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AGRICULTURAL TECHNOLOGIES FOR CLIMATE CHANGE ADAPTATION IN THE SAHELIAN ZONE OF NIGERIA

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ABSTRACT
Climate change is perhaps the most serious environmental threat to fight against food security, mainly through its impact on agricultural productivity. The paper discusses the agricultural technologies for adaptation to climate change in the Sahelian zone of Nigeria. The paper identifies the implications of climate change for policy in Nigeria. It describes the agricultural technologies for adaptation to climate change to include; new traits and varieties, water management and irrigation, production management and practices, information, and insurance. The implications of climate change for agricultural extension was also highlighted.. The challenges, facing agricultural adaptation to climate change were identified to include: hunger, poverty and disease, funding for agricultural research and technology development, traditional agricultural practices, polices and institutions, and information and human capital. It is recommended that efforts of the government should include; fostered institutional linkages for agricultural sustainability, development of special rural micro-credit schemes, improved extension and information delivery, availability and accessibility of existing technology options, national agricultural research policy framework and human capital development.

Keywords: *Agricultural Technologies, Climate Change Adaptation, 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 variations in different climatic parameters such as cloud cover, precipitation, temperature and vapour pressure, etc. (Environmental Resources Management, 2009). Increase in greenhouse gases (GHG) emissions through human activities has resulted in additional warming of the earth's surface, with several anticipated disastrous impacts (Harris, 1999; Mortimore *et al.*, 2000).

Sahel in general is a poor environment in terms of production of food, fuel and fibre, ,inhabited by poor people struggling with harsh climate, degraded soils and underdeveloped structures (Ardo and Bashir, 2007). The vegetation cover composed annual grasses with few shrubs and stunted trees which becomes denser as one moves towards the south. The climate is characterized by dry and hot weather with an annual temperature ranging from 25-37^{0}C (Gambo, 2007). Annual rainfall is generally low and highly variable with less than 500mm per annum (Odo *et al.*, 1999; Odo and Leghe, 1998).

It is anticipated that climate variability and change in Nigerian Sahel will have an overwhelming impacts 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 livelihoods in the country. Initial efforts at dealing with the problem of global warming concentrated on mitigation, with the aim of reducing and possibly stablising the GHG concentrations in the atmosphere (Odjugo, 2010). Even if this stabilization was achieved to some extent, global warming would continue to increase over centuries. Consequently, adaptation was seen as a viable option in reducing vulnerability associated with anticipated negative impacts of Climate Change (Jones, 20101). 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 adoption 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 fore of the international climate debate. The focus is centred largely upon enhancing the capacity of developing countries such as Nigeria and the poor 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 decades, 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 agricultural technologies for adaptation to climate change in the sahelian zone of Nigeria. This was with a view to suggesting recommendations for improved agricultural adaptation to climate change in the Sahelian zone of Nigeria.

2.0 THE SAHELIAN ZONE OF NIGERIA

The Sahelian Zone of Nigeria forms an undulating plain at a general elevation from about 450m to 700m(Mortimore and Adams1999).The sahelian zone consists of Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara States in Nigeria A large proportion of the region is also 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, 1989). 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(Mortimore and Adams1999).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 Adams1999). 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 as cited earlier. 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 as well as where increasing drought incidents have caused changes in plant species, such as the invasion of the Kano area (Sudan) by thorn bushes native to the Sahel. 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. Moreover, in terms of human activities, the sahelian zone of Nigeria have been inhabited and cultivated for centuries. Thus the pressure on the land is much more than it is in some other parts of the country.

3.0 IMPLICATIONS OF CLIMATE CHANGE FOR POLICY

There is urgent need for climate policy at the global, regional, national and local levels in order to avert the imminent dangers of climate change. Ozor (2009) reported that it was assumed that without more intensive mitigation and adaptation efforts, by the end of the 21st century global averaged surface temperature will rise by 7^{o}c relative to the pre-industrial value. This depends on the amount of GHGs emitted into the atmosphere and the uncertainties in the climate system. A successful climate policy then becomes preventive as experts have noted that if the rise in global averaged surface temperature does not exceed 2-7^{o}C relative to the pre-industrial value, the climate-induced threat to the international security could be averted (IPCC, 2007; Mude *et al., 2009*).

The Nigerian Sahel is characterized by wide climatic variations and fluctuations of drought with a highly irregular rainfall (Pittock, 2005). Thus an appropriate policy options are required to avert the devastating effects. The key challenge is to take resolute climate change policy action urgently in order to avert the socio-economic distortions and security of Nigeria in particular and the world at large. Nigeria has no clear climate change policy. Particularly; adaptation policy and bills to enhance good practice for sustainable agriculture and environment are not yet implemented (Ozor, 2009; Odjugo 2010). These situations are not helpful ,especially with the excruciating impacts of climate change. Nigeria, therefore needs to make climate change adaptation policy in line with the international provisions.

