Climate Change Adaptation, Mitigation, and the Attainment of Food Security in the Sudano-Sahelian Belt of Nigeria

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Abstract

Climate change and rainfall variability are evident in rainfall amount and the hydrologic growing season across the zone located between longitudes 3° and 15° east of the Greenwich meridian and latitudes 10° and 14° north of the Equator. These changes have continued to escalate the vulnerability of people's livelihood, as extreme weather conditions lead to reduction in agricultural yields which subsequently aggravate food insecurity. There is a general understanding of climate change and variability across the belt as indicated by the varying adaptation practices by individuals and communities to enable them to cope with the challenges of changing climate. Generally, in Nigeria, there are numerous crucial policies and programs aimed at addressing issues related to climate change adaptation and agricultural sustainability. However, the major concern is the level of implementation and its role in promoting, developing, and instituting effective adaptation strategies and practices that will enhance resilience of the

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vulnerable communities. Consequently, bottom-up approaches should be developed and promoted to identify and document existing adaptation practices, alongside with assessing these adaptation practices for scaling up potential cost-effective practices for enhanced climate change adaptation, attainment of food security, and resilience.

The Sudano-Sahelian Belt of Nigeria

The Sudano-Sahelian belt of Nigeria is located between longitudes 3° and 15° east of the Greenwich meridian and latitudes 10° and 14° north of the Equator. However, in reality, this extends to about latitude 9° in recent times. The extreme northern part of the belt approaches the desert fringes, particularly sharing boundaries with the semiarid and arid zones of the Niger Republic. The states located in this zone are Sokoto, Kebbi, Zamfara, Katsina, Kano, Jigawa, Yobe, Borno, Gombe, Adamawa, Bauchi, and northern Kwara, Plateau, Niger, Nasarawa, and Taraba. Typical feature of this belt is land degradation in response to increase in both climate change and human activities: overcultivation and overgrazing.

The climate is characterized by alternate wet and dry seasons in response to the changes in pressure patterns. There is high variability in dates of onset and cessation of rains across the region which results in variability in length of the rainy season; this can also be attributed to the migratory patterns of the Intertropical Discontinuity (ITD). The rainy season in this belt is associated with late onset and early cessation which is associated with strong storms which destroy life and property. The rainy season in this zone has high rainfall intensity concentrated within a short period of time, thus increasing the rate and intensity of runoff. Hence, the Sudano-Sahelian zone is a moisture stress zone seen to be tending toward increased degradation. The latitudinal location of the belt also results in high temperature throughout the year, at about 27 °C. Generally, the highest temperature in the country is recorded in this zone. In addition, temperature range is highest in the northwest and northeast above 10 °C and reduces southward. The belt is dominated by savanna vegetation types: Guinea, Sudan, and Sahel savannas. The density of trees and grasses decreases northward, hence responding to climatic conditions.

Agriculture is the dominant economic activity in Northern Nigeria; crops such as groundnuts, cotton, millets, beans, Guinea corn, cassava, yam, and maize are cultivated in the region which also has the highest concentration of cattle in the country. In this belt the livelihood of rural farmers is highly tied to the availability of natural resource (land, water, and vegetation), thereby aggregating the impact and intensity of climate change on the community. A large proportion of the inhabitants depend on rain-fed agriculture. Also, irrigation scheme is employed mostly for cultivation of vegetable during the dry seasons but is characterized by low input and output.

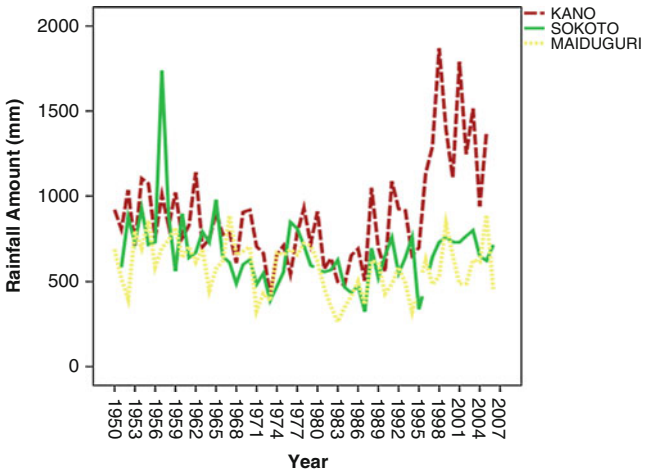

Fig. 1 Annual rainfall amount (1950–2007)

