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The Role of Extension in Agricultural Adaptation to Climate Change in the Sahelian Zone of Nigeria

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Abstract
It is anticipated that climate variability and change in the Sahelian zone of Nigeria will have an overwhelming impacts on agriculture, land use, ecosystem and biodiversity. Recent years have seen adaptation come to the international climate debate. The focus is centered largely upon enhancing the capacity of developing countries such as Nigeria to adapt to the impacts of climate change. The paper discussed the role of extension in agricultural adaptation to climate change in the Sahelian zone of Nigeria. It identified the evidence of climate change in the Sahelian zone of Nigeria and described the adaptation strategies to the changing climate. The paper also explored the role of agricultural extension services in climate change adaptation. The challenges facing agricultural adaptation to climate change were also discussed. The paper recommended that efforts of the government should include; development of special rural micro-credit schemes, improved extension delivery and human capital development

Keywords: Agricultural adaptation, Climate change, Extension, Role, Sahelian Zone, Nigeria

1.0 INTRODUCTION

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (Ozor, 2009). According to Intergovernmental Panel on Climate Change (2007), the changes in climate are attributed directly to human activities and the composition of the global atmosphere over comparable time periods. The changes occur due to variation in different climatic parameters such as cloud cover, precipitation, temperature and vapour pressure. (Environmental Resources Management, 2009). Increase in Green House Gases (GHG) emission through human activities has resulted in additional warming of the earth's surfaces, with several anticipated disastrous impacts (Harris, 1999; Motimore *et al*, 2000).

It is anticipated that climate variability and change in the Sahelian zone of Nigeria will have an overwhelming impact on agriculture and land use, ecosystem and biodiversity, human settlements, diseases and health, hydrology and water resources. With respect to agriculture and land use, climate change will likely elicit a significant change in agricultural production both in terms of the quantum of products as well as the location or area of production. These could have an adverse implication for food security and livelihood in the country. Initial efforts dealing with the problem of global warming concentrated on mitigation, with the aim of reducing and possibly stabilizing the GHG concentrations in the atmosphere (Odjugo, 2010). Even if this stabilization was achieved to some extent, global warming would continue to increase over countries. Consequently, adaptation was seen as a viable option in reducing vulnerability associated with anticipated negative impacts of Climate Change (Jones, 2010). Adaptation methods are those strategies that enable the individual or the community to cope with or adjust to the impact of climate in the local areas (Jones, 2010, Nyong et al, 2007). Such strategies will include the adaptation of early maturing crops, drought resistant varieties and selective keeping of livestock in areas where rainfall declined.

Recent years have seen adaptation come to the international climate debate. The focus is centered largely upon enhancing the capacity of developing countries such as Nigeria to adapt to the impacts of climate change (Jones, 2010). Concerns about adapting to climate change are now renewing in the impetus for investments in agricultural research and emerging as additional innovation priorities. In the coming decade, the development and effective diffusion of new agricultural technologies will largely shape how well farmers adapt to climate change (Adams, 1998, Kandji et al, 2007).Therefore, it was found imperative to identify the adaptation strategies to climate change and to explore the role of extension in the Sahelian zone of Nigeria. This was with a view to suggesting recommendations for improved agricultural adaptation to climate change in Nigeria.

2.0 THE SAHELIAN ZONE OF NIGERIA

Sahel in general is a poor environment in terms of production of food, fuel and fibre and is inhabited by poor people struggling with harsh climate, degraded soils and underdeveloped infrastructures (Ardo and Bashir, 2007). Climate and soil conditions, i.e. the basis for production of food, fuel and fibre, are limiting factors for production in most areas of Sahelian Zones. The natural resource base on which the rural poor depend for their livelihoods is rapidly degrading. The rural population is largely dependent on agriculture, which is facing a number of converging environmental trends that leads to unsustainable production and degradation of natural resources on which rural livelihood depends. Managing the world's Sahelian environment is perhaps one of the most challenging and pressing developmental problems of today.

