Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.16, 2014

Coping Strategy of Rainfall Variability due to Changing Climate in Dry Sub-Humid Region of Borno State of Nigeria

A.B. Mustapha[1,2*] and Adzemi Mat Arshad[1]
1.Soil Science Laboratory, School of Food Science and Technology, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia
2.Department of Agricultural Technology, Ramat Polytechnic, Maiduguri Borno State, Nigeria
*Email:nusuwu.kam1000ye@gmail.com

Abstracts
It is evident that human population is growing with proportional increase in demand for food and water and global warming is already taking its toll on Nigeria particularly, dry sub-humid zone of Borno State like any other parts of the world. The significant long term increased trend of drought and dry spells has exacerbated water shortages thereby undermining agriculture and threatening livelihood. It was testified that there is likelihood of higher temperatures than the hottest growing seasons of recent times with subsequent variable rainfalls plus possible yield losses of 6–10% per 1^{o}C of warming in the average temperature of the growing season. More serious impacts of global climate change will be felt by smallholder farmers in the developing countries who are depending on small farm sizes, low technology and capitalization, poor infrastructure and institutional support. It was confirmed that shortage of soil moisture in the dry rainfed areas often occurs during the most sensitive growth stages of flowering and grain filling of the crops resulting in poor growth and consequent low yield. Supplemental irrigation, using a limited amount of water, if applied during the critical crop growth stages, can possibly result in substantial improvement in yield and water productivity which will curtail the impacts of climate change in the agro-ecological zone.
Keywords: Borno, Climate, Coping-Strategy, Dry Sub-Humid, Rainfall Variability

Introduction

The world's human population grew from 2.5 billion in 1950 to 6.1 billion in the year 2000 (Carvalho, 2006) and is estimated to reach over 9.3 billion by the year 2050 (U.S. Census Bureau 2014). On the other hand, global warming is posing threats to food security in many developing nations including Nigeria because of the climate-dependent nature of agricultural systems and lack of coping capabilities (Bello *et. al.,* 2012). The total numbers of food insecure people exceed one billion hungry in mid-2009 (FAO, 2009). Bossio *et al.,* (2010) and De Fraiture *et al.,* (2007) projected that, by 2050, global food demand would be 70-90% higher than current requirements. Food security is defined as a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Kastner *et. al.,* (2012) perceived the shifts in diets toward animal products, oils, and other resource intensive foodstuffs are placing ever more pressure on agricultural systems to increase production. Climate change affects agriculture and food production in complex ways. It is likely to reduce food production directly through changes in agro-ecological conditions and indirectly by affecting growth and distribution of incomes. At the same time, degraded soils as well as water, arable land, and other resource limitations challenge production increasing serious threat to livelihood (Lobell *et. al.,* 2008). Dempewolf *et. al.,* (2014) predicted that by the year 2050, much of the world will experience a growing season that will likely have higher temperatures than the hottest growing seasons of recent times and this increase in temperatures will probably be accompanied by more variable rainfall resulting in drought and dry spell. Crops will be impacted in various ways, such as increased sterility at higher temperatures and starting of early senescence under warmer conditions (Lobell *et. al.,* 2012). Shortage of soil moisture in the dry rainfed areas often occurs during the most sensitive growth stages of flowering and grain filling of the crops. As a result, rainfed crop growth is poor and yield is consequently low. Supplemental irrigation, using a limited amount of water, if applied during the critical crop growth stages, can result in substantial improvement in yield and water productivity (Wani *et. al.,* 2009). Therefore, supplemental irrigation is an effective response to alleviate the adverse impact of soil moisture stress during dry spells on the yield of rainfed crops. Supplemental irrigation as defined by Oweis and Hachum (2003) and Wani *et. al.,* (2009) is the addition of small amounts of water to essentially rainfed crops during times when rainfall fails to provide sufficient moisture for normal plant growth in order to improve and stabilize yields. By this definition, and since rainfall is the major water supply source for crop growth and production, the amount of water added by supplemental irrigation cannot by itself support economical crop production. In addition to yield increases, supplemental irrigation also stabilizes rainfed crop production.