An Overview of Climate Change Impact in the Sudano-Sahelian Belt of Nigeria

The impact of climate change is already apparent across the Sudano-Sahelian zone of West Africa where a large proportion of the population engages in subsistent agriculture which is highly vulnerable to erratic weather conditions typical of the region. In Nigeria, climate changes coupled with increased human population and overexploitation of natural resources have aggravated environmental degradation which the teeming population rely on for their livelihoods. The recurring drought, desertification in the extreme Northern Nigeria, devastating flood across the riverine communities, soil erosion, and attendant loss of soil nutrients have continued to increase southward migration since the last century. Figures 1 and 2 depict the variability and gradual changes typical of the annual total rainfall amount and the hydrologic growing season in the three states across the belt. The vulnerability of developing countries and their populations to increased climate variability and change is of great concern and has attracted considerable research interest over the past decades with calls for increased funding for adaptation (Patt et al. 2010). These in addition to rainfall break, dry spell, drought, and flood during the growing season have continued to escalate the vulnerability of people's livelihood as extreme weather conditions lead to reduction in agricultural yields which subsequently aggravate individual/community poverty levels, susceptibility to climate change pressures, and food insecurity.

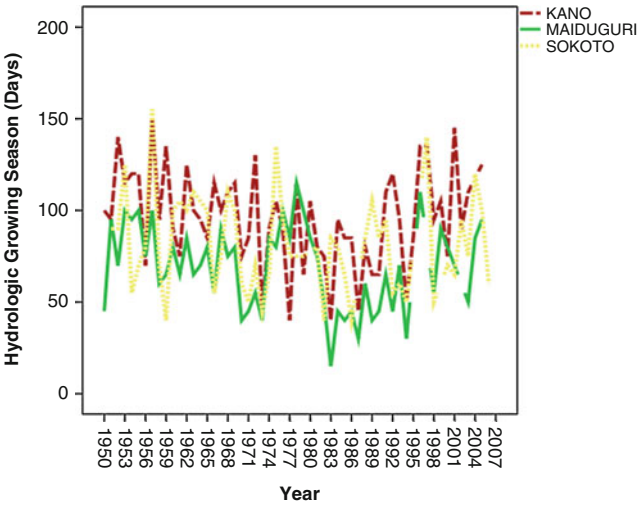

Fig. 2 Hydrologic growing season (1950–2007)

Climate Change Adaptation Practices and the Attainment of Food Security

There is a general understanding of climate change and variability across the belt as varying practices are being adapted by individuals and communities to enable them cope with the challenges of changing climate for the attainment of food security. The adaptation practices adopted are mixed farming, adoption of improved seeds that require less water and short maturing period, water conservation strategy, irrigation, and imbedding soil conservation culture through crop rotation. As such, agricultural adaptation that has always taken, and continues to take, place in Africa is responding more to perceived climate variability than climate change (Gina et al. 2008). These adaptation practices are taken to lessen the effects of climate change/variability and to increase socioeconomic well-being as well as enhance human livelihood. Adaptation to climate change is linked to sustainable socioeconomic development in the belt because large proportions of the inhabitants rely on natural resources (land and water) for their livelihood. They continue to identify measures for sustainable agriculture which is their main economic activity. Adaptation is adjusting the natural system or human system in response to actual or expected climatic stimuli or their effects (IPCC 2007). Basically, the emphasis has been on adjusting farming systems to expected climatic condition. How successful or otherwise these have been is yet to be determined. There is considerable knowledge gap with respect to climate change impact, vulnerability, and adaptation to increased climate variability and change (Molly and Brent 2011).

