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AGRICULTURAL ADAPTATION STRATEGIES TO CLIMATE CHANGE IMPACTS IN AFRICA: A REVIEW

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Abstract

Climate change is expected to intensify existing problems and create new combinations of risks, particularly in Africa. The situation is made worst due to factor such as widespread poverty, over dependence on rain fed agriculture, inequitable land distribution, limited access to capital and technology, inadequate public infrastructure, such as roads, long term weather forecasts and inadequate research and extension. By lessening the severity of key damages to the agricultural sector, adaptation is the key defensive measure. Adaptation to climate change involves changes in agricultural management practices in response to changes in climate conditions. This paper reviews agricultural adaptation strategies employed by farmers in various countries in Africa in cushioning the effects of climate change. The common agricultural adaptation strategies used by farmers were the use of drought resistant varieties of crops, crop diversification, changes in cropping pattern and calendar of planting, conserving soil moisture through appropriate tillage methods, improving irrigation efficiency, and afforestation and agro-forestry. The paper concluded that improving and strengthening human capital through education, outreach programmes, extension services at all levels will improve capacity to adapt to climate change impact.

Keywords: Adaptation strategies, agriculture, climate change, impacts and Africa.

Introduction

Climate change is rapidly emerging as a global critical development issue affecting many sectors in the world and is considered to be one of the most serious threat to sustainable development. Globally, an unprecedented increase in greenhouse emissions has led to increased climate change impacts. Agricultural activities have been shown to contribute immensely to climate change as it ranks third after energy consumption and chlorofluorocarbon production in enhancing green house emissions. In fact, emissions from agricultural sources are believed to account for some 15% of today's anthropogenic greenhouse gas emissions. Land use changes, often made for agricultural purposes, contribute another 8% or so to the total (Ozor and Nnaji, 2011).

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Agriculture is the economic mainstay in most African countries, except in oil-exporting countries, contributing 20-30% of Africa's gross domestic product (GDP) and 55% of the total value of African exports, with 70% of the continent's population depending on the sector for their livelihood (Organization for Economic Cooperation and Development (OECD), 2009). In most African countries, crop farming is mainly subsistence and rain-fed, but due to climate change frequent and untimely raining affects harvest of produce and thus, food production. This makes Africa particularly vulnerable to the impacts of climate change. The vulnerability of the region is further worsened by the fact that the climate is already too hot as it is tropical in nature.

With reference to sub-Saharan Africa, there is growing interest on the likely impacts of climate change on agriculture, economic growth and sustainable development. This is because the region has been experiencing increased drought in recent times due to increased temperature and reduced rainfall. Incidences of climate change include changes in soil moisture, soil quality, crop resilience, timing/length of growing seasons, yield of crops and animals, atmospheric temperatures, weed insurgence, flooding, unprecedented droughts, sea level rises and many more (Ozor and Nnaji, 2011) This adversely affects agricultural activities which are the mainstay of most African economies. The situation is made worst due to factors such as widespread poverty, over dependence on rain fed agriculture, inequitable land distribution, limited access to capital and technology, inadequate public infrastructure such as roads, long term weather forecasts and inadequate research and extension (Intergovernmental Panel on Climate Change (IPCC, 1998).

Therefore, this paper reviews the agricultural adaptation strategies employed by farmers in African to cushion the effects of climate change.

Agricultural adaptation strategies to climate change impacts

Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. The Intergovernmental Panel on Climate Change (2007) defines adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. It also refers to actions that people, countries, and societies take to adjust to climate change that has occurred. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities. In this paper, the adaptation used in Africa was discussed under crop and livestock adaptation strategies.

1.0 Crop adaptation strategies

1.1 Planting of drought resistant varieties of crops: Emphasis on more drought-resistant crops in drought-prone areas could help in reducing vulnerability to climate change. For example, wheat requires significantly less irrigation water compared to dry season rice. The use of drought-resistant crop varieties have been tried by smallholder farmers as adaptation methods to climate change in Nigeria, Senegal, Burkina Faso and Ghana (Ngigi, 2009). Also, strategies against drought were adopted by nomadic pastoralists living in the desert margins of Kenya (Langill and Ndathi, 1998).