Guarino and Lobell (2011) forecasted possible yield losses of 6–10% per 1◦C of warming in the average temperature of the growing season. This means the world could see significant production losses in the future. Adamson and Bird (2010) viewed drought as a socio-economic process of water shortage and its impacts. There may be food price increases due to reduced domestic agricultural output and possibly of their replacement with more expensive imports. There may be power rationing due to reduced generating capacity and some industries that are high consumers of water might have to reduce production causing grave concern for future food security. The objective of this paper is to review the important strategy to rainfall variability due to changing climate in dry Sub-Humid Region of Borno State of Nigeria

Impacts Rainfall Variability and Dry spells

Barron *et. al.,* (2010) defined dry spell as a maximum of 5mm of rainfall within a 14-day period, implies temporal water shortages during the season and a deficit of moisture in the root zone, which is a major constraint to farming. In Sub-Saharan Africa, there is a tendency that dry spells are getting more frequent. An increase in dry spell frequency is a main driver behind poverty and implies a degree of vulnerability as illustrated in a case study in Makanya in north-eastern Tanzania (Enfors, 2009).

Bello *et. al.,* (2012) investigated the spatiotemporal pattern of temperature and rainfall of Nigeria between 1901 and 2005 (105 years) and concluded that there is an increase in temperature (1.1℃) and decreasing rainfall amount (81mm) in Nigeria from 1901 but rapidly as from 1970. The air temperature patterns from 1901-1935 and 1936-1971 were found to be almost the same but differ significantly between 1971 and 2005. The rainfall was unpredictable and decreasing, which also differ significantly from 1971-2005. Coastal region is experiencing slightly increasing rainfall since the early 1970s and August break (short-dry-season) is currently being experienced more in July as against August in the Savannah ecology. These evidences show that Nigeria like most parts of the world is experiencing the basic features of climate change.

Nigeria is the most populous country in Africa with an estimated population of over 140 million and a total land area of 923,773 km^2 (Odiogor, 2010). It is currently losing about 351,000 hectares annually to desert encroachment which is estimated to be advancing southwards at the rate of about 0.6 km per year (Medugu *et al.,* 2009). FGN (1999) and Odiogor, (2010) also reported that Nigeria loses about 351,000 hectares of land every year to desert encroachment a condition which has resulted to demographic displacements in villages in the North. It was estimated that Nigeria loses about 5.1billion US Dollars every year owing to rapid encroachment of desert in most parts of the north out of which land degradation alone (including desertification and soil erosion) accounts for about 73%. Odiogor (2010) further estimated that over 70 million Nigerians have direct and indirect experiences of the negative impacts of drought and desertification; and that between 50% and 75% of Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara States in Nigeria are being affected by desertification. These states with a population of about 35 million people account for about 35% of the country's total land area (Abdulrahim *et. al.,* 2013). About 42 million people are believed to have been affected by this development. This has led to gradual disappearance of fertile lands and steady decline in food production, massive death of persons, cattle and vegetation in Northern Nigeria.

Rainfall is by far the most important element of climate change in Nigeria and water resources potential in the country (Adejuwon, 2004). The northeast region of Nigeria is increasingly becoming an arid environment at a very fast rate per year occasioned by fast reduction in the amount of surface water, flora and fauna resources on land (Obioha 2008). Consistent reduction in rainfall leads to a reduction in the natural regeneration rate of land resources (Fasona and Omojola 2005). This makes people to exploit more previously undisturbed lands leading to depletion of the forest cover and increase on sand dunes/Aeolian deposits. Climate change is the most severe problem the world is facing today which (King 2004) referred as more serious threat than even global terrorism.

Ati *et. al.,* (2009) reported that dry sub-humid and semi-arid bioclimatic zone Nigeria is characterized by a savannah type climate with alternating wet and dry seasons. Rainfalls in these regions vary from 1500mm per annum in the southern part to 400 mm around Maiduguri in the northern part. The rainy season lasts from about 7 months (April to October) in the southern part to as low as 3 months (July to September) in the northern part. The rainfall intensity in these zones is very high between the months of July and August. As a result, rapid surface run-off, soil erosion and water-logging are experienced though the environment is generally dry. Besides, inter annual variability is high (Iwegbu, 1993) which subject the zone to frequent dry spells, often resulting in severe and widespread droughts, capable of large scale destruction of plants, animals and human life (Ati *et al*., 2002).