In Nigeria, the Sahelian zone consists of Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara States (Odjugo,2010) A large proportion of the region is characterized by sandy-fixed undulating topography. The sandy soil is usually low in organic matter, nitrogen and phosphorus and may degrade rapidly under conditions of intensive rainfall (Mortimore *et al* 2000). When over-use occurs in this generally sandy environment, denuded patches may appear when the wind-blown sand becomes mobile. Average annual rainfall in the Sahelian Zone of Nigeria varies from 500mm in the northeastern part to 1000mm in the southern sub-area, but it is unreliable in many parts (Harris,1999).Unpredictability and unreliability characterize the pattern of rainfall. As in other arid and semi-arid areas of the world, it is not just the total amount of rainfall that is important, but the timing and distribution. In this respect, the pattern of rainfall in the region is highly variable in spatial and temporal dimensions with an inter-annual variability of between 15 and 20 percent (Mortimore and Adams,1999). The nature of the rainfall in the region supports mostly savanna vegetation. Thus, apart from some relic forests in low lying ground along the southern boundary, the whole region is covered by savanna vegetation with the density of trees and other plants decreasing as one moves northwards. Because of its generally low and variable biological production, the savanna ecosystem of the zone in Nigeria is very sensitive to human and animal population pressure.

In addition to high inter-annual variability, the rainfall regimes of the sahelian zone of Nigeria are characterized by high concentration in a few months, intermittence and violence of storms. Thus the region is, by nature, prone to recurrent and sometimes intense and persistent periods of drought .Also, the soils in most part of the sahelian zone, though well drained, are sandy, low in soil organic matter and are characterized by low water holding capacity(Gwary,2005). The only exception to this observation is the fadama soil that is fine-textured with a higher organic matter content and relatively higher water-holding capacity. Furthermore, this zone is the most grazed and where increasing drought incidents have caused changes in plant species. It is also the zone where farmers have encroached on grazing reserves and climatically marginal areas, leading to increased incidence of pastoralists-farmers conflict and desertification.

3.0 EVIDENCE OF CLIMATE CHANGE IN THE SAHELIAN ZONE OF NIGERIA

Ahmad and Ahmed (2000), NEST (2003) and Hengeveld et al. (2005) provided indicators that one could use to assess the evidence of climate change in a region. These include increasing temperature, increasing evapotranspiration, decreasing rainfall amount in the continental interiors, increasing rainfall in the coastal areas, increasing disruption in climate patterns and increasing frequency and intensity of unusual or extreme weather related events such as thunderstorms, lightning, landslides, floods, droughts, bush fires, unpredictable rainfall patterns, sea level rise, increased desertification and land degradation, drying up of rivers and lakes and constant loss of forest cover and biodiversity.These studies reveals that an indicator (increasing temperature) is already present in Nigeria. Odjugo(2010) shows gradual increasing air temperatures between 1901 and 1970 and a higher increase since 1970. An increase of 1.7OC in air temperature has been observed in Nigeria for the 105 years (Odjugo, 2010). He added that the implication is that if the increase continues at this rate, by 2100, Nigeria will fall within the low or medium scenario of global warming of not less than 2.5°C. Should it continue at the 1971-2005 rates, Nigeria will then be placed among areas that will experience high scenario of 2.5 - 4.5°C. Another indicator is the increasing frequency and intensity of unusual or extreme weather related events such as erratic rainfall pattern, floods and sea level rise among others. Recent researches confirm their existence in Nigeria (Molega, 2006).

Odjugo (2010) observed decline in rainfall amount in Nigeria. A further support of the evidence of climate change in Nigeria by the two studies is the increase in rainfall amount in the coastal areas since the 1970s, and a constant decline in rainfall amount and duration in the continental interiors of the semi-arid region of Nigeria. The increasing temperature and decreasing rainfall in the sahelian zone of Nigeria might have resulted in the increasing

evapotranspiration, drought and desertification as reported by (Adefolalu, 2007). Constant loss of forest cover and biodiversity in the sahelian zone of Nigeria Nigeria could be linked to global warming and climate change (NEST, 2003; Ayuba et al., 2007). Available evidence also shows that climate change has impacted on agriculture and health in the sahelian zone of Nigeria (Mshelia, 2005; Adefolalu, 2007). The decreasing rainfall, increasing temperature and evapotranspiration have resulted in either reduction of water levels or total dry up of some rivers and lakes in the sahelian zone of Nigeria, while lake Chad in Nigeria is reported to be shrinking in size at an alarming rate since the 1970s (Ayuba et al., 2007). With these factors, one can say with a high level of confidence that the sahelian zone of Nigeria as reported by related works cited have successfully revealed that the sahelian zone of Nigeria , like most parts of the world, is experiencing the basic features of climate change.