1.2 Crop diversification: Diversification towards high value crops is feasible in the medium to long term. Crop diversity is a high priority adaptation measure in both irrigated and non-irrigated areas. In Southern Africa for example, land use is manipulated leading to land use conversion, such as the shift from livestock farming to game farming. (Ziervogel *et al*., 2008). In Kordofan and Drafur states of Western Sudan, food crops have replaced cash crops, and more resilient crop varieties have been introduced (DFID, 2004). In Tanzania, farmers diversify crop types as a way of spreading risks on the farm (Orindi and Eriksen 2005; Adger *et al*., 2003). Crop diversification can serve as insurance against rainfall variability.

1.3 Change in cropping pattern and calendar of planting: Climate change adversely affects crop production through long-term alterations in rainfall resulting in changes in cropping pattern and calendar of operations. According to Urama and Ozor (2011), farmers in Central Africa (Cameroon, Equatorial Guinea and Central African Republic) noted that the trend of uncertainties in extreme weather events had generally increased within the past five years as shown in Table 1 below.

Table 1. Trends in extreme weather events in Central Africa from 2005 to 2009.

Extreme weather events	2005	2006	2007	2008	2009
Thunderstorms					
Same	51.2	48.8	43.9	36.9	33.1
Declined	29.4	29.2	28.3	25.2	25.5
Increased	19.4	22.0	27.8	37.9	41.4
Heavy winds					
Same	43.2	39.6	33.6	23.5	18.2
Declined	27.5	27.5	27.0	19.9	20.7
Increased	29.4	32.9	39.4	56.7	61.1

Table 1. Cont'd.

Incidence of dust covering the atmosphere					
Same	49.0	46.7	42.6	34.9	26.8
Declined	16.4	16.5	15.4	13.6	10.5
Increased	34.5	36.9	42.0	51.5	62.6
Flooding					
Same	49.7	48.2	45.0	43.0	40.5
Declined	36.1	36.1	37.4	38.1	39.9
Increased	14.2	15.7	17.6	18.9	19.5
Drought					
Same	33.4	34.8	27.8	18.6	14.0
Declined	11.5	9.6	8.9	8.3	9.2
Increased	55.0	55.5	63.3	73.1	76.8
Erosion					
Same	47.9	47.3	42.6	37.4	35.7
Declined	19.6	18.5	18.7	18.3	19.4
Increased	32.5	34.2	38.7	44.3	44.9
Heat waves					
Same	43.4	39.7	36.5	26.3	24.9
Declined	14.2	14.2	11.5	10.0	9.8
Increased	42.4	46.1	52.0	63.7	65.3
High Sun intensity					
Same	34.1	31.2	23.8	14.9	11.7
Declined	11.7	11.6	7.6	6.2	6.0
Increased	54.2	57.2	68.7	78.8	82.3
Heavy rainfall					
Same	29.0	26.1	19.3	15.9	12.7
Declined	40.9	40.8	45.9	43.2	43.9
Increased	30.1	33.1	34.8	40.9	43.4
Desertification or loss of forest resources					
Same	27.0	27.1	13.4	9.3	8.8
Declined	11.3	11.1	8.5	7.8	7.5
Increased	61.8	61.8	78.1	82.9	83.8
Volume of sand encroachment					
Same	62.6	61.4	55.5	50.4	46.9
Declined	23.0	23.7	23.3	20.3	21.3
Increased	14.5	14.8	21.2	29.2	31.8

Source: Ngoh *et al.* 2011

In Tanzania, to avoid crop production risks due to rainfall variability and drought, staggered plating is very common to most farmers whereby crops are planted before rain onset (dry land) on uncultivated land. Others were planted immediately after rain, while still other plots were planted a few days after the first rains. Tilling the land commences in fields which were planted prior to cultivation on the third week after the onset of rain which also enables destroys early geminating weeds and reduces weeding. These were done purposely to distribute risk by ensuring that any rain was utilized to the maximum by the crop planted the in dry field (Liwenga, 2003).

1.4 Mixed cropping: Mixed cropping involves growing two or more crops in proximity in the same field. The system is commonly practised in Tanzania where cereals (maize, sorghum), legumes (beans) and nuts (groundnuts) are grown together. The advantages of mixing crops with varying attributes are in terms of maturity period (e.g. maize and beans), drought tolerance (maize and sorghum), input requirements (cereals and legumes) and end users of the product (e.g. maize as food and sunflower for cash). A research conducted by Mendelsohn *et al.* (2000) on analyzing adaptations made in Africa reveals that in all countries apart from Cameroon and South Africa, the planting of different varieties of the same crop is considered to be one of the most important adaptations. Different planting dates are also considered an important adaptation in Egypt, Kenya and Senegal.

