrous oxide (N_2O), hydrofluorocarbon (HFC), perfluorocarbon (PFC) and sulfurhexafluoride (SFC). All these gases absorb terrestrial infra-red radiation. These gases trap a greater quantity of rays which are reflected on the earth and course it to heat up. This is called greenhouse effect and it is the major causes of climate change. These gases are produced from burning fossil fuels, deforestation, coal and natural gas.
- Land use patterns: when trees and other plants are removed for various purposes, these result in more concentration of GHGs in the atmosphere when they die and decay, so also is agricultural activities such as crop cultivation, tilling the soil, application of agro-chemicals like fertilizers, pesticides and herbicides.

Implications of Climate Change on Agricultural Productivity

Climate change and agriculture are interrelated processes, both of which take place on a global scale. Global warming is projected to have significant impacts on conditions affecting agriculture, including precipitation and temperature. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals [3]. Most farmers lack adequate knowledge of climate-smart agriculture and sustainable environmental practices, which further increases their vulnerability, as well as the risks to agriculture and the environment.; Many smallholders continue to follow environmentally harmful practices, i.e., cutting down trees, slash and ;burn, flood irrigation and forest degradation. There is also widespread use of and dependence on synthetic fertilizers and harmful chemicals in crops and soils, which hinders the soil's capacity to retain moisture and nutrients.

Since the industrial revolutions, there has been an increase in the emission of greenhouse gases (GHGs) especially CO_2, the most abundant from human sources. CO_2 acts like a blanket over earth's surface, keeping it warmer than it would otherwise be. Some effects of climate change on agricultural productivity are numerated below:

- Reduction in Crop yields due to unfavourable weather conditions like high temperature, decreased in water availability and emergence of new pests.
- Reduction in livestock production due to low quantity and quality of fodders, heat stress, increasing diseases and disease-Spreading pest.
- The fish stock at the coast are diminishing due to gradual drying up of lakes. The diminishing of fish is one of the factor that causes the overgrazing of stocks of bush meat.
- Displacement of farmers due to storm surge, flood, erosion and other hazards as a result of rise in sea level.
- Global warming causes an increase in rainfall in some areas followed by increase of atmospheric humility and high temperatures, favour pathogens, crop pests, disease vectors and weeds.
- Desertification is known as one of the world's most serious environmental problems. It is caused by a combination of natural and human-induced factors such as over-farming, population pressure, unsustainable water use systems and deforestation.
- Loss of biodiversity due to climate variability and climate change. According to United Nation assessment, 20-30% of earth's planet and animals face extinction if the world warms by 1.5 and 2.5 °C.
- Extreme weather such as thunderstorm, heavy wind and floods, devastate farm land leading to crop failure.
- Direct impacts include health problems such as Maleria, Cholera, Typhoid, Fever, Cerebro-Spinal merningitis (CMS) are aggravated due to extreme climatic conditions such as flooding, poor drainage, heat and drought. All these affect the effectiveness and productivity of the farmers.
- Climate change is a major threat to food security in many regions of the developing world, Nigeria inclusive which are largely dependent on rain fed labour intensive and extensive system of livestock production.
- Livestock production is one of numerous livelihood diversification strategies through which rural households fight food insecurity unfortunately, this aspect of livelihood diversification strategies is under serious threat due to climate change [4].

Agricultural activities are threatened by climate change impacts on rainfall, as discussed in the previous section. Furthermore, poor land-use practices in the form of unsustainable soil and water management, compromised biodiversity and unsuitable choice of crops are resulting in degradation of the resource base within which agriculture is anchored. Climate change and variability will accelerate food insecurity, which is gaining traction insidiously in Zimbabwe. It is predicted that increasing temperatures will result in more frequent occurrences of heat stress and increased infestations of pests and outbreaks of diseases, thus eroding the productivity of crops and livestock, as well as increasing expenditure on pesticides, herbicides and veterinary drugs. In addition, there are likely to be shifts of between four and six weeks in the onset and cessation of the rainy season. This implies shifts in planting and harvesting dates, as well as changes to the length of the growing season and to the types of crops and livestock that are suitable to these changes. This will result in increased demands for irrigation and increased strain on groundwater resources to support crops and livestock, especially in areas where water is climatologically scarce Livestock and wildlife will suffer equally from a lack of good pastures and vegetation due to erratic rainfall and heat waves associated with high temperatures. The frequency of fires, both natural and anthropogenic, is likely to increase due to a combination of dry vegetation and high temperatures. Wheat, maize and horticultural growing areas will shift in tandem with changes to the agro-ecological zones mentioned above. The IPCC predicts maize yield losses of between 18% and 30% in southern Africa by 2050 [5].and also mentions the possibility of sorghum yields declining. Areas suitable for maize cultivation are projected to decrease by 2080. One study predicts that the south and west of Zimbabwe will become less suitable for growing sorghum and maize, while the north, central and eastern areas will support sorghum and cotton [7]. Crops such as groundnuts, groundnuts and cassava could benefit from enhanced CO_2 levels [5].while areas suitable for sorghum and cotton cultivation are likely to increase by 2080.

