Agricultural Innovations for Climate Change Adaptation and Food Security in West Africa: The Case of Nigeria, Sierra Leone and Liberia

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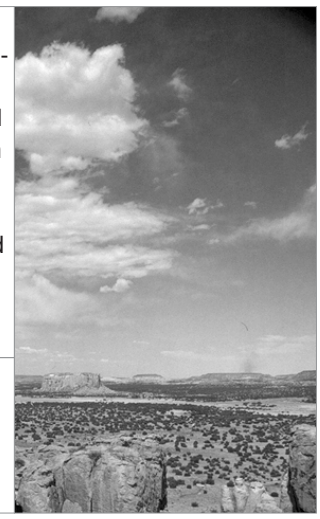

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Table of Contents

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List of Acronyms

ATPS	African Technology Policy Networks Studies
ADB	African Development Bank
AIDS	Acquired Immune Deficiency Virus
AEZ	Agro-Ecological Zones
AKIS	Agricultural Knowledge and Information System
ACGS	Agricultural Credit Guarantee Scheme
IADPs	Integrated Agricultural Development Projects
AGOA	African Growth and Opportunity Act
AKIS	Agricultural Knowledge and Information System
AIS	Agricultural Innovation System
CAADP	Comprehensive Africa Agricultural Development Programme
CTA	Technical Centre for Tropical Agriculture
CFSNS	Comprehensive Food Security and Nutritional Survey
DFRRI	Directorate for Foods, Roads and Rural Infrastructure
DRR	Disaster Risk Reduction
ECOWAP	Economic Community of West African Agricultural Policy
EIA	Environmental Impact Assessment
EU ACP	European Union- African, Caribbean and Pacific Group of States
EEG	Export Expansion Grant
FGN	Federal Government of Nigeria
FAO	Food and Agriculture Organization of the United Nations
FMARD	Federal Ministry of Agriculture and Rural Development
FEPA	Federal Environmental Protection Agency
FSP	Food Security Policy
FAD	Forestry Development Authority
FGD	Focus Group Discussion
GRP	Green Revolution Programme
GDP	Gross Domestic Product
HIV	Human Immuno Virus
IPRSP	Interim Poverty Reduction Strategy Paper
IITA	International Institute of Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
ICTs	Information and Communications Technologies
LDHS	Liberia Demographic and Health Survey

MDGs	Millennium Development Goals
NSPFS	National Special Food Security Programme
NDPs	National Development Plans
NAPEP	National Poverty Eradication Programme
NARS	National Agricultural Research System
NEEDS	National Economic Empowerment Development Strategy
NEPAD	New Partnership for Africa's Development
NGO	Non Governmental Organization
NRS	National Regulatory Services
NPC	National Population Commission
NERDC	National Educational Research and Development Council
NFSP	National Food Security Programme
OAU	Organization of African Unity
R&D	Research and Development
SAP	Agriculture in Structural Adjustment Programme
STI	Science, Technology and Innovation
SLPMB	Sierra Leone Produce Marketing Board
SSA	Sub-Saharan Africa
UN WFP	United Nations World Food Programme
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
UNISDR	United Nations International Strategy for Disaster Reduction
PRSP	Poverty Reduction Strategy Programme
WHO	World Health Organization
WTO	World Trade Organization

1. Problem Statement

In the Millennium Declaration, 189 nations resolved to halve extreme poverty by 2015 and all agencies involved in this paper are committed to contribute to this aim. Hence, the Millennium Development Goal (MDG) agenda, to eradicate extreme hunger and poverty, became one of the goals of nations as an effort to reduce / eradicate food insecurity / crises. In the wake of this new push, the MDG was launched, bringing together the international community to work together to achieve the set goals by the year 2015 (Migotto, Davis, Canetto and Kathleen, 2005).

Despite international efforts, poverty has become more widespread in many countries in the last decade, making poverty reduction the core challenge for development in the 21st century. Less than 5 years to the target year, available statistics still cast doubt on whether this goal could be achieved by the year 2015.The incidences of food insecurity and poverty are particularly devastating in the developing countries, and a lot of resources are being channeled toward programmes aimed at eradicating food insecurity and poverty by various international organizations and governments of developing nations (Millennium Development Goals Report, 2006). According to MDG (2006) report, more than 1.2 billion people (28%) of the developing world's population lived in extreme poverty as at 1990. By 2002, the proportion decreased to 19%. During that period, the rate of extreme poverty fell rapidly in Asia, where the number of people living on less than one dollar a day dropped by nearly a quarter of a billion people. Progress was not so rapid in Latin America and the Caribbean, which has a larger share of people living in poverty than South-eastern Asia and Oceania.

Chronic hunger measured by the percentage of people lacking the food needed

to meet their daily needs has declined in the developing world. However, overall progress is not fast enough to reduce the number of people going hungry, which increased between 1995-1997 and 2001-2003 (Millennium Development Goals Report, 2006). An estimated 824 million people were affected by chronic hunger in 2003. The worst affected regions were sub-Saharan Africa and Southern Asia. These regions though have made progress in recent years, but their advances have not kept pace with those of the early 1990's and the number of people going hungry is increasing. In sub-Saharan Africa, although the poverty rate declined marginally, the number of people living in extreme poverty increased by 140 million. Many sub-Saharan Africa countries are now showing potentials for long term growth that could bring up their standard of living (Millennium Development Goals Report, 2006). Data in Table 1 shows the proportion of people in percentage living in extreme hunger compared with the 2015 target of the Millennium Development Goals across different Sub-regions of the world.

Table 1: Prevalence of undernourishment in the world in percentage for 1990-92, 1995-97 and 2001-03

	1990-1992	1995-1997	2001-2003	2015 Target
Sub -regions				
Sub -Saharan Africa	33	34	31	18
Southern Asia	25	23	21	14
Common Wealth of Independent States, Asia	16	N.A	20	9
Eastern Asia	16	12	12	9
Southeast Asia	18	14	12	10
Oceania	15	14	12	8
Latin America and Caribbean	13	11	10	7
Western Asia	6	9	9	4
Northern Africa	4	4	4	3
Common Wealth of Independent State, Europe	4	N.A	3	2.8

Source: Millennium Development Goals Report (2006); N.A is data not available.

In many African countries, food security at both the national and household level is a dismal. Africa has the highest prevalence of undernourishment. In 2004, whereas 14% of the global population was undernourished, 27.4% of the population in Africa as a whole was undernourished (Babatunde, Omotesho and

Shotolan, 2007). In some countries, the rate of undernourishment is above 40% while it exceeds 50% in those countries experiencing or emerging from armed conflict (Todd, 2004). In West African sub-region, Liberia and Sierra Leone are among those with the highest rate of undernourishment in the continent with 1.4 and 2.3 million undernourished people respectively in 2002 (Babatunde et. al.,2007). In Nigeria, the most populous country in Africa, the majority of households are food insecure, especially the rural farming households.