1.5 Improved irrigation efficiency: Success of climate change adaptation depends on availability of fresh water in drought-prone areas. It should be emphasized that most adaptation methods provide benefits even with the lower end of climate change scenarios, such as improved irrigation efficiency. As water becomes a limiting factor, improved irrigation efficiency will become an important adaptation tool, especially in dry season, because irrigation practices the for dry area are water intensive. Climate change is expected to result in decreased fresh water availability (surface and groundwater) and reduced soil moisture during the dry season, while the crop water demand is expected to increase because of increased evapo-transpiration caused by climate change and the continuous introduction of high-yielding varieties and intensive agriculture (Selvaraju *et al*., 2006).

In Egypt, Kenya, and South Africa, significant numbers of farmers have adapted by increased use of irrigation. In Gambia, South Africa, and Sudan, farmers employ such adaptation measures as irrigation water transfer, water harvesting and storage to cushion the effects of rainfall variability (Nkomo *et al.*, 2005 and Osman *et al.* (2005). As temperature increases, farmers tend to irrigate more frequently. Irrigation is clearly an adaptation strategy to warming. When precipitation increases, they tend to irrigate less often and resort to natural rainfall more often. Farms in the deserts reduce irrigation when temperature

increases. Similarly, when precipitation increases, farms close to the deserts increase irrigation.

1.6 Adopting soil conservation measures that conserve soil moisture: Soil conservation techniques are increasingly practiced in Burkina Faso, Kenya, Senegal, and Niger. A study carried out by Lema and Majule (2009) in Manyoni District of Tanzania revealed that farmers in Kamenyanga and Kintinku ensure proper timing of different farming activities, burying of crop residues to replenish soil fertility, burning crop residues to enhance quick release of nutrients and allowing livestock to graze on farmlands after harvesting crops so as to improve soil organic matter. In Tanzania, farmers used contour ridges as a strategy to minimize soil erosion to encourage better root penetration and enhance moisture conservation (Lema and Majule, 2009). In Senegal and Burkina Faso, local farmers have improved their adaptive capacity by using traditional pruning and fertilizing techniques to double tree densities in semi-arid areas. These help in holding soils together and reversing desertification. Nyong *et al*. (2007) noted that local farmers in the Sahel conserve carbon in soils through the use of zero tilling practices in cultivation, mulching and other soil management techniques. Natural mulches moderate soil temperatures and extremes, suppress diseases and harmful pests, and conserve soil moisture. Before the advent of chemical fertilizers, local farmers largely depended on organic farming, which also is capable of reducing GHG emissions.

1.7 Planting of trees (afforestation) and agroforestry: Tree planting is the process of transplanting tree seedlings, generally for forestry, land reclamation, or landscaping purposes. It differs from the transplantation of larger trees in arboriculture, and from the lower cost but slower and less reliable distribution of tree seeds. In silviculture the activity is known as reforestation, or afforestation, depending on whether the area being planted has or has not recently been forested. It involves planting seedlings over an area of land where the forest has been harvested or damaged by fire or disease or insects. Rural farmers in most of the Africa countries have been planting trees as a way of adapting to the effect of climate change.

Agroforestry is a rational land-use planning system that tries to find some balance in the raising of food crops and forests (Adesina *et al.,* 1999). A practice similar to this has been described in a part of south western part of Nigeria to raise shade tolerant crops, such as *Dioscorea spp*, and cocoyam in essentially a permanent forest setting (Adesina, 1988). In addition to the fact that agroforestry techniques can be perfected to cope with the new conditions that are anticipated under a drier condition and a higher population density, they lead to an increase in the amount of organic matter in the soil thereby improving agricultural productivity and reducing the pressure exerted on forests. In the drier parts of the Sahel, baobab (*Adansonia digitata*) and acacia (Acacia) trees is usually planted

by local farmers as it realized as a valuable tree, especially during the hot and dry parts of the year (Nyong *et al.*, 2007).