In recent times, the effect of climate change has forced farmers to diversify their economic activities, as most farming communities now combine crop cultivation and livestock farming or fishery. This to some extent is supported by the National Economic Empowerment and Development Strategy (NEEDS 2004) whose developmental plan is inspired by current challenges for vigorous growth. NEEDS emphasis is on job creation, strengthening the skill base, protecting the vulnerable, and promoting peace and security. This generally consists of robust plan to identify the major problems facing the various communities across the country with a view to proffering solutions using integrated economic development processes and programs across the tiers of the government (federal, state, and local government levels). However, the major concern is to what extent has the implementation of these robust plans reduced the vulnerability of the communities to climate change.

In a belt with the highest concentration of animal husbandry in the country, there is no realistic climate change adaptation practice as the existing adaptation practices are mainly reactive whereby the nomads move their animals southward for greener pastures, coupled with the fact that most of the local breed adapts to climatic stress. Livestock production in Africa and Southern Africa, especially its developing component, is vulnerable and at high risk of being severely affected by climate change (Rust and Rust 2013). This mobility will not only aggravate land, vegetation, and water degradation but also climate change as the dominance of grazing in the Guinea savanna in recent times is a potential for increased carbon dioxide emission into the atmosphere. The resultant problem of the practice is apparent in the widespread crisis between the traditional farmers and the encroaching nomads across the country. Consequently, there is an imperative need to maintain the existing grazing reserves and establish more grazing reserves to meet the growing demands of animal husbandry across the country. Furthermore, there should be capacity building for herders to enable them develop and adopt effective and affordable improved livestock management practices that will boost their adaptation to climate change.

The general approach to climate change adaptation in Nigeria has been top-down approach; usually, general policies and decisions are taken without the involvement of the communities or working together with the community groups to develop community-based climate change adaptation practices. The ministries and agencies should develop bottom-up approaches that will identify, document, quantify, and assess the existing adaptation practices for scaling up potential cost-effective practices that will enhance climate change adaptation and resilience. Integrating indigenous knowledge can add value to the development of sustainable climate change mitigation and adaptation strategies that are rich in local content and planned in conjunction with the people (Nyong et al. 2007). The community-based practices should be developed with the community by identifying their agricultural potentials and climate change challenges as well as promoting improved land and water management practices at community levels such that it will lead to the attainment of community food security in the country in general.

The Federal Government of Nigeria mandated the Nigerian Meteorological Agency (NIMET) to monitor weather and climate in Nigeria and provide meteorological information for sustainable development and safety of life and properties in the country. Hence, the agency annually gives detailed seasonal rainfall prediction (SRP) before the onset of rain so as to provide essential weather advisories and early warning to planners, decision makers, and the various operations in rainfall-sensitive socioeconomic sectors, e.g., transport, water resources, health, and agriculture. Onset and cessation dates, length of the rainy season, annual rainfall amount, expected changes in the prediction of the parameters, and socioeconomic implications are annually predicted to guide the farmers and stakeholders on the types of crops to be planted and what to expect of the growing season, dry spell, drought, and flood. Furthermore, the agency publishes agrometeorological products and services to advise the Federal Ministry of Agricultureand Rural Development and associated agencies as well as farmers to take advantage of the information contained in the two to enhance their adaptation to adverse weather conditions. NIMET – SRP (2015) predicted 3–13 days delay of onset of rains: late onset of growing season in Makurdi, Lokoja, and Enugu; early cessation of growing season in Zaria, Nguru, Kano, and Jos; shorter length of the growing season in Niger, Gusau, and Kaduna; below-normal rainfall amount in parts of the extreme southwest; and above-normal rainfall in Warri, Calabar, Bauchi, Gombe, and Nguru.

The seasonal rainfall prediction and agrometeorological products are beneficial to agriculture and other economic sectors as they contribute toward effective adaptation to the effect of climate change annually. However, considering the fact that large proportions of the vulnerable communities are uneducated, it is crucial to organize community-based sensitization programs that will enhance their understanding of these valuable information. These will reduce their vulnerability to climate-related hazards as it will enhance safe sowing and boost crop and food production. Developing countries are more exposed to experience the negative impacts of climate change owing to their fragile economic sectors and the reliance of many livelihoods on climate-sensitive sectors such as rain-fed agriculture (IPCC 2013; Stockmann et al. 2013; World Bank 2012). The relevant institutions, stakeholders, extension workers, and traditional leaders should strengthen community's capacity for climate change adaptation. Authorities, individuals, and communities' awareness will provide them with adequate capacity to act by adapting strategies for effective adaptation to the changing climate as well as facilitate the attainment of food security.