4.0 ADAPTATION STRATEGIES TO CLIMATE CHANGE IN THE SAHELIAN ZONE

The core challenge of climate change adaptation in agriculture is to provide (i) more efficient food, (ii) under more volatile production conditions, and (iv) with net reductions in GHG emissions from food production (Lybbert and Sumner, 2010; Kandji *et al,* 2007). There is a lot of current and emerging strategies with particular relevance to Sahelian environments and climate change. In this section, the paper highlights some specific relevant strategies for climate change adaptation in the sahelian zone of Nigeria as follows:

4.1 Climate Information and Forecasting

As farmers deal with changes in climate and more variability in weather, history becomes less reliable guide. Under these conditions there is greater payoff to improvements in forecasts of weather events and inter-seasonal weather probabilities (Harris, 1998; Adams, 1998). Farmers with foreknowledge of such events can respond by planting and rearing more appropriate crop varieties and livestock breeds. Thus, major innovations in response to climate variability will take the form of improved information through global monitoring and forecasting (Sumner *et al,* 1998). Better and more timely information could also help to forecast impending "slow on set" weather events such as drought more effectively and thereby improve response times and adaptation (Mude *et al*, 2009). Thus, improved information delivery is a critical component for agricultural adaptation to climate change in the Sahelian zone of Nigerian.

One of the important strategies to cope with climate variability in Nigeria is to use seasonal climate forecasting. The Nigerian Meteorological Agency (NIMET) has an important role to play in this regard. If farmers can adapt to current year-to year variability through the use of advanced information, communities will be in a position to adapt to longer-term climate changes.

4.2 New Traits and Varieties.

Increasing agricultural productivity requires technological advances in both crop and livestock yields. New varieties and traits could lead to less intensive use of other inputs such as fertilizers and pesticides (Adams and Mortimore, 1997). In addition to increasing productivity generally, several new traits and varieties offer farmers greater flexibility in adapting to climate change, including traits that confer tolerance to drought and heat, and early maturation in order to shorten the growing season and reduce farmer's exposure to risk of extreme weather events. These promising new traits and varieties, which are mostly still in development, could emerge from traditional breeding techniques that leverage existing varieties that are well suited to vagaries of the Sahelian environment as well as from advanced biotechnology techniques such as genetic modification (Smith and Lenhart, 1996; Jones, 2010). Climate change could also lead to new pests and diseases pressure. Crop varieties and traits that are resistant to pests and diseases will improve producers' ability to adapt to climate change. To the extent that these varieties reduce the need for pesticides, they also reduce carbon emissions by decreasing pesticides demand as well as the number of field applications (Mortimore and Adams, 1999; Chiroma *et al,* 1999).

Various Research Institutes in Nigeria are involved with crop improvement programs. More funds should be allocated for the breeding of crops varieties that are heat and drought tolerance, low-water-use efficiency, and salt tolerance for use in the dry land regions. The use of such varieties will enable farmers to diversify and produce profitably' even under adverse conditions. Substantial progress is also being made through National Research Institutes, ICRISAT and IITA in the provision of such needed crop/livestock varieties which are being distributed through the Extension system of the Agricultural Development Programs (ADP) of the country.

4.3 Cropping Adjustments

Throughout the world agricultural scientists have devised various means of coping with variability in weather. Fallowing land for water conservation or nutrient conservation or nutrient restoration is an age-old practice of proven value in modern and traditional agriculture. Deep seeding and wide spacing of plant increases the chances of soil moisture being available for seedling establishment and growth. Crop farmers in Sahelian zones make frequent decisions about crops to plant. If rains come early, long-season cultivars are planted to take advantage of their greater yield producing potential (Gwary,2010). If rains are late or if dry periods kill crops planted early, short-season cultivars of the same crop or a different crop are planted. Management decisions of this type are a normal response to temporal variability in rainfall, whether or not the season turns out to be drought affected. One of the most promising methods of reducing the problem of rainfall variability is the adoption of response farming proposed by Stewart in 1982 (Gwary, 2005). The response farming technique consists of an analysis of dates of onset of rains, followed by decisions of when to plant, the spacing to use, when and if fertilizers should be applied, and the plant-thinning schedule to follow.