Disruptions of existing food and water systems will have devastating implications for development and livelihood. These are expected to add to the challenges climate change already poses for poverty eradication (De Wit and Stankiewicz, 2006). According to Obioha (2009), the sustainability of the environment to provide all life support systems and the materials for fulfilling all developmental aspirations of man and animal is dependent on the suitability of the climate which is undergoing constant changes. The effect of these changes is posing threat to food security in Nigeria especially the dry sub-humid region of Borno state where rainfed farming with variable rainfall events on poor soil is the major means of livelihood.

Possible Interventions

Taking more land under cultivation to increase food production is not an option in most parts of the world without serious impacts on biodiversity. The provision of ecosystem services increasing agricultural yields in a framework of sustainable intensification is therefore an important solution (Garnett *et. al*., 2013). Significant headway can be made by improving agricultural practices and creating more favorable policy on environments. It will be crucial to adapt agriculture to the increasingly challenging environmental conditions by breeding new crop varieties, improving soil fertility and more importantly increasing yield per drop of rainfall. The list of possible plant traits that could be used is long, including everything from enhanced root growth to faster grain filling. Obviously more attention should be given to crops that will thrive under such unfavourable climatic condition. Water harvested during very high storms of July and August can be used to mitigate dry spells during grain filling in early September in pearl millet in dry sub humid zone of Maiduguri.

FAO (2009) stressed that important responses will be to include both (blue) water oriented activities such as storages, water use efficiency improvements, water accounting and data gathering, and (green) water oriented activities on croplands such as soil and water management and supplementary irrigation based on rainwater harvesting. They also stressed that crop patterns could be altered, crop breeding further developed, and crop storage from good to bad years implemented. Water storages of different scales will be needed to protect users from large fluctuations due to droughts. Surface water, soil moisture and groundwater storages will be needed. For quick solutions, surface storages may benefit from small reservoirs and natural wetlands. Soil moisture can be managed through improved farming practices like soil management, conservation tillage, and rainwater harvesting. And groundwater storage can be improved by intentional recharge arrangements.

Rainfed farmers are often the first ones impacted during droughts and could be encouraged to develop rainwater-based supplementary irrigation to reduce the risk of crop yield reduction and starvation. For irrigation-based farming systems, water use efficiency should be improved by measures that reduce the often large water losses (Falkenmark, 2013). He further stressed that most vulnerable people to global change will be those living in the semi-arid tropics and subtropics, home of the majority of poor and undernourished populations.

Most serious impacts of global climate change will be felt on smallholder farmers in the developing countries (Esham and Garforth, 2013). Their vulnerability to climate change comes from being predominately located in the tropics, high dependence on natural resources, small farm sizes, low technology and capitalization, poor infrastructure and institutional support limiting their capacity to adapt to change (Morton, 2007; World Bank, 2008 and Conway, 2009). Vulnerability to climate change is the propensity of human and ecological systems to suffer harm from exposure to stresses associated with climate change and from the absence of capacity to adapt (Adger, 2006; Adger *et. al.,* 2007).

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli in order to ameliorate negative effects and take advantage of opportunities associated with climate change. Climate change adaptation simply means reducing the vulnerability of people's lives and livelihoods to the risk posed by climate change.

Climate change is likely to more adversely affect food security in many sahelian and savannah regions of West Africa where a large fraction of the population is already facing chronic hunger and malnutrition (Sultan *et al.,* 2013). In such countries, the survival of the population will depend on the effective adaptation of agriculture to climate change.

Conclusion

Studies have indicated that, global food demand may rise by 90% due to population growth and at same time, global warming is posing threats to food security in many developing countries including Nigeria because of the climate-dependent nature of agricultural systems and lack of coping capabilities. Although the natural causes of climate change cannot be stopped, the effects of climate change can either be stopped or drastically reduced by human. In order to evade irreversible land degradation and ecological imbalance, farming practices that will be adaptive to the increasingly challenging environmental conditions should be implored. Governments at all levels should train and encourage small holder farmers to adopt supplemental irrigation with rainwater harvesting to increase yield per drop of rainfall. Breeding new crop varieties, improving soil fertility, providing farm inputs on time and subsidies should be entrenched. Credit facilities with no or very low interests should be made available to all farmers. Extension services, effective processing and storage technologies and market systems should be provided to farmers. Educating and training of farmers to adapt innovations on their farming practices should be encouraged. Agricultural research funds should be made available and making the farmers to participate so as to increase adoption easier. There should be integration of indigenous knowledge and practices into formal climate change mitigation and adaptation strategies. With the decreasing rainfall amount and duration, drought resistant and short duration high yielding crops should be developed and made available to farmers. Investments on small scale rainfed agriculture should be enhanced by incorporating with supplemental irrigation to make it more reliable and profitable.