Summarily, the climate change negative impacts can be condensed into: A modest decrease in the total amount of rainfall [6].and changes in the onset and cessation of rainy seasons, More frequent and prolonged mid-season droughts, Reduced groundwater recharge, Erratic spatial rainfall distribution across the country, Temperature increase between 1°C and 3°C, which is greater than the global average increases. These climate changes are likely to result in: Reduced water supply for domestic and agriculture uses, The expansion and contraction of Natural Regions V and I respectively, Degradation of natural resources, especially soil, water, natural vegetation, crops and livestock and reduced food security because of negative impacts on agriculture.

Climate Change Impacts on Crop Production

Owing to its effects on precipitation and temperature, climate change directly affects crop production, as the latter is highly dependent on the aforementioned factors. The effect on biomass production of the driver of climate change: rising atmospheric CO2-concentrations. Subsequently, the effects on crop production of expected changing temperature regimes, water availability and extreme weather events vital variables that influence agricultural production. Other factors of influence in agriculture include: weeds, pests and diseases, which in turn pose a potentially high risk to crop production [8].

Co2 Fertilization

Increase in atmospheric CO2 concentrations is the most important driver of climate change, but is also supposed to enhance biomass accumulation and ultimately yield of many crops. This can be partly explained by the partial closure of stomata, which reduces water loss by transpiration and thus improves water use efficiency [9].However, crop yield does not always respond positively to CO2 fertilization. Cassava (Manihot esculenta) biomass production, for example, declines with CO_2 concentrations increasing from 360 to 550 - 710 ppm [10]. Until recently, the significance of the effect of CO_2 fertilization on plant yield was unclear. Free-air carbon dioxide enrichment (FACE) experiments tried to validate CO_2 fertilization models in field experiments and at first showed only half the modelled yield was realized in real conditions [11]. However, the latter findings proved to be due to technical and statistical inconsistencies. Results from recent simulations are consistent with the values from FACE experiments [12].

The third IPCC assessment report extensively reviewed and confirmed the CO_2 fertilization effect but states its impact depends on photosynthetic pathway, species, growth stage and management regime, such as water and nitrogen application [12,15]. At 550 ppm CO_2 (SRES B1 prediction for 2100), crop yield (ceteris paribus) would increase in the range of 10-20 % for C3 crops (such as wheat and rice) and 0-10 % for C4 crops (such as maize, sorghum and millet) [13].

However, temperature and precipitation changes (see further) in future decades will modify, and often limit, direct CO_2 effects on plants. Future CO_2 levels may favour C3 plants over C4 plants; yet, the opposite is expected under temperature increases that will result from increased CO_2 concentrations. The net effects, however, remain uncertain. In fertile grasslands, it is predicted that legumes will benefit more from elevated atmospheric CO_2 concentrations than non-nitrogen fixing species [13]. They summarize yield sensitivity against mean local temperature increase - used as a proxy to indicate magnitude of climate change - of the three most important cereals (maize, wheat and rice) as derived from the results of 69 studies. This clearly illustrates (i) how climate change negatively influences cereal yield harder in the tropics (low latitude) in comparison with mid- to high latitudes; (ii) that adaptation measures include changes in planting time, changes in cultivar and shifts from rain fed to irrigated conditions) alleviates these negative effects; and (iii) that C3 and C4 plants cannot be distinguished in their response to climate change, probably because of counterbalancing effects of elevated CO_2 concentrations and associated higher temperatures [8].

A final important remark is that higher biomass production not necessarily implies higher nutritional quality. Some cereal and forage crops show lower protein concentrations resulting from elevated CO_2 concentrations. As food utilization is an intrinsic part of food security, food quality should not be neglected in studying the effects of CO_2 concentrations on crop production.