4.4 Investment in Water Management and Irrigation

As climate change advances, water management will play an even more crucial role. In almost all intervention regions of development cooperation, it could be expected that climate change will be expressed in changing precipitation (distribution and quantities). Extreme weather events will lead to floods and increased surface water run-off, reduce infiltration and, as a result, hamper the natural regeneration of groundwater. Investments in the protection and rehabilitation of watersheds, in the improvement of the soil water balance and the creation of artificial water storage facilities (such as cisterns, water retention basins, small reservoirs) are necessary across extensive areas. At the same time, the supply of drinking water must be ensured and water needs to be made available for farming. In order to ensure the continuous and sustainable yields required in the light of climate change, in the future farmers will increasingly be forced to produce crops using additional irrigation.

With higher temperature and changing precipitation patterns, controlling water supplies and improving irrigation access and efficiency will become increasingly important (Leeuwis, 2006). Climate Change will burden currently irrigated areas and may even outstrip current irrigation capacity due to general water shortages, but farmers with no access to irrigation are clearly most vulnerable to precipitation volatility in the Sahelian zone of Nigerian (Lybbert and Sumner, et al, 2010). Sahelian zone farmers are in desperate need of technologies, techniques and investments that improve water management efficiency, access to irrigation or to find ways to improve incomes with less secure and more variable water availability (Nyong *et al,* 2007; Adesina *et al*, 1999). In Whether a particular zone expects to become wetter or drier on average in the coming decades, water management is central to farmers' adaptation to climate change (Lybbert and Sumner, 2010; Kandji *et al*, 2007). Expansion and improved efficacy of water shortage is fundamentally important to account for increasing rainfall variability and longer stretches of dry days in the Sahelian zone of Nigeria (Mortimore and Adams, 1999).In Nigeria, River Basin Development Authorities (RBDAs), Federal and State Ministries of Water Resources are charged with the responsibilities of water management and irrigation services.

4.5 Production Management and Practices

Production techniques may be as important as production technologies in climate change adaptation. One such technique stands out in particular: conservation or reduced tillage agriculture (Smith and Lenhart, 1996; Nyong *et al,* 2007). This technique aims to build up organic matter in soils and create a healthy social ecosystem by not tilling the soil before each planting. By increasing the organic matter in soils, conservation agriculture improves the moisture capacity of the soil and thereby increases water use efficiency. The practice also reduces carbon emissions by reducing tilling. An array of other production management practices and technologies could similarly improve sahelian zone farmers' adaptation to climate change, including information that enables more precise application of inputs, especially fertilizer (Adams and Mortimore, 1997).The spectrum of climate change adaptation measures ranges from a moderate modification of technologies that can be implemented by the target group without much financial effort (e.g. changing over from maize to millet) and the use of a fundamental change of land-use systems (changeover from annual crops to plantations or transfer from arable farming to pasture and animal husbandry) and the abandonment of farmland and migration.

4.6 Insurance systems

It is expected that in most years, even in times of climate change, normal yields will be generated. The rising frequency of extreme weather events entailing occurrences of total crop losses, however, can cost smallholders their basis of livelihood. Supporting the introduction
of specific insurance systems can help safeguard the bases of nutrition. Innovations in micro-insurance products could aid farmers' capacity to adapt to climate change. This is especially true in production settings that are exposed to greater variability and more frequent extreme events, such as in sahelian regions (Lybbert and Sumner, 2010; Harris, 1998). In the absence of micro-insurance services, farmers often face serious constraints in their responses to both good and bad harvests and in their ability to adopt new technologies. The Nigeria Agricultural Insurance Corporation (NAIC) is mandated to provide insurance cover for both crop and livestock enterprises. Some private insurance companies are also providing insurance cover for agriculture.

5.0 THE ROLE OF EXTENSION IN CLIMATE CHANGE ADAPTATION

Agricultural extension has been defined as a series of embedded communicative interventions which supposedly help to resolve problematic situations (Leeuwis, 2006). This definition confers to agricultural extension the mandate to accommodate the issue of climate change in its duties (Ozor, 2009). However, in order to achieve results, there is need for change in roles and capacity in the extension system so as to accommodate the new dimensions brought about by climate change. Discussed below are three ways in which extension can play roles in adaptation to climate change: technologies and management information; capacity development; and facilitating, and implementing policies and programs.