4.0 CLIMATE CHANGE ADAPTATION POLICY OPTIONS IN AGRICULTURE

Climate Change Adaptation refers to actions intended to improve the resilience of agriculture, to enhance its capacity to deal with conditions associated with climate change, and hence to reduce the vulnerability of agriculture to changing climate (including changes in temperatures, moisture, extremes, and its indirect effects on water, disease, etc.). The direct and intended beneficiaries of climate change resilience building initiatives are agricultural producers, households, livelihoods, consumers.

Adaptation within agriculture, food systems and rural communities involves adjustments in land and water management, resource use, access to assets, livelihood strategies, among others. Agricultural adaptations are invariably undertaken by individuals or households (private agents at the farmer level), usually autonomously or spontaneously, and often reactively (*post hoc*). Public agencies, from community to national levels, can facilitate or constrain adaptations, and they have a role to play in promoting anticipatory or planned (*ex ante*) adaptations. Adaptations are influenced by the structures, functions and actions of governments at local, national and international levels, as well as by conditions and forces largely beyond the direct influence of national governments (markets, preferences, cultures, technologies, etc). Many (perhaps most) climate change adaptations are initiated and undertaken locally. However, adaptations can be initiated, enhanced or constrained by national policies. Policies relating to land and water management, resources use, access to assets, environmental conservation and livelihood strategies, crop development, land-use, land tenure, risk management, food security, and trade all have the potential to influence adaptation to climate change.

4.1 Approaches to Climate Change Adaptation

Two main types of adaptation are autonomous and planned adaptation. Autonomous adaptation is the reaction of, for example, a farmer to changing precipitation patterns, in that s/he changes crops or uses different harvest and planting/sowing dates. Planned adaptation measures are conscious policy options or response strategies, often multisectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. For example,
deliberate crops selection and distribution strategies across different agro-climatic zones, substitution of new crops for old ones and resource substitution induced by scarcity (Easterling, 1996). Farm level analyses have shown that large reductions in adverse impacts from climate change are possible when adaptation is fully implemented (Mendelsohn and Dinar, 1999). Short term adjustments are seen as autonomous in the sense that no other sectors (e.g. policy, research etc.) are needed in their development and implementation. Long-term adaptations are major structural changes to overcome adversity such as changes in land-use to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency related techniques.

5.0 AGRICULTURAL TECHNOLOGIES FOR CLIMATE CHANGE ADAPTATION

The core challenge of climate change adaptation in agriculture is to provide (i) more food, (ii) more efficiently (iii) under more volatile production conductions, and (iv) with net reductions in GHG emissions from food production (Lybbert and Sumner, 2010; Kandji *et al.*, 2007). Agricultural technologies would play a central role in enabling the Sahelian farmers in meeting these core challenges because agriculture is inseparably linked to Climate and Feedback runs in both directions. Most new technologies could change the use of farm inputs, often in ways that alter the impact of weather on production and of production on carbon emissions (Harris, 1998; Harris, 1999). While most agricultural technologies therefore have Climate change implications, there is a lot of current and emerging technologies with particular relevance to sahelian environments and Climate Change. In this section, the paper highlights some specific relevant technologies for climate change adaptation in the sahelian zone of Nigeria as describe below.

5.1 New Traits and Varieties

Increasing agricultural productivity requires technological advances in both crop and livestock yields. New varieties and traits could lead to less or probably more 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 being developed, could emerge from traditional breeding techniques

that leverage existing varieties, which 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 disease pressures. 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,* 1997). Some of the National Agricultural Research Institutes (NARIs) charged with the mandate and responsibilities for development and extension of new traits and varieties are, Cereals Research Institute, Badeji; Lake Chad Institute, Maiduguri and National Animal Production Research Institute, Zaria.

5.2 Water Management and Irrigation

With higher temperature and changing precipitation patterns, controlling water supplies and improving irrigation access and efficiency will become increasingly important (Leeuwis, 2006; Oladipo, 2010). 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 Nigerian Sahel (Lybbert and Sumner, 2010). Sahelian farmers are in 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 places with limited access to irrigation, well-trained "deficit irrigation" can make a substantial difference in productivity (Ajibade and Shokemi, 2003). With dwindling water supplies, such deficit irrigation techniques will become increasingly important. 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; Kadji *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 Nigerian Sahel (Mortimore and Adams, 1999). River Basin Development Authorities(RBDAs), Federal and State Ministries of Water Resources charged with the responsibilities of Water Management and Irrigation Services could provide the irrigation services needed by sahelian farmers in Nigeria.