Temperature

Using two different climate models (NCAR and CSIRO) 2, based on SRES scenario A2 [24]. Show that increases in the average maximum temperature change are globally expected, but significant variation is observed between regions and between models. When one considers also other SRES scenarios, global mean surface temperature is projected to rise from between 1.1 °C and 2.9 °C in scenario B1 to between 2.4 °C and 6.4 °C in scenario A1 by 2100 [14].

All models expect large variation in temperature increases over regions. Not considering changes in frequency of extreme events (see further), moderate warming may benefit crop and pasture yields in temperate regions, while it would decrease yields in semi-arid and tropical regions [13]. Moderate warming (1-2 °C) is expected in the first half of the 21st century, whereas more intense warming (4-5 °C) is projected for 2080 and beyond. The latter warming will have negative effects on crop yields in all regions [8].

Water Availability

More than 90 % of climate model simulations predict decreases in precipitation by the end of the 21st century for the northern and the southern subtropics [8].Currently, half a billion people live in countries chronically short of water. By 2050, the number will have risen to between 2 billion and 7 billion people [16,17]. Water availability is a major determinant in crop production, perhaps even more important than the expected temperature increase [18,19].

However, future precipitation changes are expected to be unevenly distributed around the globe [20].The NCAR and CSIRO climate models (see also previous section on temperature change) show that precipitation changes are highly variable not only between regions, but also between models. Changes in precipitation patterns will significantly influence water resource availability, thus also affecting crop irrigation. Water availability will be affected by factors related to climate change, but other than changes in precipitation. They include increased water withdrawal for irrigation from rivers, lakes and aquifers, and glacial and snowmelt.

Especially in the Greater Himalayas Hindu Kush region and Central Asia, water availability for irrigation is threatened by glacier melting [19]. Although irrigated land only represents 17 % of total arable land, irrigated crops supply a significant portion of total agricultural output in the world (around 40 % in the case of cereals), consuming over 2,500 billion m^3, or 75 % of total fresh water resources, annually [13]. Even when positive CO2 effects on crop water use efficiency are taken into account, increased evapotranspiration and longer growing seasons resulting from increased temperature are likely to increase net crop irrigation requirements by 20 % globally by 2080 [21].

Consequently, water resource management needs to be explicitly addressed in adaptation strategies focusing on agriculture [18,20]. call for an integrated approach in water resource management as many other factors (population, pollution, etc.) play an important role as well. In all areas where water availability will decrease, water harvesting techniques and soil moisture conservation will be important management measures [1].

Impact of Climate Change on Agricultural Prices

Guaranteed access to food - one of the food security dimensions (see chapter 3) – will largely depend on purchase power of food consumers. Food prices consequently are an important food security indicator (notwithstanding the fact that other factors dramatically determine purchase power. Food prices are in theory determined by the equilibrium between supply and demand, but the agro-food system is extremely complex so that many other factors play a role in how food prices are shaped. Since the late 1950s and until the early nineties, world prices for food commodities have steadily declined. The last two decades, prices have stabilized, even though with quite some short term variations.

Sheds light on the causes of recent global price spikes for food commodities from late 2007 to early 2008 [16]. Growing demand for food in e.g. emerging economies of China and India only partly explains this phenomenon. Without going into details, the other factors explaining the recent food price spikes include increased demand of cereals for biofuel production, the rise in petroleum prices, slowing rates of farm productivity increases, gradual decline in food commodity stocks, and often-underestimated commodity speculation and macro-economic factors such as a weak US dollar and low interest rates [19,16].

Although sustained higher food prices potentially increase income and could consequently alleviate food insecurity, the period of high global food prices in 2007-2008 had the immediate consequence of sharply increasing the number of hungry people, while boosting the income of only a few relatively well-off farmers with large plantations in developing countries [7]. Household data for ten observations on nine low-income countries show that the short-run impacts of higher staple food prices on poverty differ considerably by commodity and by country, but that poverty increases are much more frequent, and larger, than poverty reductions. The recent large increases in food prices raised overall poverty in low-income countries substantially. According to the World Bank, in 2008 at least 110 million people have been driven into poverty and 44 million more were added to the already undernourished [22,19]. One of the main reasons behind this observation is that the vast majority of poor rural and urban households in developing countries are currently net food buyers [23]. Sustainably raising their income cannot be achieved by huge price shocks for only a few, but important food commodities. It requires a combination of policies that gradually reshapes current production and trade of food products. Examples include protection of domestic food markets and policies aimed at improving market integration of smallholders. It is expected that the aforementioned factors will persist in the future so that food price volatility will increase dramatically [7].