5.1 Technologies and management information

Extension traditionally has played a role in providing information and promoting new technologies or new ways of managing crops and farms. Extension also links farmers to researchers and other actors in the innovation system. Farmers, extension agents, and researchers must work together on farmers' fields to prioritize, test, and promote new crop varieties and management techniques (Davis, 2009; Ozor, 2011). While extension must now go beyond such methods, there is still a need for simple technology transfer in order to increase resilience to climate change.

Today's farmers will need to be able to quickly respond to climate change and adeptly manage risk. This will be especially challenging for extension in terms of knowledge and information systems. Farmers need to have access to this kind of information—be it climatic information, forecasts, adaptive technology innovations, or markets—through extension and information systems (Anyade,2009). Extension agents can introduce locally appropriate technologies and management techniques that enable farmers to adapt to climate change by, for example, disseminating local cultivars of drought-resistant crop varieties with information about the crops'. Additionally, extension staff can share with farmers their knowledge of cropping and management systems that are resilient to changing climate conditions such as intercropping, sequential cropping, and no-till agriculture (Davis, 2009). Some of these practices have the added advantage of improved natural resource management. It is important to provide farmers with information about how the various options will potentially increase income and yields, protect household food security, improve soils, enhance sustainability, and generally help to alleviate the effects of climate change. At the same time, extension staff can play an important role in transferring indigenous technical knowledge to help farmers worldwide.

A core challenge for extension in the future is to shift from providing "packages" of technological and management advice to, instead, supporting farmers with the skills they need to choose the best option to deal with the climate uncertainty and variability. Some farmers will also need access to new technologies and management options in those areas where climate change renders their current farming systems enviable.

5.2 Capacity Development

One of extension's major activities over time has been adult and nonformal education. This role continues today and is even more important in light of the changing climate. In addition, extension is also responsible for providing information using techniques ranging from flyers and radio messages to field demonstrations (Davis, 2009; Anyadike, 2009). Recent innovative extension activities include the adult education and experiential learning approaches utilized in farmer field schools, an extension and education approach already working with farmers on issues of climate change.

Climate change will initiate extreme events like sudden onset disasters and new vectors of human and livestock diseases. Evidence is emerging that the biggest impacts will be in the form of small droughts, floods, and other events that cause severe hardship but do not attract the attention of the international community. The capacity of farmers to cope with such different forms of risk will become ever more crucial, and extension efforts must pay special attention to educating farmers about their options to enhance resilience and response capacity (IPCC, 2007). There is a need for capacities to engage new sets of actors, including humanitarian agencies. Education must thus move beyond technical training to enhance farmers' abilities for planning, problem solving, critical thinking, and prioritizing, negotiating, building consensus and leadership skills, working with multiple stakeholders, and, finally, being proactive.

Capacity development is important within extension as well. Extension agents have traditionally been trained only in technical expertise and often lack "soft" skills such as communication, development of farmer groups, systems thinking, knowledge management, and networking (Davis, 2009). To improve outcomes in rural development, farmers and extension agents need new skills that will require agricultural education and extension curriculums to include valuing and understanding the knowledge and experiences of rural people and co-learning (that is, farmers and extension agents learning together rather than extension agents training farmers in a one-way information transfer). There are different ways to inform and educate farmers about adaptation options.

5.3 Facilitating and Implementing Policies & Programs

Another role of extension, which will be critical for climate change adaptation, is that of bringing together different actors within the rural sector. Traditionally this has meant linking farmers to transport agents, markets, and inputs suppliers, among others (Davis, 2009). With climate change, it will be increasingly important for the extension system to link farmers and other people in rural communities directly with private and public institutions that disseminate adaptation technologies, and funding programs for adaptation investments. Increased access to meteorological information will be imperative.

Extension also has an enormous challenge in bringing together farmers' concerns and those of other actors as they address both climatic and market uncertainties together. Extension has the chance to make a significant contribution to overcoming this gap through enhanced farmer decision making. Extension agents may also play a role in assisting farmers in implementing policies and programs that deal with climate change adaptation. For instance, extension agents could be employed to educate farmers in their area; assist in forming community groups; link farmers to governmental, nongovernmental, and private organizations at the national and international levels; and perhaps assist with proposal preparation or negotiations with other players.