Climate change is a serious risk to poverty reduction and threatens to undo decades of development efforts through direct negative effects on production and indirect impacts on purchasing powers (African Development Bank (ADB) Report (2003)). As the Johannesburg Declaration on Sustainable Development states, "the adverse effects of climate change are already evident, natural disasters are more frequent and more devastating and developing countries more vulnerable." While climate change is a global phenomenon, its negative impacts are more severely felt by poor people and poor countries because of their high dependence on natural resources, and their limited capacity to cope with climate variability and extremes.

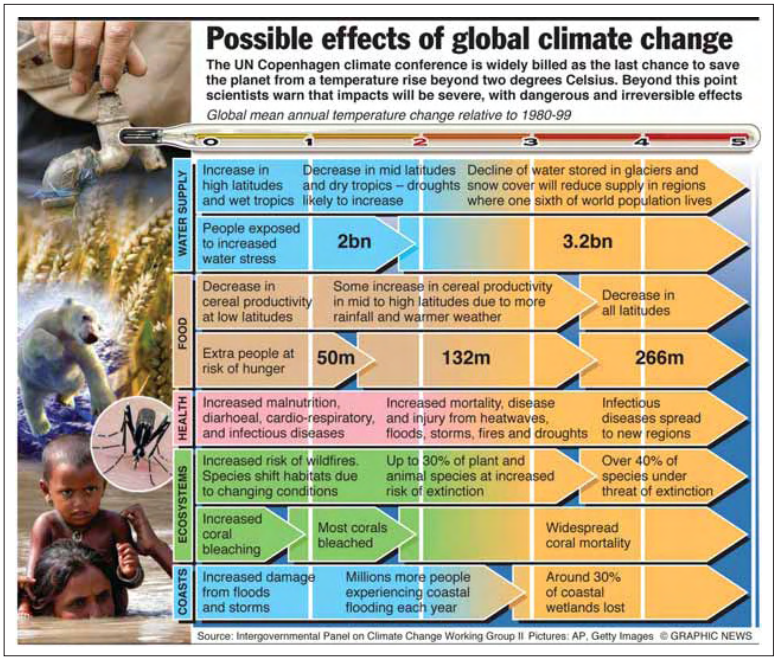


Fig 1: The Possible Effects of Global Climate Change

Experience suggests that the best way to address climate change impacts on the poor is by integrating adaptation responses into development planning (ADB, 2003). This is fundamental to achieve the Millennium Development Goals, including the over-arching goal of halving extreme poverty by 2015, and sustaining progress beyond 2015. Figure 1 shows the possible effects of global climate change.

Africa remains one of the most vulnerable continents to climate change because of multiple stresses (resulting from both politics and economic conditions), the continent's dependence on natural resources and its weak adaptive capacity. According to the Intergovernmental Panel on Climate Change 4th Assessment Report (2007) between 75 and 250 million people may be exposed to increased water stress due to climate change by 2020 in Africa and this will adversely affect livelihoods in the region. The area suitable for agriculture, the length of growing seasons and yield potentials, are expected to decrease due to climate change. Yields from rain-fed agriculture in some countries could be reduced by up to 50%. Thus, climate change may have particularly serious consequences in Africa, where some 800 million people are undernourished.

In the West Africa sub region, the report showed that agriculture is critical to the economy. While the world average contribution of the agriculture sector to the Gross Domestic Product (GDP) is only 4.5 %, the sector's contribution is about 30 % in West Africa. In addition to the above, over 65 % of the population in the region is rural, and about 90 % of the rural population directly depends on rain-fed agriculture for income and food security. Therefore reduction in rainfall as predicted by various climate models translates to threat to livelihood of the population and the economy of the sub-region.

Unfortunately, research data from Nigeria, Sierra Leone and Liberia show that the performance of the agricultural sector continue to be relatively disappointing in the sub-region as growth has been increasingly on the decline. Traditionally, the agricultural research systems in the region are characterized by a top-down, centralized, monolithic and isolated structures. Linkages, interactions and learning mechanisms among the component actors are notably weak and/or often non-existent. Empirical evidence revealed several linkage gaps and missing links among and between the actors in the systems (Agbamu, 2000; Egyir, 2009). Institutions, for example, universities and research institutes

innovate in isolation and although research were taking place at various national and international organizations, the coordination is dysfunctional, and poorly linked to the productive sector. Besides, farmer innovations were not being included in the knowledge system because traditional approaches such as the NARS (National Agricultural Research System) perspective and AKIS (agricultural knowledge and information system) depict research as the sole source of innovation. Without research, it implies, there is no innovation.

A more accurate way is one in which the NARS is no longer seen as the epicenter of innovation but simply one of its various sources. Knowledge and information may spill into the innovation system from domains other than the NARS and, perhaps even more crucially, knowledge and information may emerge from outside the realm of formal research because of on-farm as well as off-farm learning (up and down the agricultural production chain)—that is, learning through doing, using, and interacting. This comprises a far broader set of actors than the traditional agricultural research, extension, and education agencies. In other words, not all innovations have their origin in formal S&T nor are they all exclusively technical. Hence, this new perspective places more emphasis on the role of farmers, input suppliers, transporters, processors and markets in the innovation process.

Innovation refers to the process of creating and putting into use combinations of knowledge from many different sources. Thus, innovation may be brand new, but usually it involves new combinations of existing knowledge, i.e., small, gradual changes in technology, processing, organizational management, etc and/or creative imitation. Studies on innovation indicate that the ability to innovate is often related to collective action and knowledge exchange among diverse actors, incentives and resources available for collaboration, and having in place conditions that enable adoption and innovation e.g., by farmers or entrepreneurs (World Bank 2006). In other words, contemporary concept of innovation sees innovation not as mere technologies or products but as the process through which knowledge is generated, crafted from various sources and put into use. Thus, innovation may address new creations of social and economic significance (such as climate change adaptation measures), technological artifacts, improvements in technical and managerial issues, institutional and policy aspects (Smits, 2002). Hence, innovation requires systemic view as it involves various dimensions that are contributed by different actors. As innovation results

from interactions of various actors and factors, there is a high chance of convergence of multiple drivers of innovation (e.g., access to information, markets, finance, collective actions, and institutional changes) through networks of actors initiated in the Innovation System.

According to Roling, (2007) farmers are very quick to take up opportunities. The recent increase in the FOB price of cocoa in Ghana from 40 to 70% led to a doubling of cocoa production without any technological break-through. Hence, if farmers are to cope, compete, and survive, they need to innovate continuously. African farmers are not only innovating in terms of component technologies, but also in terms of farming systems. Farmers often know more than scientists when it comes to the characteristics and dynamics of the environment in which they farm, including risks of water logging, drought, pests, climate change and adaptation measures, thieves, and so forth. However, emerging issues such as high food prices, climate change, and demands for bio-fuels require complementary knowledge from formal agricultural research and development (R&D) and support from policies and other institutions (Asenso-Okyere and Davis, 2009). Hence, formal and informal knowledge and innovation must therefore be linked to accelerate sustainable agricultural development in the West African sub-region.