2.0 Livestock adaptation strategies

Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. The following have been identified by several experts (IFAD, 2009; FAO, 2008; Thornton *et al.*, 2008; Sidahmed, 2008) as ways to increase adaptation in the livestock sector:

***2.1 Production adjustments*:** Changes in livestock practices could include: (i) diversification, intensification and/or integration of pasture management, livestock and crop production; (ii) altering the timing of operations; (iii) conservation of nature and ecosystems; (iv) modifying stock routings and distances; (v) introducing mixed livestock farming systems, such as stall-fed systems and pasture grazing. Adaptation strategies that are applied among pastoralists in the Sahel region of Africa include the use of emergency fodder in times of droughts, multi-species composition of herds to survive climate extremes, and culling of weak livestock for food during periods of drought. During drought periods, pastoralists and agro-pastoralists change from cattle (Bos) to sheep (Capra) and goat (Capra) husbandry as the feed requirements of the later is less than the former (Oba 1997). Pastoralists' nomadic mobility reduces the pressure on low carrying capacity grazing areas through the circular movement from the dry northern areas to the wetter southern areas of the Sahel. This system of seasonal movement represents a local type of traditional ranching management system of range resources.

***2.2 Breeding strategies*:** Many local breeds are already adapted to harsh living conditions. However, developing countries are usually characterized by a lack of technology in livestock breeding and agricultural programmes that might otherwise help to speed adaptation. Adaptation strategies address not only the tolerance of livestock to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases (Hoffmann, 2008). Such measures could include: (i) identifying and strengthening local breeds that have adapted to local climatic stress and feed sources and (ii) improving local genetics through cross-breeding with heat and disease tolerant breeds. If climate change is faster than natural selection, the risk to the survival and adaptation of the new breed is greater (Hoffmann, 2008)

2.3 Livestock management systems: Efficient and affordable adaptation practices need to be developed for the rural poor who are unable to afford expensive adaptation technologies. These could include (i) provision of shade and water to reduce heat stress from increased temperature. Given current high energy prices,

providing natural (low cost) shade instead of high cost air conditioning is more suitable for rural poor producers; (ii) reduction of livestock numbers – a lower number of more productive animals leads to more efficient production and lower GHG emissions from livestock production (Batima, 2006); (iii) changes in livestock/herd composition (selection of large animals rather than small); (iv) improved management of water resources through the introduction of simple techniques for localized irrigation (e.g., drip and sprinkler irrigation), accompanied by infrastructure to harvest and store rainwater, such as tanks connected to the roofs of houses and small surface and underground dams.

2.4 Capacity building for livestock keepers: There is a need to improve the capacity of livestock producers and herders to understand and deal with climate change increasing their awareness of global changes. In addition, training in agro-ecological technologies and practices for the production and conservation of fodder improves the supply of animal feed and reduces malnutrition and mortality in herds.

3.0 Other adaptation strategies

3.1 Labour migration: Migration is a dominant mode of labour (seasonal migration), providing a critical livelihood source. The role of remittances derived from migration provides a key coping mechanism in drought and non-drought years but is one that can be dramatically affected by periods of climate shock, when adjustments to basic goods, such as food prices are impacted by food aid and other interventions (Devereux and Maxwell, 2001). Migration is (and always has been) an important mechanism to deal with climate stress. Pastoralist societies have of course habitually migrated, with their animals, from water source to grazing lands in response to drought as well as part of their normal mode of life. But it is becoming apparent that migration as a response to environmental change is not limited to nomadic societies. In western Sudan, for example, studies have shown that one adaptive response to drought is to send an older male family member to Khartoum to try and find paid labour to tide the family over until after the drought (McLeman and Smit, 2004).

Temporary migration as an adaptive response to climate stress is already apparent in many areas. But the picture is nuanced; the ability to migrate is a function of mobility and resources (both financial and social). In other words, the people most vulnerable to climate change are not necessarily the ones most likely to migrate. In the West African Sahel, recent studies have cast light on the use of temporary migration as an adaptive mechanism to climate change. The region has suffered a prolonged drought for much of the past three decades and one way that households have adapted is by sending their young men and women in search of wage labour after each harvest. But how far they travel depends, in part, on the success of the harvest (Oli, 2008).

***3.2 Income diversification*:** A survey carried out by Mertz *et al.* (2010) indicated that in Southern Burkina Faso, farmers adapt to the effects of low yield by indulging in the dry season market gardening and non-farm income sources. This is corroborated by additional in-depth studies at local level in northern Burkina Faso, where local people focus on activities that are less dependent on climate (Nielsen and Reenberg 2010a, 2010b). An analysis of national household survey data in Burkina Faso between 1998 and 2007 showed that the average wealth increased for almost all major livelihood groups and the number of wealthy people steadily increased. These results highlight the importance of off-farm income which generates opportunities, especially in marginal rural areas, for long-term adaptation strategies to climate variability and change.