6.0 CONSTRAINTS OF AGRICULTURAL ADAPTATION TO CLIMATE CHANGE

Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production (FAO, 2008). That is, socio-economic factors, international competition, technological development as well as policy choices will determine the pattern and impact that agro-climatic changes will have on agriculture (Brussel, 2009). Some of the constraints facing agricultural adaptation to climate change in Nigeria, particularly in Sahelian zone include the following:

6.1 Poverty, Hunger and Disease

Food security threat posed by climate change is greatest for African Sahels, where agricultural yields and aggregate food production have been steadily declining, and where population growth will double the demand for food, water and forage in the next 30 years (Odjugo, 2010). Africa has a higher proportion of people living in poverty than any other region of the world of even more concern, the total number of poor people is increasing (Medugu 2009). Presently, it is estimated that two thirds of the Nigerian population are poor (Garba, 2006). In addition, there is the problem of HIV/AIDs and malaria, which adversely affects government staff and private agricultural service providers. These pandemics are major cause for concern in many African countries. Besides placing a great strain on the health infrastructure, results from several studies across Africa show that there are strong links between HIV/AIDs and Malaria and heightened vulnerabilities in various sectors, including agriculture.

The foregoing is expected to have dire consequences for farmers' capacity to adapt to climate change in Nigeria. Anselm and Taofeeq (2010) reported that most of the problems encountered by farmers in adaptation to climate change are associated with poverty. This is because poor and hungry farmers would naturally divert their

limited farm income towards the basic necessities like feeding and medication rather than plouging them into climate change adaptation measures.

6.2 Funding for Agricultural Research and Technology Development

Technical change in agriculture has played a major role as a leading engine of growth and poverty reduction in many developing countries including Nigeria (Ansalem and Taofeeq, 2010; Garba, 2006). While some African countries such as Ghana, Uganda and Malawi have stabilized their budget expenditures on agriculture around 10%, Nigeria, has consistently spent less than 5% of its annual budget on agriculture (Anselm and Taofeeq, 2010). Malaysia, on the other hand, has achieved accelerated agricultural development through sustained annual expenditure of between 20-25% of its budget on agriculture in the last three decades (Yongsters Foundation, 2010). The funding pattern in Nigeria clearly does not befit the sector that is acknowledged to be prime driver of growth and poverty reduction in the country.

6.3 Traditional Agricultural Practices

In Nigeria, the traditional and predominant method of clearing farm land is through bush burning. In addition, the use of firewood as cooking energy source has gained prominence, because of the high cost and non-availability of other cleaner sources such as natural gas (Anselm and Taofeeq, 2010; Medugu, 2009). Furthermore, there is the problem of deforestation. These activities increase the concentration of Green House Gases (GHGs) in the atmosphere trapping heat and causing global warming and climate change (Medugu, 2009). Garba (2006) reported that one of the major causes of poverty is destruction of natural resources, leading to environmental degradation, high temperature, drought and consequently reduced productivity. In addition, the Nigerian agriculture is almost entirely rain-fed and hence inherently susceptible to the vagaries of weather. As global warming accelerates, it is expected that agricultural adaptation to climate change can only be meaningful, if irrigated agriculture gains prominence. Unfortunately, agricultural practices in Nigeria is still predominantly rain-fed and therefore, particularly vulnerable to the impacts of climate change (Medugu,2009;IFAD, 2007).

Land tenure and fragementation systems could also limit the capacity to adapt to climate change by farmers. Among most Africans, farm land is not owned but held in trust by the present generation on behalf of their future descendants. It could be held by individual, families, extended families or entire village communities and then fragmented to individual farmers, who only enjoy user rights (Nweke and Enete, 1999). This limits the level of individual farmer's investment in the development of a farmland, since the user right could be withdrawn anytime. In addition, fragmented nature of farmland could hamper the farmer's capacity to adopt innovative farming practices that may be necessary for climate change (IFAD, 2007).