This general prediction needs to be developed into effective community- based early warning schemes that will be easily adapted by the immediate community and relevant stakeholders as cost-effective tools for climate change adaptation and attainment of food security. In the Sudano-Sahelian belt where about two-thirds of the population lives in rural areas, the starting point for the adaptation should be by promoting the culture of resilience based on existing community knowledge. In addition, the community should be well informed through dissemination of accurate and adequate information in local languages to enhance people's adaptation and resilience. Consequently, collection, compilation, and dissemination of relevant information and knowledge of climate change, vulnerabilities, and capacity at

Table 1 Agricultural research institutes in Northern Nigeria

Name of research institute	Mandate
Lake Chad Research Institute, P.M.B 1293, Gamboru Road Maiduguri, Borno State	Genetic improvement and development of production technologies for wheat, millet, and barley; the improvement of the productivity of the entire farming system in the northeastern zone
Institute for Agricultural Research, P.M.B 1044, Ahmadu Bello University, Samaru, Zaria	Genetic improvement and development of production and utilization technologies for sorghum, maize, cowpea, groundnut, cotton, and sunflower and the improvement of the productivity of the entire crop-based farming system in the northwest zone of Nigeria
National Cereals Research Institute, P.M.B 8, Badeggi, Bida, Niger State	Genetic improvement and production of rice, soybean, benniseed, and sugarcane and improvement of productivity of entire farming system of the central zone
Nigeria Stored Products Research Institute, P.M.B 1489, Km 3 Asa Dam Road, Ilorin, Kwara State	Research into improvement of major food and industrial crops and studies on stored product, pest and diseases, pesticide formulation, and residue analysis
National Animal Production Research Institute, P.M.B 1096, Shika, Zaria	Research on food, animal species, and forages
National Veterinary Research Institute, P.M.B 01, Vom	Research into all aspects of animal diseases and their treatment and control, as well as development and production of animal vaccines and sera
National Institute for Freshwater Fisheries Research, P.M.B 6006, New Bussa	Research into all freshwater fisheries and long-term effects of man-made lakes on ecology and environment throughout the country
National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria	Research into technology transfer and adoption studies; overall planning and development of extension liaison activities nationally; collation and evaluation of agricultural information

community level will enhance climate change adaptation, mitigation, and resilience. The low adaptive capacity of crop farmers in Nigeria can be attributed to a variety of factors, including poverty, lack of access to resources, and poor infrastructure (Chinedum et al. 2011). Investigating the strategies for coping with current climate change will provide pointer for addressing adaption needs in Nigeria particularly in the area of food security and socioeconomic well-being.

Similarly, several agricultural research institutes are established across the zone (Table 1). Most of these institutes are mandated to conduct researches that will lead to sustainable agriculture in the zone through development of improved seed species that are today widely accepted by farmers across the zone. Ministries of agriculture have also continued to promote adoption of improved cultivation and higher-yield varieties through Agricultural Development Projects (ADP) that are widely spread across the country. The adoption of these improved species enhances community

capacity in adapting to climate change; practical adaptation initiatives tend to focus on risks that are already problematic (Barry and Johanna 2006). There are also centers like the Centre for Climate Change and Freshwater Resources (CCCFR) established in 1995 (as a linkage center of the Federal Ministry of Environment) to create awareness, educate, and train Nigeria's teeming population while conducting credible research to guide policy making. Centers like these should be empowered adequately and promoted to climate change institutes with the mandate to take leadership role in climate change monitoring, modeling, impact assessment, and development of adaptation and mitigation strategies that will enhance resilience to climate change. Generally, it is crucial to initiate polices, guidelines, programs, strategies, and projects to reduce vulnerability across the zone and help farmers adapt to the changing climate for the attainment of food security.