By adopting an AIS perspective, bigger issues come into focus than when adopting a more limited NARS or AKIS concept. By starting at the knowledge-application end, the question of why farmers innovate or why they don't becomes a major issue for debate and research. What are the constraints that hold them back? Is it the prices in the market, for example, or the lack of (or lack of access to) technology? Are farmers passive recipients of technology or do they actively search for innovations? What are the roles of input suppliers, cooperatives, traders, processors, NGOs, and government-extension services in technology diffusion? What are the relative strengths and weaknesses of each diffusion channel? How can they be improved and what can be done to reach more farmers? This study therefore sought to identify and document the agricultural innovations used for climate change adaptation and food security in Nigeria, Sierra Leone and Liberia, using the Agricultural Innovation Systems Framework.

1.1 Study Objectives

Specifically, this research project sought to:

1. Promote some selected agricultural innovations through targeted training and field demonstrations with selected Agriculture Extension Officers and farmers in Nigeria and Sierra Leone;
2. Identify and document indigenous innovations and good practices by climate change vulnerable communities for improved food security in Nigeria, Liberia and Sierra Leone;
3. Identify and document emerging innovations suitable for climate change adaptation in Nigeria, Liberia and Sierra Leone;
4. Establish collaborative network involving researcher, ministry of food and agriculture or its equivalent and farmers to enhance agricultural innovations for increased productivity in the face of climate change in Nigeria, Liberia and Sierra Leone;
5. Build capacity of farmers and extension officers from the ministry of food and agriculture or its equivalent in order to enhance behavioural change towards sustainable farming and agri-business innovation in Nigeria, Liberia and Sierra Leone;
6. Build capacity of the research team on agricultural innovation systems through participating in an integrated capacity building programme, including hand on case studies and country tour to showcase and learn from good practices; radio jingles, drama, plays, TV shows, etc all aimed at disseminating evidence-based climate change adaptations and resilience methods and food security to vulnerable communities and people in the three countries; and
7. To support the implementation of the NEPAD CAADEP program in the West Africa region through popularisation and policy advocacy.

1.2 Rationale of the Study

Innovation system approach offers a more holistic, multidisciplinary and comprehensive framework for analyzing innovation processes for climate change adaptation and food security, as well as the roles of science and technology actors and their interactions because of its emphasis on wider stakeholder participation, linkages and institutional context of innovation and processes.

Whilst climate change is presenting specific additional challenges to development, it cannot be addressed in isolation. Unless concrete and urgent steps are undertaken to reduce vulnerability and enhance adaptive capacity of poor people, and unless these actions are integrated in national strategies for poverty eradication and sustainable development, it may be difficult to meet some MDGs by 2015. Adaptation which refers to consciously planned adjustments in a system to reduce, moderate, or take advantage of the expected negative impacts of climate change (Smit, Burton, Klein and Wandel, 2000) aims to reduce the vulnerability of individuals and communities by building on and strengthening their existing coping mechanisms with specific measures.

Hence, the starting point for addressing the critical issues for policy should be an analysis of existing agricultural, environmental and food security policies in these countries as well as documentation of effective agricultural innovations for climate change adaptation and food security in the West African sub-region and the consequences of climate change for different rural communities. Since adaptation can help farmers achieve their food, income and livelihood security, negligence will have devastating implications for development and livelihood. Moreover, mainstreaming climate issues into national development policies ensures consistency between the needs of adaptation and poverty eradication. Separation of the two runs the risk of adaptation policies inadvertently conflicting with development and poverty policies, or conversely, development policies inadvertently increasing vulnerability to climatic factors. Accordingly, this research project is critical to the successful eradication of poverty and needs to be undertaken.

Also, in order to enlighten the major stakeholders on the dynamics of climate change; there is the need to understand the different local knowledge and innovations that have sustained the rural people in these countries. We therefore need research in this area for evidence-based advocacy. Again, this work is very vital at this point in time in order to provide foundations upon which the building blocks of STI policies on climate change adaptations will be laid. Finally, research findings from this study will feed into future STI policy documents on climate change adaptation and food security measures.

2. Definition of Terms

2.1 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) (2001) defines climate change as: Any change in climate over time, whether due to natural variability or as a result of human activity. In other words it encompasses both natural variability and anthropogenic changes and hence refers to the observed and projected increase in average global temperature, and the associated impacts, including: an increase in extreme weather events; melting of icebergs, glaciers and permafrost; sea level rise; and changes in the timing and amount of rainfall. (CARE/Angie Dazé/2007), it is unnecessary to separate "climate change" caused by humans from natural "climate variability".

2.2 Vulnerability to Climate Change

Vulnerability to climate change has been defined as: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (CARE/Angie Dazé/2007). Systems here, refers to communities (recognizing that communities are not homogeneous, so particular households or individuals within communities may have differing degrees of vulnerability). Exposure to climate variation is primarily a function of geography. For example, coastal communities will have higher exposure to sea level rise and cyclones, while communities in semi-arid areas may be most exposed to drought. Sensitivity is the degree to which the community is affected by climatic stresses. A community dependent on rain-fed agriculture is much more sensitive than one where the main livelihood strategy is labour in a mining facility, for instance.

2.3 Adaptive Capacity

Adaptive capacity is defined as: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001). One of the most important factors shaping the adaptive capacity of individuals, households and communities is their access to and control over natural, human, social, physical, and financial resources. Examples of resources that may be important to adaptive capacity include:

- Human Knowledge of climate risks, conservation agriculture skills, good health to enable labour
- Social Women's savings and loans groups, farmer-based organizations Physical Irrigation infrastructure, seed and grain storage facilities
- Natural Reliable water source, productive land Financial Micro-insurance, diversified income sources.

Access to and control over the resources necessary for adaptation varies within countries, communities and even households. It is influenced by external factors such as policies, institutions and power structures. Adaptive capacity can vary over time based on changing conditions, and may differ in relation to particular hazards. In general, the world's poorest people are also the most vulnerable to climate change. This is often because they have limited access to those resources that would facilitate adaptation. For instance, women are often particularly vulnerable to the impacts of climate change due to their responsibilities in the home and their limited access to information, resources and services. Other groups such as pastoralists, persons living with HIV&AIDS and the elderly may also represent highly vulnerable populations.