6.4 Policies and Institutions

The development of dynamic farming systems capable of adapting to the challenges of climate change, require a conducive and stable policy environment. This has generally been lacking in Nigeria .Successive governments most often turn down on policies put in place by predecessors. Some of the problems that could result from inconsistent agricultural policies in Nigeria include; high apathy on the part of the farmers regarding anything from government. At the moment, there are scanty and ill-equipped weather stations, and agricultural infrastructures (Odjugo, 2010). The World Bank (2006) reported the existence of inadequate storage facilities and dilapidated agricultural infrastructure in Nigeria. Farmers have continued to face unfavourable terms of trade and poor access to many agricultural inputs such as improved seeds and agro-chemicals. FAO(2007) recognized the concentration of efforts in the agricultural sector in Nigeria at the Federal level and private-sector has been so weak and negligible. This trend clearly revealed that policies are centralized at the Federal level at the disadvantage of agricultural activities at the State and Local Government levels in the country, which does not augur well for climate change adaptation by farmers.

6.5 Information and Human Capital

The evolution of farming systems based upon increasing climate change, specialization or integrated intensification has required extra knowledge on the part of farm operators. The need for better information and enhanced human capital has also increased, as production systems have become more integrated with regional, national and international market systems (Anselm and Taofeeq, 2010). This knowledge-based approach has not yet been effectively adopted in Nigeria. Lack of education, information and training is frequently a key limiting factor

to small holder development. The report of Medugu (2009) confirmed that the poor state of the country's education has also had its roll on the poor people, majority of who are farmers in rural areas. The continued reduction in government expenditure on extension and agricultural training has reduced the access of farmers to technology and market information, and consequently climate change adaptation.

7.0 CONCLUSION AND RECOMMENDATIONS

The paper revealed that climate change had significant implications for agricultural sector in the Sahelian zone of Nigeria. It equally identified the implications of climate change for policy and extension. The paper indicated that agricultural strategies for climate change adaptation were developed through policies and institutions which could reduce the vulnerability of the agricultural sector in the Sahel. The paper also highlighted the critical challenges faced by Nigerian agriculture in trying to adapt to the problem of climate change. These challenges need urgent attention by the relevant authorities because of the fact that the problems of climate change are already on course.

The strategies discussed in the paper, can each make important contributions, but there are no quick, technological shortcuts because the efficacy depends on the broader technological, economic, environmental and political context. However, with these hope for improvements, the sensitivity of agriculture to climate change remains a global concern. Based on the paper, the following recommendations were made:

(i) Institutional linkages should be fostered for agricultural sustainability

Since climate change could exacerbate rainfall variability, close collaboration between meteorological and agricultural services will be necessary for a more effective use of climate forecasts. Extension services need to be strengthened and agents provided with the necessary equipments and logistics so that they can reach farmers more easily with agricultural technologies for adaptation in the face of changing climate.

(ii) Development of Special rural micro-credit Schemes

Because of the lack of adequate rural financial facilities, small holder farmers have often been by-passed by new technologies. The agricultural bank that exists usually targets either big commercial farms or comes up with collaterals as pre-conditions for accessing such loans. As such the loans should be free from interests and collaterals in order for the poor farmer to access and adapt to the impacts of the climate change.

(iii) Improved Extension and information delivery

Information delivery is critical in the process of enhancing the adaptive capacities of the rural areas to climate change. Information on weather or new technologies could be transmitted to the farmers using rural radio and other media and gatherings such as traditional ceremonies. The rapid development of mobile telephony is now opening up new opportunities and should be exploited fully to reach the otherwise remote and unreachable areas.

(iv) Existing technology options should be made more available and accessible

Climate change will almost surely make life even harder for the world's poorest and most vulnerable populations. Therefore, avoidance should be made in restricting their capacity to adapt by limiting their options. Technology options, in particular, should become more available.

(v)*Human Capital Development*

Agriculture needs to become professionalized with educational training incentives and development of human capital in the direction of crop and livestock production. There is need for effective capacity to strengthen the most vulnerable group in agricultural production with requisite knowledge and information necessary for climate change adaptation.

(vi)Climate Change Adaptation Funding.

Climate change adaptation funding should focus on extension systems and programs that incorporate a good understanding of what practices and skills are needed to best promote activities that help in the climate change effort and on increasing the capacity of extension agents and farmers, where needed.

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