Notwithstanding climate change will add to the factors influencing future prices and price volatility, its precise importance remains unclear. According to [14]. Until 2050, climate change will have a negligible effect on food prices. After 2050, with larger temperature increases, prices would increase more substantially. Using different models in the SRES A2 scenario [21].expects real cereal prices to increase by 21 % to 23 % and overall agricultural real prices by 7 % to 8 % by 2080.

However, huge uncertainties, which are related to the models used, the SRES scenario considered, and the assumption of successful and full agronomic adaptation by farmers to climate change, cast doubt on the accuracy of Fischer's predictions. Furthermore, price changes from the effects of global warming are expected to be much smaller than price changes resulting from socio-economic factors. For instance, the SRES A2 scenario would imply a price increase in real cereal prices by 170 %, whereas additional price increase caused by climate change would only be 14 % [14]. In addition to annual variation, prices of food staples also exhibit a distinct seasonal pattern that will considerably be affected by climate change. Impact assessments of climate change on food commodity prices must therefore thoroughly consider seasonal variation [7].

Need For Climate-Smart Agriculture

Climate-smart Agriculture is defined by the Food and Agriculture Organization (FAO) as agriculture that sustainably increases productivity, enhances the resilience of livelihoods and ecosystems, reduces and/or removes greenhouse gases (GHGs) and enhances the achievement of national food security and development goals. The ravages of climate change and variability on agricultural production made it imperative for the government to call for the introduction of CSA practices into the tertiary education curriculum and agricultural extension advisory services—hence the need for the CSA Manual. CSA includes proven practical techniques such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agroforestry, improved grazing and improved water management. It also involves the introduction of innovative practices such as more dependable weather forecasting, early-warning systems and climate-risk insurance. The climate-smart agriculture concept reflects the ambition of further integrating agricultural development and climate responsiveness. The concept aims to achieve food security and broader development goals in circumstances of a changing climate and increasing food demand. Increased planning is vital in order to address trade-offs and synergies; between the three pillars of productivity, adaptation and mitigation.

By addressing challenges in the environmental, social and economic dimensions across productive landscapes, CSA practices coordinate the priorities of multiple countries and stakeholders in order to achieve more efficient, effective and equitable food systems. While the concept is new and still evolving, many of the practices that make up CSA already exist worldwide and are currently used by farmers to cope with various production risks. Mainstreaming CSA calls for critical analysis of successfully completed, on-going practices and their relationship with current and future institutional and financial enablers. The role of higher and tertiary education in CSA includes research and development, networking and capacity-building. Capacity-building relates to both technical skills and knowledge diffusion. Tertiary institutions in Zimbabwe also participate in the provision of training materials for various stakeholders.

Conclusion

Agricultural productivity brings food security which is the goal of agricultural production overall. Variation and fluctuations climate variables brings the implications of climate change which in turn affect agricultural productivity on the negative side, thereby leading to food insecurity and insufficiency which implications cannot be under estimated in a location. For food security to be attained, climate change issues have to be addressed in all their ramifications. Agricultural productivity is the sure sustainability in tackling food insecurity, it therefore requires consideration of the whole system rather than its individual parts in tackling food insecurity issues in Nigeria and the whole world.