2.4 Resilience

Resilience can be defined as: The ability of a community to resist, absorb, and recover from the effects of hazards in a timely and efficient manner, preserving or restoring its essential basic structures, functions and identity (IPCC, 2001). Resilience is a familiar concept in the context of disaster risk reduction (DRR), and is increasingly being discussed in the realm of adaptation. A resilient community is well-placed to manage hazards to minimize their effects and/or to recover quickly from any negative impacts, resulting in a similar or improved state as compared to before the hazard occurred. There are strong linkages between

resilience and adaptive capacity; consequently, resilience also varies greatly for different groups within a community.

2.5 Hazard

In the context of disaster risk reduction, a hazard is defined as: A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2009). Hazards refers both to shocks, such as droughts or floods (rapid onset), and to stresses, such as changing rainfall patterns (slow onset). It is important to distinguish between the hazard - for example a flood, and the effects of the hazard - for example death of livestock. Some effects, such as food shortages, may be the result of a combination of hazards, including climate shocks and stresses, declining soil fertility, and insecure access to markets. To effectively analyze vulnerability, we must understand the dynamic nature and interactions of hazards.

2.6 Adaptation to Climate Change

In order to reduce vulnerability to climate change, we must focus on building adaptive capacity, particularly of the most vulnerable people; and, in some cases, on reducing exposure or sensitivity to climate impacts. We must also ensure that development initiatives don't inadvertently increase vulnerability. We call this process adaptation. Adaptation is defined as:

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007).

The adaptation of human systems is a process which requires the engagement of a wide range of stakeholders at multiple levels and in multiple sectors. It requires analysis of current exposure to climate shocks and stresses, and model-based analysis of future climate impacts. It demands an understanding of the existing vulnerability of individuals, households, and communities. With this information, adaptation strategies can be designed and implemented. Monitoring and evaluating the effectiveness of activities, as well as sharing knowledge and lessons learnt, are critical components of the process.

2.7 Concepts in Innovation Systems

2.7.1 Innovation

This is any new knowledge introduced into and utilized in an economic or social activity. Innovations may be technical or social. Innovations may be by an individual or by a group.

2.7.2 Innovation system

This is defined as a set of interrelated agents, their interactions, and the institutions that condition their behavior with respect to the common objective of generating, diffusing, and utilizing knowledge and/or technology. In other words it is an interactive learning process in which enterprises in interaction with each other and supported by organizations and institutions play a key role in bringing new products, new processes and new forms of organization into social and economic use (Francis, 2006).

2.7.3 Agents

This comprises individuals and firms as well as public institutions and non state actors that constitute the principal operating components of the system. Agents primarily engaged in the generation, dissemination, or use of knowledge or technology (Clark, 2002).

2.7.4 Knowledge

Knowledge can be categorized in many different ways. Knowledge may be classified according to form—for example, as scientific/technical knowledge or organizational/managerial knowledge, as well as codified/explicit (which is knowledge that has been written down in the form of scientific articles, books, and patents = information) and tacit/implicit knowledge (which is the knowledge people acquire during their life, education and at their job) (Hall, Sulaiman, Clark, Sivamohan, and Yoganand. 2002; CABI/CTA/KIT/ VRIJE / WUR, 2006). Knowledge economy requires trained / skilled people at all levels (farmers, scientists, policymakers) that are continuously learning & innovating.

2.7.5 Sources of knowledge

Knowledge is not only created through formal research but also gained from experiences. Knowledge sources may be external to a given agent within an innovation system—for example, a scientific journal article documenting a

laboratory breakthrough, or a neighbour who introduces one to a new way of achieving something. Others include public research organizations, private laboratories, universities, practices and behaviors of individuals, households, and civil society organizations (Clark, 2002).

2.7.6 Interactions

This refers to relationships between and among agents in an innovation system. Interactions are numerous and varied, and include such relationships as spot market exchanges of goods and services that embody new knowledge or technology; costless exchanges of non-rival, non-excludable knowledge made available in the public domain, interactions among individuals and organizations that are characterized by learning and feedback processes.

2.7.7 Cooperation

This refers to incompletely specified exchange (non-market) relationships that allow for opportunistic behaviour by agents involved in the exchange, in the context of an innovation systems framework (Fritsch, 2004). Cooperation is one of the several forms of interaction that is a key behavioural aspect of agents in an innovation system and is conditioned by the institutions that promote or impede it.

2.7.8 Institutions

This are factors that affect the process by which innovations are developed and delivered, the laws, regulations, conventions, traditions, routines, and norms of society that determine how different agents interact with and learn from each other, and how they produce, disseminate, and utilize knowledge. These are the factors that determine the efficiency and stability of cooperation and competition, and whether agents in an innovation system are able to interact so as to generate, diffuse, and utilize knowledge such as farmer exchanges of seed and other planting materials.

3. Literature Review

Literature was reviewed under the following headings:

1. Concept and Elements of Food and Nutrition Security;
2. NEPAD's Response to the Present Food Crisis in Africa;
3. Food Security Situations in West Africa: The Case of Nigeria, Sierra Leone and Liberia;
4. Nexus Between Climate Change and Food Security;
5. Impacts of Climate Change and the Need for Adaptation;
6. A Critical Review of Policies Relating to Agriculture, Food Security, Environment and Climate Change in Nigeria;
7. A Review of Agricultural Policies in Sierra Leone;
8. Review of Agricultural Policies on Climate Change and Food Security in Liberia and
9. The Innovation System Perspectives.

3.1 Concept and Elements of Food and Nutrition Security

Food security as a concept originated only in the mid-1970's, in the discussions of international food problems at a time of global food crisis (FAO, 2000). The initial focus, reflecting the global concerns of 1974, was on the volume and stability of food supplies. Food security was defined in the 1974 World Food Summit as availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices (FAO, 2003).

In 1983, FAO expanded its concept to include securing access by vulnerable people to available supplies, implying that attention should be balanced between

the demand and supply side of the food security equation and thus defined food security as the condition which ensures that all people at all times have both physical and economic access to the basic food that they need (FAO, 2003). However, this term has gone through stages of definition and redefinition; approaches to its definition have ranged from an emphasis on self-sufficiency to an emphasis on coping with vulnerability and risk in food and nutrition access. In the 1970s, food security was equated to adequate food production. In the 1980s, food security was considered to refer to the security of food access and availability. In the 1990s, the importance of nutrition was recognized, and hence the concept of food security was combined with that of nutrition security. In the 2000s, with vulnerability, risk coping, and risk management considerations.

In 1986, the highly influential World Bank report "Poverty and Hunger", focused on the temporal dynamics of food insecurity (World Bank, 2005). It introduced the widely accepted distinction between chronic food insecurity, associated with problems of continuing or structural poverty and low incomes, and transitory food insecurity, which involves period of intensified pressure caused by natural disaster, economic collapse or conflict. This concept of food security is further elaborated in terms of access of all people at all times to enough food for an active healthy life.