Conclusion and Recommendations

Africa is already under pressure from climate stresses which increase vulnerability to further climate change and reduce adaptive capacity. The adverse effects of climate change have a particularly devastating effect on agriculture, which is the mainstay of most African economies. This has affected food production with its resultant effect on widespread poverty. Some African communities have developed traditional agricultural adaptation strategies to cope with climate variability and extreme events. Experience with these strategies needs to be shared among communities. Techniques include: diversification of herds and incomes, use of forest products as a buffer against climate induced crop failure, soil fertility improvement techniques, soil moisture and water conservation practices, decentralization of governance of resources and the manipulation of land use leading to land use conversion, to name a few. However, some of these techniques may need to be adjusted to face additional climate risks associated with climate change.

The major constraints to applying agricultural adaptation strategies in Africa has been a general lack of knowledge, expertise and data on climate change issues; a lack of specific climate change institutions to take on climate change work and the need for a better institutional framework in which to implement adaptation. Actions to address these gaps include: training programmes for local government officials, dedicated research activities and post-graduate courses; and the initiation of specific institutional frameworks for climate change. Proactive adaptation can improve capacities to cope with climate change by taking climate change into account in long term decision-making, removing disincentives for changing behaviour in response to climate change (removing subsidies for maladaptive activities), and introducing incentives to modify behaviour in response to climate change (use of market-based mechanisms to promote adaptive responses). Furthermore, improving and strengthening human capital, through education, outreach, and extension services, improves decision-making capacity at every level and increases the collective capacity to adapt.

References

Adesina F.A. 1988. Developing stable agroforestry systems in the tropics: An example of local agroforestry techniques from south western Nigeria. Discussion papers in Geography 37, Department of Geography, University of Salford, United Kingdom, Pp. 27.

Adesina F.O, W.O. Siyambola, F.O Oketola, D.A Pelemo, L.O Ojo, A.O. Adegbugbe. 1999. Potentials of agroforestry for climate change mitigation in Nigeria: Some preliminary estimates. *Glob. Ecol. Biogeogr*. vol. 8, Pp. 163–173.

Adger, W.N., S. Huq, K. Brown, D. Conway and M. Hulme. 2003. Adaptation to climate change in the developing world. *Progress Dev. Stud*. **3:** 179-195.

Batima, P. 2006. Climate change vulnerability and adaptation in the livestock sector of Mongolia. Assessments of impacts and adaptations to climate change. International START Secretariat, Washington DC, US.

Devereux, S., S. Maxwell. 2001. *Food Security in Sub-Saharan Africa*. ITDG Publishing, London.

Department for Food and International Development (DFID). 2004. Adaptation to climate change: The right information can help the poor to cope. Global and local environment team, policy division.

Food and Agriculture Organization (FAO). 2008. *Climate change for fisheries and aquaculture: Technical background document from the expert consultation held on 7-9 April 2008*, Rome.

Hoffmann, I. 2008. Livestock genetic diversity and climate change adaptation. *Livestock and Global Change Conference proceeding*. May 2008, Tunisia.

International Fund for Agricultural Development (IFAD). 2009. Livestock and climate change. Livestock thermatic papers. Available online at www.ifad.org/irkm/index.tm

Intergovernmental Panel on Climate Change (IPCC) 1998. The regional impacts of climate change: An assessment of vulnerability. Special Report of IPCC Working Group II [Watson, R.T., M.C. Zinyowera, and R.H. Moss (eds.)]. *Intergovernmental Panel on Climate Change*, Cambridge Univer. Press, Cambridge, United Kingdom and New York, NY, USA P. 517.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: Climate change impacts, adaptation and vulnerability - Summary for policymakers*. Contribution of Working Group II to the Fourth Assessment Report of the IPCC.

Langill, S. and A.J.N. Ndathi. 1998. *Indigenous knowledge of desertification: A progress report from the Desert Margins Program in Kenya*. People, Land and Water Series Report 2. Ottawa: International Development Research Centre.

Lema, M.A. and A.E. Majule. 2009. Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. *African Journal of Environmental Science and Technology.* **3** (8), Pp. 206-218.

Liwenga E.T. 2003. Food insecurity and coping strategies in semi-arid areas: The Case of Mvumi in Central Tanzania. Ph.D Dissertation No. 11. Stockholm Studies in Human Geography, Stockholm University Stockholm, Sweden.