References

1. Howden SM, Soussana JF, Tubiello TN, Chhetri N, Dunlop M, et al. (2007) Adapting agri-culture to climate change. Proceedings of the National Academy of Sciences of the United States of America, 104: 19691-19696.
2. Ozor N (2014) Understanding climate change: Implications for Nigerian Agriculture, policy and extension: climate change agriculture and higher education, multi-disciplinary issues and prospectives Grand Heritage Global Communications, publishers, Nsukka, Enugu State, Ni-geria 1-3.
3. Washington state department of ecology (2007) what is climate change? Assessed from www.ecy.wn.gov/climatechange/whatishtm on 2;5/05/2011.
4. FAO (2007) World Agriculture: Towards 2030/2050. An FAO study N. Alexandrators (ed.) John Willy. Chlechester, Uk.and FAO, Rome.
5. Alonge GO, Sangetagbe NS, Owolade EO (2012) Effects of climate change on food security of rural livestock farmers in Oyo State, Nigeria Agricultural extension strategies for climate change adaptation, conference proceedings of the 17th Annual National Conference, publish-ers, agricultural extension society of Nigeria (AESON).
6. Intergovernmental Panel on climate change (IPCC) (2007a) Climate change 2007 update. "(Fourth assessment Report / AR4)" Green facts scientic Board Publication.
7. Intergovernmental Panel on climate change (IPCC) (2007b). Effects of global Warming by region. Climate change 2007 update, April 2007.
8. Brown LR (1999) Crossing the threshold: early signs of environmental awakening. World-watch, 12: 13-22.
9. Vanhove W, Van Damme P (2011). Climate Change and Food Security – A Dynamic Per-spective. KLIMOS working paper 2, KLIMOS, Leuven, Belgium.
10. Rötter R, van de Geijn SC (1999) Climate change effects on plant growth, crop yield and livestock. Climatic change 43: 651-681.
11. Gleadow RM, Evans JR, McCaffery S, Cavagnaro TR (2009) Growth and nutritive value of cassava (Manihot esculenta Cranz.) are reduced when grown in elevated CO2. Plant Biology, 11: 76- 82.
12. Tubiello NT, Amthor JS, Boote KJ, Donatelli M, Easterling W, et al. (2007a) Crop response to elevated CO2 and world food supply. A comment on "Food for Thought…" by Long et al., Science 312:1918-1921, 2006. European Journal of Agronomy, 26: 215-223.
13. Tubiello NT, Soussana JF, Howden SM (2007b) Crop and pasture response to climate change. Proceedings of the National Academy of Sciences of the United States of America 104: 19686-19690.
14. Schmidhuber J, Tubiello FN (2007) Global food security under climate change. Proceedings of the National Academy of Sciences of the United States of America, 104: 19703-19708.
15. Long SP, Ainsworth EA, Leakey ADB, Nösbereger J,Ort DR (2006) Food for Thought: Lower-Than Expected Crop Yield Stimulation with Rising CO2 Concentrations. Science, 312: 1918-1921.
16. Sarris A (2009) Evolving Structure of World Agricultural Trade and Requirements for New World Trade Rules. Paper presented at the Expert Meeting on "How to Feed the World in 2050", June 24-26, 2009. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, 29p.
17. UNESCO (2003) Water for People, Water for Life. The United Nations World Water Devel-opment Report. Executive Summary. World Water Assessment Programme, UNESCO Pub-lishing, Paris, 32p.
18. Kang Y, Khan S, Ma X (2009) Climate change impacts on crop yield, crop water productivi-ty and food security - A review. Progress in Natural Science 19: 1665-1674.
19. Nellemann C, MacDevette M, Manders T, Eickhout B, Svihus B, et al.(2009) The environ-mental food crisis – The environment's role in averting future food crises. United Nations Environment Programme. Rapid Response Assessment. Birkeland Trykkeri, Norway, 101p.
20. Stecher KH, Fechter J (2009) Food Security and adaptation to climate change. Online Posi-tion Paper of the kfw Entwickelungsbank, Frankfurt, Germany, 8p.
21. Fischer G (2009) World Food and Agriculture to 2030/50: How do Climate Change and Bio-energy alter the long-term outlook for for Food, Agriculture and Resource Availability. Paper presented at the Expert Meeting on "How to Feed the World in 2050", June, 2009. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy 24-26.
22. Ivanic M, Martin W (2008) Implications of Higher Global Food Prices for Poverty in Low-Income Countries. Policy Research Working Paper 4594. Trade Team, Development Research Group, World Bank, Washington 54p.
23. FAO (2008) High Food Prices: Impact and Recommendations for Actions. Paper prepared by FAO, IFAD and WFP for the meeting of the Chief Executives Board for Coordination on April 2008, Bern, Switzerland 28-29.
24. Nelson GC, Rosengrant MW, Koo J, Robertson R, Sulser T, et al. (2009) Climate Change Impact on Agriculture and Costs of Adaptation. Food Policy Report, International Food Pol-icy Research Institute (IFPRI), Washington DC, USA, 28p.
25. Daily Trust (April, 30, 2011). Nigeria: climate change and food challenge, Daily Trust, 30 April, 2010 URL: http: // allafrica.com/stories/201004290231.html.
26. IPCC (2000) IPCC Special Report Emissions Scenarios. Summary for Policymakers. Inter-governmental Panel on Climate Change, 20p.
27. Spore (2008) Global trends: Time is running out spore magazine (Special issue). CTA.