Much of the recent discussion of food security has revolved around the following major topics
(ODI 2002):

a) What are the links between food availability, access, and nutrition, given that food availability does not ensure nutritional well-being?
b) What implications do the new challenges to Africa—notably globalization, rapid urbanization, market liberalization, health and HIV/ AIDS, and biotechnology—have for the food security agenda?
c) Does food security remain a useful concept for the discussion of development assistance and national policies, given the new approaches coming to the fore (for example, livelihoods analysis) and the current focus of donors on poverty reduction?
d) Does food aid still have an important role in supporting food security, and how can it be shaped to support long-term food security?

Essentially, food security can be described as a phenomenon relating to individuals. It is the nutritional status of the individual household members that is the ultimate focus, and the risk of that adequate status not being achieved or becoming undermined. The latter risk describes the vulnerability of individuals in this context. As the definitions reviewed above imply, vulnerability may occur both as a chronic and transitory phenomenon.

Recognizing the distinction between food and nutrition security as well as the links between the two concepts is imperative for the success of national development strategies (Benson, 2004). The secure access to food that is necessary for food security must be complemented with access to health services, education, sanitary environments, and safe water sources, among other resources, to achieve nutrition security. A much more comprehensive developmental approach is thus required to ensure that all groups in a population achieve both food and nutrition security. According to Heidhues, Atsain, Nyangito, Padilla, Ghersi, and Le Vallée, (2004) the following research findings on the links between food availability, food access, and nutritional well-being are relevant to Africa:

1) Women's education has accounted for over 40 percent of the reduction in malnutrition over the past 25 years because of its strong influence on child nutrition. Other major factors are improvements in per capita food availability (25 percent), health, environment, and women's status (Smith and Haddad 2000). About 26 percent of the hungry have caloric intakes so low that they are unable to work or care for themselves (Millennium Project 2003).

2) How food is made available is just as important as the overall supply. Strategies to boost national food production only improve food access if they raise the incomes of large numbers of rural farm and nonfarm households and reduce the consumer prices of food, particularly for net buyers.

3) Agricultural market reform may improve the food security of poor consumers by improving the private production, distribution, and processing of the types of foods consumed by them.

4) A higher household income does not always translate into more and better food for all family members. If women control the household income,

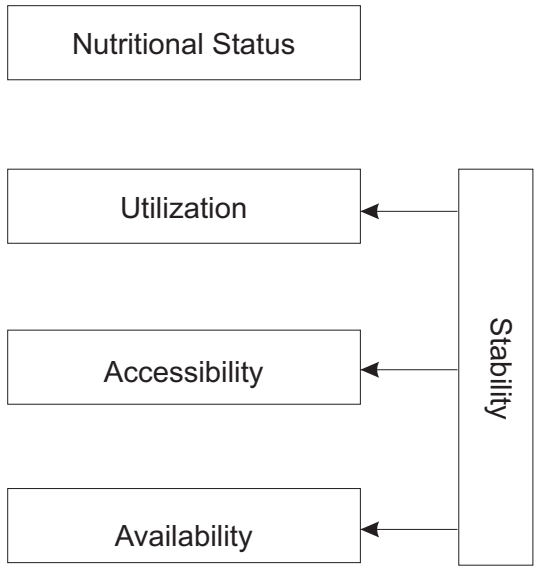
otherwise undernourished children are likely to benefit.

Food security is increasingly though not universally treated as a basic human right. The intertwined relationships between food security, poverty, and development have moved to the forefront on current thinking about food security, as has the recognition that long-term food security is a function of current policies and actions, such as development strategies, macroeconomic policies, trade and exchange rate policies, research and innovation policies, and modifications to institutions and infrastructure (Heidhues, et. al., 2004).

Guaranteeing food and nutrition security at the micro level requires policymakers to go beyond the question of physical access at the national level, that is, whether there is sufficient food at the national level to feed all people. A number of considerations are required, including the following:

1) Physical access at the local level—making sure food is available in local markets and in local fields;
2) Economic access—addressing the question of whether households can afford to purchase the food items they need for food and nutrition security;
3) Social access—promoting adequate access to food for all household members;
4) Food quality and safety—ensuring food of sufficient diversity and safety to promote good health;
5) Proper physiological access—providing high quality care and good health and sanitation environments so that ingested nutritious food results in healthy growth and development;
6) Low risk of loss of access—providing institutional set-ups that enable households to absorb and manage shocks, cycles, and seasonality, and reduce their vulnerability; and
7) Access to food as a human right—promoting the capacity of the food system to deliver needed food and to enhance the capacity of individuals to press their claims to food.

Food security is a broad concept that is more than food production and food accessibility. In reality, it revolves around four major pillars namely, food availability, food accessibility, food utilization which determines nutritional status and stability of food supply (Babatunde et al., 2007) as depicted in figure 2.



Source: Babatunde, Omotesho and Shotolan (2007).

Fig 2: Elements of Food and Nutrition Security

Figure 2 indicates that for food security to be achieved, the aggregate availability of physical supplies of food through local production or importation is sufficient and that the available food supplies should be made accessible to households through their production, markets (given sufficient purchasing power) or other sources. Food security is ensured when there is stability in the supply of the available, accessible and utilized food. Thus, availability, accessibility and utilization of food are hierarchical in nature. Food availability is necessary but not sufficient for food accessibility and access is necessary but not sufficient for utilization.

Food availability is a function of the combination of domestic food stocks, commercial food imports, food aid and domestic food production, as well as the underlying determinants of each of these factors (Makinde, 2000). Food availability in a country, region or local area means that food is physically present through domestic agricultural output or net food imports at the national level. The use of the term availability is applied most commonly in reference to food supplies at a general or national level. Food availability is the most important component of food security because if food is not produced, there will be no distribution, exchange and all the elements associated with food access and food utilization (Omonona et. al., 2007)

The distinction between chronic and transitory (acute) states of food insecurity should be kept in mind. Transitory food insecurity may be triggered by seasonal fluctuations in food availability, food prices and/or incomes, which themselves may result in seasonal fluctuations in individual nutritional status. Depending on the level of vulnerability of a household, transitory periods of food insecurity may precipitate the chronic condition. Chronic food insecurity is a condition, which exists when food supplies are persistently insufficient to supply adequate nutrient for all individuals. A household that cannot cope with seasonality this way, may be thought of as 'fragile', while a household that weathers such periodic crisis is more 'resilient' (Clover, 2003).

According to Todd (2004) household food security is necessary but, of itself, not sufficient to ensure adequate individual nutrition. It may be possible to be malnourished in a food secure household through the effect of disease, inadequate care or inequitable food allocation. While a household may be food secure in terms of calories, dietary quality will determine the likelihood of micronutrient deficiencies occurring in individuals. It should be pointed out that it may be possible for an individual to be well nourished in a food insecure household, although this will usually be at the expense of other individuals' nutritional status, due to preferential food allocation and care. Assuring food security at the household level is thus a fundamental first step in assuring adequate nutritional status of individuals.