Acknowledgements
The authors would like to thanks Universiti Malaysia Terengganu for giving permissions to publish this paper

References

Abdulrahim, M.A., I. P. Ifabiyi and A. Ismaila (2013). Time Series Analyses of Mean Monthly Rainfall for Drought Management in Sokoto, Nigeria. *Ethiopian Journal of Environmental Studies and Management (6) 5*

Adamson, P and J. Bird (2010). The Mekong: A Drought-prone Tropical Environment. *Water Resources Development, Vol. 26, No. 4, 579–594.* Downloaded by [Agora Consortium] at 20:11 25 March 201

Adejuwon S. A. (2004). Impact of climate variability and climate change on crop yield in Nigeria. Contributed Paper to Stakeholders Workshop on Assessment of Impact and Adaptation to Climate Change (AIACC): 2-8.

Adger, W.N. (2006). Vulnerability. Global Environmental Change, 16(3), 268–281

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (Eds.), Climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group to the fourth assessment report of the Intergovernmental Panel on Climate Change (pp. 717–743). Cambridge: Cambridge University Press.

Ati, O.F., C.J. Stigter and E.O. Oladipo, (2002). A comparison of methods to determine the onset of the growing season in northern Nigeria. *Int. J. Climatol., 22: 731-742.*

Ati, O. F. C.J. Stigter, E.O. Iguisi and J.O. Afolayan (2009). Profile of Rainfall Change and Variability in the Northern Nigeria, 1953-2002. *Research Journal of Environmental and Earth Sciences 1(2): 58-63. 2041-0492.* Maxwell Scientific Organization

Ayinde, O. E., M. Muchie and G. B. Olatunji (2011). Effect of Climate Change on Agricultural Productivity in Nigeria: A Co-integration Model Approach. *J Hum Ecol, 35(3): 189-194*

Barron, J., Enfors, E., Cambridge, H. and Moustapha, A. (2010) Coping with rainfall variability in semiarid agro-ecosystems: implications on catchment scale water balances by dryspell mitigation strategies among small scale farmers in Niger. *International Journal of Water Resources Development, 26(4), pp. 543–559.*

Bello O. B., O. T Ganiyu, M. K. A.Wahab, M. S.Afolabi, F. Oluleye, S. A. Ig, J. Mahmud, M. A. Azeez and S. Y. Abdulmaliq (2012). Evidence of Climate Change Impacts on Agriculture and Food Security in Nigeria. *International Journal of Agriculture and Forestry 2012, 2(2): 49-55*

Carvalho, F. P., 2006. Agriculture, pesticides, food security and food safety, *Environmental Science and Policy, 9, 685-692.*

Conway, G. (2009). The science of climate change in Africa: Impacts and adaptation (Discussion Paper No. 1). Grantham Institute for Climate Change, Imperial College London.

Dempewolf, H., J. R. Eastwood, L. Guarino, C. K. Khoury, J. V. Müller and J. Toll (2014). Adapting Agriculture to Climate Change: A Global Initiative to Collect, Conserve and Use Crop Wild Relatives

De Wit M, Stankeiwicz J 2006. Changes in surface water supply across Africa with predicted, climate change. *Science, 311: 1917-1931.*

Enfors, E. (2009) Traps and transformations exploring the potential of water system innovations in dryland Sub-Saharan Africa. PhD thesis in Natural Resources Management, Stockholm University, Stockholm.