5.3 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 Leuhart, 1996; Nyong *et al.*, 2007). This technique aims at building 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 increase water use efficiency. The practice also reduces carbon emissions by reducing tilling. An array of other production management practices and technologies could similarly improve farmers' adaptation to climate change, including information that enables more precise application of inputs, especially fertilizer (Adams and Mortimore, 1997).

5.4 Information

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 more appropriate crops or varieties. 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 Nigerian Sahel.

5.5 Insurance

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 is mandated to provide insurance cover for both crop and livestock enterprises. Some private insurance companies are also providing insurance cover for agriculture.

6.0 IMPLICATIONS OF CLIMATE CHANGE FOR AGRICULTURAL EXTENSION

Agricultural extension has been defined as a series of embedded communicative interventions which supposedly help to resolve problematic situations (Leeuwis, 2006, Ozor, 2009). This definition confers on agricultural extension ,the mandate to accommodate the issue of climate change in its duties (Ozor, 2009). However, in order to achieve this, 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.

First, extension staff need to be re-trained so as to acquire necessary skills and knowledge in climate risk management. They have to be aware of the immediate and remote causes of climate change, its effects and the local knowledge and practices used by communities to adapt to climate change (Ozor 2009). This will enable them to know how to apply the necessary interventions in order to scale up or replicate adaptation strategies. Extension can achieve this feet using many strategies such as information exchange with people at climate risk sites, information on early warning systems for agricultural production, training of local people on tested measures for adaptation to the effects of climate change and formation of veritable climate action groups for sustainable food production.

7.0 CHALLENGES OF AGRICULTURAL ADAPTATION TO CLIMATE CHANGE

Climate change exerts multiple stress 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 challenge facing agricultural adaptation to climate change in Nigeria include the following:

7.1 Poverty, Hunger and Diseases

Food security threat posed by climate change is greatest for African sahels, where agricultural yields and per capital food production have been steadily declining, and where population growth will double the demand for food, water and forage in the next 30years (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 & 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 to the basic necessities like feeding and medication rather than ploughing them into climate change adaptation measures.

7.2 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 (Ansalem and Taofeeq, 2010; Garba, 2006). In Nigeria, funding of agricultural research from the Federal Government budget has been declining in percentage since early 1980s (Agbamu 2000). 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.

In Nigeria, all the agricultural research institutes are owned and managed by the Federal Government, the state and the local governments, which are closer to the rural farmers, have no research institutes. The consequences of this is not only over-centralization of agricultural

administration, but also that those involved are hardly in touch with the reality on ground. This could pose serious challenge for agricultural adaptation to climate change by small holder production systems.

7.3 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 recently 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 he 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 (FAO, 2008; Medugu, 2008; 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 innovate farming practices that may be necessary for climate change (IFAD, 2008).

7.4 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's successive government most often make a u-turn on policies put in place by predecessors (Garba, 2007). 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. This is because nobody knows how long such may last and failure to set up a satisfactory credit system for farming and agro-processing (Anselm and Taofeeq, 2010).

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 dilapidating agricultural infrastructure in Nigeria. Farmers have continued to face unfavourable terms of trade and poorer access to many agricultural inputs such as improved seeds and agro-chemicals ,FAO (2008) 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.

7.5 Information and Human Capital

The evolution of farming systems based on 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 adopted in Nigeria

Lack of education, information and training is frequently a key limiting factor to small holder development. The report of IFAD (2008) confirmed that the poor state of the country's education has also had its role 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.

8.0 CONCLUSION AND RECOMMENDATIONS

The paper reveals that climate change had significant implications for agricultural sector in Nigerian Sahel. It equally identified the implications of climate change for policy and extension. Agricultural technologies for climate change

adaptation were developed through policies and institutions which could reduce the vulnerability of the agricultural sector in the Nigerian 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 the problems of climate change are already here.

The technologies discussed in the paper, can 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 suggested:

(i) **Institutional linkages should be fostered for agricultural sustainability:** Since climate change could increase 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 banks that exists usually target either big commercial farms or comes up with collateral securities as pre-conditions for accessing such loans. As such the loans should be free from interests and collateral securities.

(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) **National Agricultural Research Policy Frame work**: There should be an explicit national agricultural research policy framework to provide for continuity and effectiveness in agricultural programmes. Effort should be made to reduce concentration at the Federal level. Farmers should have regular information on current issues related to climate change and agriculture. This can be achieved through the strengthening of the Nation's extension services, perhaps by devolving the bulk of the services down to the local councils which is closer to the farmers.

(vi) **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

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