3.2 NEPAD's Response to the Present Food Crisis in Africa

The present food crisis in Africa is a major challenge for the international community as well as for Africa's leadership. In response, African leaders assembled in Sirte, Libya, in September 1999 to search for a paradigm shift in the way Africa conducts its affairs. A consensus emerged that what was needed was a holistic, integrated, and coordinated agenda for the regeneration of the African continent (Heidhues, et. al., 2004). Given the evidence that the continent was failing on every front, ranging from economic management to social stability to adoption of new technologies to capacity building, African leaders agreed on a new development agenda for African renewal. What finally emerged from their deliberations was NEPAD's strategic framework document. The African leaders formally adopted the vision, principles, objectives, goals, and priorities outlined in the NEPAD document at the OAU Summit in Lusaka, Zambia, in July 2001.

According to Heidhues, et.al., (2004) the new initiative aimed to build on the CDF–PRSP process, and amalgamates African initiative and ownership of the development process with neoliberal concepts. NEPAD supports liberalization and globalization if the process is fair and the playing field of international trade is level. By endorsing NEPAD's policy framework, African leaders jointly accepted responsibility for eradicating poverty and placing their countries, both individually and collectively, on the path of sustainable development and growth. At the same time, they committed themselves to principles, values, priorities, and standards of governance that are in line with international best practice. Furthermore, they committed themselves to people centered, participative development processes. Within NEPAD's overall vision, its vision for agriculture seeks to maximize the contribution of Africa's largest economic sector to achieving a self-reliant and productive Africa that can participate fully in the world economy. The NEPAD strategy aims for agriculture-led development that eliminates hunger and reduces food insecurity and poverty, thereby opening the way for an expansion of exports, and that puts the continent on an improved economic growth path within an overall strategy of sustainable development and the preservation of the natural resource base. Heidhues, et. al., further reported that the NEPAD's strategy consists of the following aims:

1) improving the productivity of agriculture, with particular attention to small-scale and women farmers;
2) ensuring food security for all people, and increasing the access of the poor to adequate food and nutrition;
3) promoting measures against natural resource degradation, and encouraging production methods that are environmentally sustainable;
4) integrating the rural poor into the market economy and providing them with better access to national and export markets;
5) transforming Africa into a net exporter of agricultural products; and
6) making Africa a strategic player in agricultural science and technology development.

None of these goals for African agriculture are new. These goals have been proclaimed in every strategy that African leaders have designed or adopted with the aims of resolving the food crisis and reversing the effects of poverty. What does appear to be new is the high recognition of these goals by the African leaders who currently drive the implementation of NEPAD's strategy. The new emphasis and priority given to agriculture and water within NEPAD and in the

2003 Maputo Declaration of the Heads of States of the African Union is also encouraging in this respect. To ensure its full success, NEPAD must integrate lessons from OAU's past involvements in initiatives conceived or adopted by African leaders.

3.3 Food Security Situations in West Africa: The Case of Nigeria, Sierra Leone and Liberia

Almost 33 percent of the population of Sub-Saharan Africa (SSA), or close to 200 million people, is undernourished, at the same time, the region as a whole remains susceptible to frequent food crises and famines which are easily triggered by even the lightest of droughts, or floods, pests, economic downturns or conflicts (FAO, 2006), and which is also projected to be exacerbated by the impact of climate change. Studies indicate that while the world food supply does not appear to be seriously threatened by the projected global changes in climate, food insecurity in Africa will worsen and the population at the risk of hunger will increase both in terms of percentage and absolute numbers during the coming century (Downing, 1992; Fischer et. al., 1996).

According to FAO (2000) food insecurity is among the developmental problems facing Nigeria. Recent poverty assessment survey has shown that over 70% of the populations are living on less than a dollar per day and over 50% are food insecure (Babatunde, Olorunsanya and Adejola, 2008). The survey also revealed that poverty and food insecurity is especially higher in rural areas where majority of the people are resident and deriving livelihood from agriculture (National Bureau of Statistics, 2006).

Food and Agriculture Organization (FAO) in its State of Food Insecurity in the World, (2006) had indicated that Nigeria had about 12 million people reported as undernourished as at 2003. The proportion of the country's population depicted as undernourished had however been declining with the percentage reducing from about 13% from 1990 - 1992 to about 9% from 2001 - 2003. In fact, the FAO report indicated that Nigeria is moving towards reaching the target of halving the undernourished population by 2015 set by the World Food Summit in November 1996. The report was explicit about policy interventions that may result in hunger reduction. Such policies must:

a) Enhance productivity of small holder agriculture
b) Create an environment conducive to private investment
c) Combine poverty reduction with increased provision of global public good
d) Make trade work for the poor by enhancing domestic competitiveness through policy and institutional reforms, and
e) Coordinate domestic and international resources for agriculture and rural development.

In sub – Saharan Africa, there have been substantial increases in agricultural productivity in recent years (Adewujon, 2006; FAO, 2001). From an average of 100 around 1990, the index of agricultural productivity increased to 156 in Nigeria, to 142.9 in Burkina Faso and to 142 in Guinea in 1999.This notwithstanding; there are countries in the sub-region that saw a declining trend. Between 1988 and 1999, food production per capita actually declined in the Gambia, Guinea Bissau, Mauritania, Senegal and Sierra Leone (FAO, 2001; ADB, 2001/2002). According to Adewujon (2006), in 1998 the daily calorie supply per capita varied between 1,966 kilo calories in Niger Republic and 2,288 kilo calories in Nigeria; while the per capita daily supply of protein varied between 35 kilo calories in Liberia and 64 kilo calories in Nigeria. Furthermore, there was a general improvement in nutritional status in most countries with regard to total calorie intake per capita, during the period from 1970 to 1998. The notable exceptions were Liberia, Sierra Leone and Senegal. However, compared to other parts of the world, the standard of nutrition in West Africa is still very poor. While the depth of hunger, measured by the average dietary energy deficit of undernourished people, expressed in kilocalories per person per day varies from 110 to 160 in the developed countries, it varies in West Africa between 210 for Nigeria, and 390 for Liberia (FAO, 2000).

3.4 Nexus between Climate Change and Food Security

Climatic variability and change are a major threat to food security in many regions of the developing world (Archer, 2003), like Nigeria, Sierra Leone and Liberia, which are largely dependent on rain- fed and labour intensive agricultural production because of the limited amount and uneven distribution of rainfall. Hence, linking climate change impacts to food security is significant to understand the implications on economic growth. Climate change impact on food security, health and disaster management forms a complex labyrinth of network that has strong correlation with socio-economic growth and

development. For instance, it has long been acknowledged that the health status of the population of any place or country influences development. It can be a limiting factor, as generally poor individual health can lower work capacity and productivity; this impact can severely restrict the growth of economies (Philips and Verhasselt, 1994). Similarly, poor diet as a result of food shortage leads to protein and vitamin deficiency which in turn results to Kwashiorkor, Marasmus, rickets and Berry-Berry sicknesses. In aggregate, this increases expenditure and low work capacity of poorer communities-further complicating local economic growth (Morlai, Mansaray and Vandy, 2010).