Esham M. and C. Garforth (2013). Climate change and agricultural adaptation in Sri Lanka: a review. *Climate and Development Vol. 5, No. 1, 66–76*

Falkenmark, M. (2013). Adapting to climate change: towards societal water security in dry-climate countries. *International Journal of Water Resources Development, Vol. 29, No. 2, 123–136.*

FAO. (2009). How to feed the world in 2050. Proceedings of the Expert Meeting on How to Feed the World in 2050. Rome: Food and Agricultural Organization of the United Nations

Fasona M.J. and Omojola SA (2005). Climate Change Human Security and Communal Clashes in Nigeria. An International Workshop Holmen Fjord Hotel, Asker, near Oslo, 21–23 June 2005.

Garnett, T., M. C. Appleby, A. Balmford, I. J. Bateman, T. G. Benton and P. Bloomer, (2013). Sustainable intensification in agriculture: Premises and policies. *Science 341:33–34.*

Guarino, L., and D. B. Lobell. 2011. A walk on the wild side. Nature Climate Change 1:374–375.

Iwegbu, I.A., (1993). Some aspects of the spatial and temporal characteristics of drought in Nigeria: A statistical approach. Ph.D. Thesis. Department of Geography, Ahmadu Bello University, Zaria.

Kastner, T., M. J. I. Rivas, W. Koch, and S. Nonhebel. 2012. Global changes in diets and the consequences for land requirements for food. Proceedings of the National Academy of Sciences 109:6868–6872.

King D 2004. Climate change science: Adapt, mitigate or ignore? *Science, 303: 176-177.*

Lobell, D. B., M. B. Burke, C. Tebaldi, M. D. Mastrandrea, W. P. Falcon, and R. L. Naylor. 2008. Prioritizing climate change adaptation needs for food security in 2030. Science 319:607–610

Lobell, D. B., A. Sibley, and J. Ivan Ortiz-Monasterio. 2012. Extreme heat effects on wheat senescence in India. Nature Climate Change 2:186–189.

Medugu, N.I., Majid, M.R., and Johar, F. (2009), The consequences of drought and desertification in Nigeria. *The IUP Journal of Environmental Sciences, 3(3): 66-84*.

Morton, J.F. (2007). The impact of climate change on smallholder and subsistence agriculture. Proceedings of the National Academy of Sciences, 104, 19680–19685. doi: 10.1073/pnas.0701855104

Obioha, E. (2008). Climate change, population drift and violent conflict over land resources in north eastern Nigeria. *Journal of Human Ecology, 23(4): 311-324.*

Obioha, E. (2009). Climate variability, environmental change and food security nexus in Nigeria. *Journal of Human Ecology, 26(2):107-121.*

Odiogor H. (2010), Special Report on desertification in Nigeria: The sun eats our land http://www.vanguardngr.com/2010/05/ special report on-desertification-in-nigeria-the-sun-eats-our-land/May 3, 2010·

Oweis, T. and Hachum, A. (2003) Improving water productivity in dry areas of West Asia and North Africa. In: Kijne, J.W., Barker, R. and Molden, D. (eds) Water Productivity in Agriculture: Limits and Opportunities for Improvement. CAB International, Wallingford, UK, pp. 179–198.

Oweis, T and A. Hachum (2009). Supplemental Irrigation for Improved Rainfed Agriculture in WANA Region In: Suhas, P., Wani, S P., J. Rockström and T. Oweis (ed.) Comprehensive Assessment of Water Management in Agriculture Series. Rainfed Agriculture: Unlocking the Potential

Smith, R. L., C. S. Hoveland and W. W. Hanna (1989). Water Stress and Temperature in Relation to Seed Germination of Pearl Millet and Sorghum. *Agronomy Journal. Vol. 81 No. 2, p. 303-305*

Wang, J. (2010). Food Security, Food Prices and Climate Change in China: a Dynamic Panel Data Analysis. *Agriculture and Agricultural Science Procedia 1 (2010) 321–324.* Elsevier B.V.

World Bank. (2008). Agriculture for development. Washington, DC: World Bank.

Yadav, O.P., K. N. Rai and S. K. Gupta (2012). Pearl Millet: Genetic Improvement for Tolerance to Abiotic Stresses. In: Improving Crop Productivity in Sustainable Agriculture. *Wiley Blackwell, pp. 261-268. ISBN 978-3-527-33242-7*

U.S. Census Bureau. (2014). International database, June 2011 update. http://www.census.gov/population/international/data/idb/worldpoptotal.php (accessed January 15, 2014).