McLeman, R., and B. Smit. 2004. Climate change, migration and security. Canadian Security Intelligence Service, commentary no. 86, Ottawa, P. 8.

Mendelsohn, R., A. Dinar and A. Dalfelt 2000. Climate change impacts on African agriculture. Preliminary analysis prepared for the World Bank, Washington, District of Columbia, Pp. 25.

Mertz O., C Mbow JØ Nielsen, A Maiga, D Diallo, A Reenberg, A Diouf, B Barbier, IB Moussa, M Zorom, I Ouattara, D. Dabi. 2010. Climate factors play a limited role for past adaptation strategies in West Africa. *Ecology and Society* **15**(4), Pp. 25. http://www.ecologyandsociety.org/vol15/iss4/art25/.

Ngigi, S.N. 2009. Climate change adaptation strategies: *Water resources management options for smallholder farming systems in Sub-Saharan Africa*. The MDG Centre for East and Southern Africa, the Earth Institute at Columbia University, New York. Pp.189.

Nielsen JØ, A. Reenberg. 2010a. Temporality and the problem with singling out climate as a current driver of change in a small West African village. *Journal of Arid Environments* **74***:* 464–474.

Nielsen JØ, A. Reenberg. 2010b. Cultural barriers to climate change adaptation: A case study from Northern Burkina Faso. *Global Environmental Change* **20***:* 142–152.

Ngoh, S. B., G. T. Mafany, and S. A. Ndeso. 2011. Agricultural innovations and adaptations to climate change effects and food security in Central Africa: Case of Cameroon, Equatorial Guinea and Central Africa Republic. Technical Report submitted to the ATPS, Kenya.

Nyong, A., F. Adesina and O. Elasha 2007. The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitig. Adapt. Strat. Glob. Change.* **12,** Pp. 787 -797.

Oba, G. 1997. Pastoralists' traditional drought coping strategies in Northern Kenya. A report for the government of the Netherlands and the government of Kenya, Euroconsult BV, Arnheim and Acacia Consultants Ltd, Nairobi.

Organization for Economic Cooperation and Development (OECD). 2009. Climate change in West Africa: Sahelian adaptation strategies. SWAC briefing note, no.3, January, 2009, Pp. 4-6.

Oli, B. 2008. Migration and climate change. IOM migration research series no. 31, International Organization for Migration, Geneva. Pp. 1-68.

Osman Balgis N.G. Elhasssan, H. Ahmed and S. Zakieldin 2005. *Sustainable livelihood approach for assessing community resilience to climate change: Case studies from Sudan*. Working Paper No.17 (AIACC Project No. AF14), 2005.

Ozor, N. And Nnaji, C.E. 2011. The role of extension in agricultural adaptation to climate change in Enugu State, Nigeria. *Journal of Agricultural Extension and Rural Development* **3** (3): 42 – 50.

Reason, C.J.C., S. Hachigonta and R.F. Phaladi. 2005 Inter-annual variability in rainy season characteristics over the Limpopo region of southern Africa. *International Journal of Climatology* **25:** 1835-1853.

Selvaraju,R., A.R. Subbiah, S. Baas and I. Juergens. 2006. Livelihood adaptation to climate variability and change in drought-prone areas of Bangladesh. Case Study Project Under Institution For Rural Development, Pp. 1-76.

Sidahmed, A. 2008. Livestock and climate change: Coping and risk management strategies for a sustainable future. In: *Livestock and Global Climate Change Conference Proceeding*, May 2008, Tunisia.

Thornton P.K., P. G. Jones, T. Owiyo, R. L. Kruska, M. Herrero, P. Kristjanson, A Notenbaert, N. Bekele and A. Omolo with contributions from V. Orindi, B. Otiende, A. Ochieng, S. Bhadwal, K. Anantram, S. Nair, V. Kumar and U. Kulkar. 2006. Mapping climate vulnerability and poverty in Africa. Report to the Department for International Development, ILRI, Nairobi, Kenya, Pp. 171.

Urama, K. and N. Ozor. 2011. Agricultural innovations for climate change adaptation for food security in Western and Central Africa. *Agro-science Journal of Tropical Agriculture, Food, Environment and Extension* **10** (1): 1 – 16.

Ziervogel, G., A. Cartwright, A. Tas, J. Adejuwon, F Zermoglio, M. Shale and B. Smith. 2008. Climate change and adaptation in African agriculture. Stockholm environment institute, March 2008, Pp. 17-19.