Climate change influence on food productivity is already impacting on humanity. Around 800 million people are currently at risk of hunger (approximately 12% of the world's population) (Parry, 2004), and malnutrition causes around 4 million deaths annually. Studies reveal that temperature rises of 2 to 30C will increase the people at risk of hunger, potentially by 30-200 million (if carbon fertilization effect is small) (Warren et. al., 2006). In fact temperature increase by 30C will put additional 250 – 550 million at risk – over half in Africa and Western Asia. However, if crop responses to CO2 are stronger, the effects of warming on risk of hunger will be considerably smaller.

Poor communities are especially vulnerable to health outcomes resulting from the impact of climate change. Climate change is expected to alter the distribution and incidence of climate-related health impacts ranging from a reduction in cold-related deaths to greater mortality and illness associated with floods, droughts and heat stress. In particular, climate change will augment health disparities between rich and poor parts of the world. It will change the geographic incidence of illnesses such as malaria. Climatic change places a strain on the transport system needed to move produced food from the point of production to the point of consumption. During droughts, people are known to move to marginal lands, which may not have good access roads, and transporting food from such marginal farms poses a huge challenge. Drought reduces food availability, which decreases the rate of available food, and so the meal frequency decreases and the balance of nutrients can be inadequate. This leads to malnutrition in children (Ziervogel, Nyong, Osman, Conde, Cortes and Downing, 2006).

The World Health Organization (WHO) estimates that climate change since the 1970s is already responsible for over 150,000 deaths each year through the

increasing incidence of diarrhea, malaria and malnutrition (Table 2) predominantly, in Africa and other developing regions (McMichael et al, 2004). Just a 10C increase in global temperature above pre-industrial temperature could double annual deaths from climate change to at least 300,000 (Patz et al, 2005). It has been an established fact that the distribution and abundance of disease vectors are closely linked to temperature and rainfall patterns, and will therefore be sensitive to changes in regional climate in a warmer world. For instance, changes to the mosquito distributions and abundance will have profound impacts on malaria prevalence in affected areas. Mosquitoes need access to stagnant water in order to breed, and adults need humid conditions for viability. Warmer temperatures enhance vector breeding and reduce the pathogen's maturation period within the vector organism. However, very high and dry conditions can reduce mosquito survival (WHO, 2003).

Table 2: Estimates of extra deaths (per million people) from climate change in 2000

Disease/ Illness	Annual Deaths	Climate Change Components (Death/ % total)
Diarrhoeal Diseases	2.1 million	47,000/ 2%
Malnutrition	3.7 million	77,000/ 2%
Malaria	1.1 million	27,000/ 2%
Cardiovascular Disease	17.5 million	Data not provided on total heat/cold
HIV/AIDS	2.8 million	There is no climate change element here
Cancer	7.6 million	There is no climate change element here

Provided there is no change in malaria control efforts, an additional 40 to 60 million people in Africa could be exposed to malaria with just a 20C increase in temperature, increasing to 70 million to 80 million at 3-40C (Warren et al, 2006).

Also many diarrhea diseases vary seasonally, suggesting sensitivity to climate. Diarrhea diseases typically peak during the rainy season in tropical regions. Both floods and droughts increase the risk of diarrhea diseases. As stated by WHO(2003), major causes of diarrhea linked to heavy rainfall and contaminated water supplies are cholera, typhoid, hepatitis A, E-coli infections, shigella, etc. In 2006, WHO also estimated that 2% (47,000 deaths) of the total global annual death from diarrhea disease are climate-related.

One important thing to note also is that global climate change will be accompanied by increased frequency and intensity of heat waves, as well as warmer summers and milder winters. Extremes of temperature can kill. For instance, death rates during the winter season in temperate countries are 10-25% higher than those in the summer. In July 1995, a heat wave in Chicago, USA, caused 514 heat-related deaths (12 per 100,000 population) and 3,300 excess emergency admissions (WHO, 2003). Deaths resulting from thermal extreme are mostly see in people with pre-existing disease, especially cardiovascular and respiratory disease. The very old and very young are most susceptible.

3.5 Impacts of Climate Change and the Need for Adaptation

The impacts of climate change are being felt by both developed countries and developing countries. These impacts are more likely to be felt more by developing countries not necessarily because they are the highest contributors to climate variations but due to lack of economic, social and political infrastructures to address this topical issue. According to De Chavez and Tauli-Corpus (2008) the impacts of climate change on people living in different ecosystems will include, massive floods, strong hurricanes, cyclones and typhoons and storm surges which will lead to the destruction of houses, infrastructures (bridges, roads, electrical lines, dams, mine-tailing ponds, etc.), forests, agricultural lands, crops, livestock, marine and coastal resources; massive landslides; loss of freshwater supplies, increase of pathogenic micro-organisms and vectors.

Agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. While food production may benefit from a warmer climate, the increased potential for droughts, floods and heat waves will pose challenges for farmers. Additionally, the enduring changes in climate, water supply and soil moisture could make it less feasible to continue crop production in certain regions (). According to IPCC (2007) recent studies indicate that increased frequency of heat stress, droughts and floods negatively affect crop yields and livestock beyond the impacts of mean climate change, creating the possibility for surprises, with impacts that are larger, and occurring earlier, than predicted using changes in mean variables alone. This is especially the case for subsistence sectors at low latitudes. Principally, the impacts of climate change on cropping systems (CTA, 2008) which has direct effect on food production include:

a. Reduced production due to changing rainfall pattern;
b. Emerging diseases, pests and vectors;
c. Spatial redistribution of pests;
d. Erratic rainfall patterns etc.

The continent is particularly susceptible to climate change because it includes some of the world's poorest nations. The climate in Africa is predominantly tropical in nature, which is broadly classified into three main climatic zones: humid equatorial, dry, and humid temperate (Adejuwon, 2004). Within these zones, altitude and other localized variables also produce distinctive regional climates. The climate also varies cyclically over periods of decades, centuries, and millennia as well as from year to year. Climate change, especially indicated by prolonged drought is one of the most serious climatic hazards affecting the agricultural sector of the continent. As most of the agriculture activities in African countries hinge on rain, any adverse changes in the climate would likely have a devastating effect on the sector in the region, and the livelihood of the majority of the population (www.ceep.za/climate-change/index.html).