The National Emergency Management Agency (NEMA) in collaboration with the Federal Ministry of Education, in their contribution, has started the mainstreaming of climate change and disaster risk reduction (DRR) into basic and postbasic school curriculum. If accomplished and implemented, it will increase climate change awareness and subsequently enhance adaptation to climate change. However, it is also important to mainstream climate change into development interventions at the federal, state, and local government levels to enhance community climate change awareness and promote community-based adaptation policy such that it will lead to its incorporation into relevant socioeconomic activities at grass roots such as agriculture.

Climate Change Mitigation Strategies in the Sudano-Sahelian Belt of Nigeria

Since 1972, the United Nations General Assembly designated 5th of June as World Environment Day (WED), to stimulate awareness and understanding of the environment and the problems that besiege its sustainability; the Federal and States Ministries of Environment mark this day annually across the country with poorly planned and executed tree planting campaigns across the country. The practicality of these in climate change mitigation is still at very low level because in most cases these trees are hardly nurtured to maturity. The tree seedling should have been distributed to the endangered rural farmers that will be determined to plant and nurture them not only for climate change mitigation and resilience but also for enhanced community access to fruits, medicine, poverty reduction, enhanced livelihood, and attainment of food security.

Furthermore, the WED is generally used to encourage every Nigerian to plant trees in order to reduce emissions from deforestation and forest degradation (REDD) that is typical across the Sudano-Sahelian belt. To accomplish this, agroforestry is highly encouraged as economic tree seedlings are distributed to large-scale farmers by the ministry which not only help to mitigate climate change but also enhance community access to fruit and modify community microclimate (Plate 1). Nigeria's farmers reported that temperature and rainfall are increasing (Sofoluwe et al. 2011).

Plate 1 Large-scale agroforestry

Plate 2 Community's adaptation to climate change

This noble program should be well planned and implemented such that the rural farmers are incorporated or grassroots participation encouraged because it is a common method for rural community's adaptation to climate change (Plate 2). Through this, policy makers and environmentalists should have immensely contributed to climate change mitigation and improved standard of living as well as safeguarding biodiversity and preserving the natural environment. Furthermore, the Federal Ministry of Environment in collaboration with United Nations Development Programme (UNDP) and other partners is promoting the adoption of renewable energy across the country to promote the Nigerian Alliance for Clean Cookstoves (NACC) and is developing more efficient woodstoves to reduce consumption of biomass-based energy sources and to enhance climate change mitigation.

The agricultural management system is aggravating climate change impact as huge proportions of agricultural residue that cannot be consumed by animals are

burnt annually leading to the increased emission into the atmosphere. Crop residue burning is considered as a chief contributor of greenhouse gas (GHG) emissions in the atmosphere (Jordan et al. 2010). Thus, there is need to find appropriate methods which can enable farmers to incorporate these residues to land use practices as well as mitigate climate change and strengthen Africa's agricultural sectors to enable them to respond to growth in demand (John and Irene 2009). Improved management practice (IMP) techniques that will enhance soil organic matter storage with minimum soil disturbance through incorporation of crop residual into farming system should be promoted as its adoption will enhance climate change adaptation. Also, it will not only enhance soil fertility and crop performance but will also help in removing excess carbon dioxide from the atmosphere, thereby crucial for climate change mitigation and adaptation. In Nigeria rice straw and other crop residues are abundant; these can be incorporated into the soil as biological fertilizer in order to enhance soil sustainability and climate change adaptation and mitigation. Increasing atmosphere carbon dioxide is a dual consequence of poor management of crop residues and agricultural land practices (IPCC 2013). Thus, improved carbon sequestration necessitates adoption of improved land use management practices across the zone such that high-breed economic trees will be integrated into cultivated land for improved soil conservation, attainment of food security, and resilience to climate change.

Despite the fact that countries have ecological funds, it is not easy to determine what percentage of this goes to the climate change mitigation/adaptation. Climate change adaptation should be national priority such that it will be given its rightful place in planning for national development and supported with funds to implement adaptation strategies and enforce sustainable adaptation practices at large scale for the attainment of food security. Government at all levels, collaborative partners, and NGOs should specify certain percentage of fund for climate adaptation which should be invested in schemes and projects that will promote climate change adaption, mitigation, and resilience.

In Nigeria, available records in the Federal Department of Forestry show that Nigeria has a total of 1,160 constituted forest reserves covering over 10,752 ha of land, and this represents about 10 % of the total land area. Also, game reserves and national parks are excluded from this. However, most of these reserves only exist on paper and the Federal Department of Forestry argues that deforestation in Nigeria is now progressing at the rate of 3.5 % per annum. In Africa, for example, deforestation accounts for nearly 70 % of total emissions (FAO 2005). Furthermore, Anselm and Taofeeq (2010) stated that climate change is perhaps the most serious environmental threat to the fight against hunger, malnutrition, disease, and poverty in Africa, mainly through its impact on agricultural productivity. Hence, there is need to check the way in which people interact with these crucial resources such that it will reduce the rate of deforestation and increase biodiversity, conservation, and reforestation using introduced or indigenous species that will promote sustainability of the forest. These will not only enhance climate change adaptation and mitigation but contribute greatly toward the attainment of food security.

Future Direction

Generally, in Nigeria, there are numerous crucial policies and programs aimed at addressing issues related to climate change adaptation and agricultural sustainability. However, the major concern is the level of implementation and its role in promoting and developing institutions of effective adaptation strategies and practices that will enhance resilience of the vulnerable communities across the country. There should be an agency/organization empowered to collate, synthesize, implement, and promote climate change policies and programs at all levels of the government such that it will be widely adopted across the country particularly the vulnerable community. Bottom-up approaches should be developed and promoted to identify, document, and quantify existing adaptation practices, along with assessing these existing adaptation practices for scaling up potential cost-effective practices for enhanced climate change adaptation and resilience.

Institution and organization plans should be realistically implemented to enhance vulnerable community climate change adaptation and mitigation through such programs that will integrate environmental and natural resource development into socioeconomic development process for the attainment of food security and improved rural livelihood. Similarly, government interventions such as NEEDS should be channeled toward identifying the major problems facing the various communities across the country with a view to building their capacity in proffering solutions using integrated economic development processes and programs at community levels in job creation, strengthening the skill base, reducing vulnerability, and promoting peace and security that are today threatened across the country.

The federal, state, and local government initiatives should be proactive; the Nigerian Meteorological Agency (NIMET), NEMA, State Emergency Management Agency (SEMA), and ADP should collaborate in the development and communication of effective community-based early warning schemes as a cost-effective tool for climate change adaptation and attainment of food security. In addition to the agricultural research institutes well spread across the zone, climate change institutes should be established to take leadership role in climate change monitoring, modeling, and impact assessment, to collaborate with all the relevant agencies in the development of adaptation and mitigation strategies, and to initiate policy guidelines, programs, and projects that will enhance resilience to climate change. The institutes should identify ways of mainstreaming climate change into all developmental interventions at the federal, state, and local government levels as pathways for promoting community-based adaption policies at the grass roots. Bottom-up approaches should be enforced by identifying the varying community's agricultural potentials and the strategies of land and water management practices that will boost their adaptation to climate change.

WED should be marked by distributing tree seedlings to communities that will be determined to plant and nurture them not only for climate change mitigation and resilience but for enhanced community access to fruits, medicine, poverty reduction, improved livelihood, and attainment of food security instead of political tree planting

campaigns. Thus, agroforestry should be integrated into crop cultivation and animal husbandry by making economic tree seedlings available to small- and large-scale farmers. Renewable energy and clean cooking stoves should be promoted across the country, and more efficient stoves should be developed to reduce the use of fuel wood as source of energy as well as enhance climate change mitigation.

Furthermore, there is need to design and implement local adaptation strategies that will bridge the gap between scientific and local knowledge in order to create projects capable of increasing community adaptation and resilience. In addition to the high-breed crop varieties, relevant stakeholders should promote breeding of high-breed economic trees and make them available to farmers at subsidized rates. This will not only promote effective climate change adaptation but enhance mitigation and resilience. Diversification of the economy through provision of credit, cooperative, and micro-finance at lower interest rates should be promoted. Also, community-based organizations (CBOs), improved land and water management practices, irrigation strategies, building crop storages, developing marketing facilities, subsidizing agricultural inputs, and establishment of safe nets will enhance diversification of the economy. Generally, these are cost-effective tools for climate change adaptation, mitigation, and attainment of food security.

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