In West Africa, more frequent and longer dry periods are expected, again threatening crop failures. Coastal areas may also be affected by rising sea levels and intrusion of salt water into inland freshwater resources (http://www.unep.ch/regionalseas/main/eaf/eafenv.html). Another damaging repercussion on marine ecosystems is ocean acidification. The oceans have increasingly become acidic over the past 200 years, mainly as a result of chemical changes caused by increasing amounts, of CO2 dissolving in sea water (Turely et al, 2006). If global emissions continue to rise on current trends, ocean acidity is likely to increase further, with PH declining by an additional 0.3 units if CO2 levels double (to 560ppm) relative to pre-industrial and an additional 0.3units CO2 levels treble to 840ppm (Royal Society, 2005). Increasing ocean acidity makes it harder for many ocean creatures to form shells and skeletons from calcium carbonate (CaCO3). These chemical changes have the potential to disrupt marine ecosystems irreversibly – at the very least-halting the growth of corals, which provide important nursery grounds for commercial fish, and damaging mollusks and certain types of plankton at the base of the food chain. Plankton and marine snails are critical to sustaining species such as salmon, mackerel and baleen whales; and such changes are expected to have serious but as-yet-unquantifiable wider impacts.

Apart from the effects on cropping pattern and marine eco- system, climate change brings with it proliferation of pests and diseases; these can hinder storage when the need arises because of temperature increases. Diseases tend to spread to area where they were previously unable to thrive. A good example is the spread of tse tse fly to the drier regions of northern Nigeria from the southern part. This change also affect the agro-pastoral system as animals have to trek very long distances in search of green grass (De Chavez and Tauli-Corpus, 2008). These movements of the animals also contribute to spread of disease causing organisms and leads to conflict on available resources.

Adaptation to the adverse effects of climate change is a key issue for all countries, especially developing countries, which are often the most vulnerable and least, equipped to defend themselves. Adaptation is widely recognized as a vital component of any policy response to climate change because it helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socioeconomic conditions, including climate variability, extreme weather conditions such as droughts and floods, and volatile short-term changes in local and large-scale markets (Kandlinkar & Risbey, 2000).

Studies show that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced (Easterling, Crosson, Roseberg, McKenney, Kartz and Lemon 1993; Smith 1996; Mendelsohn 1998; Smit and Skinner, 2002). The degree to which an agricultural system is affected by climate change depends on its adaptive capacity. Adaptive capacity as earlier pointed out, is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC 2001). Thus, the adaptive capacity of a system or society describes its ability to modify its characteristics or behaviour so as to cope better with changes in external conditions (Glwadys, 2009).

Adaptation is understood to include efforts to adjust to ongoing and potential effects of climate change (Muthukumara, Anil and Viju, 2008). Also, adaptation to climate change consists of initiatives to reduce the vulnerability of natural climate change effects (Intergovernmental Panel on Climate Change, 2007). Adaptation to climate change requires that farmers first notice that the climate has changed, and then identify useful adaptations measures and implement them (Maddison,

2006). Adaptation to climate change refers to any adjustment that occurs naturally within ecosystems or in human systems in response to climatic change that either moderates harm or exploits beneficial opportunities in response to actual or expected climate related environmental changes (IPCC Third Assessment Report). It looks into ways of responding to changes that pose greater risks to life and livelihood and increasing damage-related costs such as climate change effects on rainfall, the strength and distribution of tropical storms, sea levels and glacier melt.

3.6 A Critical Review of Policies Relating to Agriculture, Food Security, Environment and Climate Change in Nigeria.

3.6.1 A Review of Agricultural Policy in Nigeria

Agriculture in the context of the economy is tied with the various sectors and is essential for generating broad based growth necessary for development. Sustainable agricultural development is propelled by agricultural policy. (http://www.nationsencyclopedia.com/World-Leaders-2003/Nigeria-DOMESTIC-POLICY.html). Nigeria's agricultural policy is the synthesis of the framework and action plans of Government designed to achieve overall agricultural growth and development. The policy aims at the attainment of self sustaining growth in all the sub-sectors of agriculture and the structural transformation necessary for the overall socio-economic development of the country as well as the improvement in the quality of life of Nigerians.

Nigeria's agricultural policy framework has gone through a number of evolutionary processes and fundamental changes that reflected, in a historical perspective, the changing character of agricultural development problems and the roles which different segments of the society were expected to play in tackling these problems. But, the form and direction of agricultural policy at a point in time were dictated by the philosophical stance of government on the content of agricultural development and the role of government in the development process. In retrospect, four distinct agricultural policy phases can be identified in Nigeria, The first phase spanned the entire colonial period and the first post-independence decade from 1960 to about 1969; the second covered the period from about 1970 to about 1985; the third phase started from about 1986 in the structural adjustment period; and, the fourth was what could be characterized as the post-structural adjustment era, starting from about 1994.

It is worthy to note, however, that three broad policy and economic instruments currently bear on the agricultural sector. These include the National Policy on Agriculture (2001), National Economic Empowerment and Development Strategy (NEEDS I & II), and the 7 Point Agenda. Within the three broad framework are sub policies (including Agricultural Trade Policy, National Fertilizer Policy, Agricultural Subsidy Policy, and Food Security Policy) and programmes (including the Presidential Initiatives on Commodities, National Special Food Security Programme (NSPFS), Commerce 44, Export Expansion Grant (EEG), Agricultural Credit Guarantee Scheme (ACGS), National Fadama Development Programme, National Cocoa Development Programme, and Commodity Development and Marketing Companies).

3.6.2 Agriculture in the National Development Plans

Accelerating the growth of agricultural productivity and incomes has been a key component of Nigeria's development and poverty reduction strategies, since independence in 1960. At independence in 1960, Nigeria adopted five year National Development Plans (NDPs), based on import substitution industrialization and agricultural development strategies, to promote social and economic development. From 1962 1985, the country executed four NDPs. The objectives of Nigeria's agricultural policy, as contained in the 4 National Development Plans (1962 1968; 1970 1974; 1975 1980 and 1981 1985) include: promotion of self sufficiency in food and raw materials for industries; improvement of the socio economic welfare of rural people engaged in agriculture; and diversification of the sources of foreign exchange earnings through increased agricultural exports arising from the adoption of appropriate technologies in food production and distribution. The first two National Development Plans (1962 68, 1970 74) conceived agriculture as a source of surplus through market board taxation to finance development of the national economy.

It is obvious that the Nigerian government from independence considered avenues for increasing food sufficiency without considering measures to sustain the environment to enhance greater food production in the country. The NDPs captured issues of increasing food, improving income without giving attention to measures that will conserve the natural resources.

3.6.3 Agriculture in Structural Adjustment Programme (SAP)

The Nigerian SAP in 1986 set out to restructure and diversify the economy's productive base and reduce the economy dependence on petroleum exports, eliminate distortion and rationalize consumption and expenditure patterns, expand non oil exports, increase the reliance of the economy on market forces, and reduce government controls and roll back government direct participation in market and the economy and give the private sector a larger role in the domestic economy, towards encouraging competition and rational resource allocation. The assessments of the impact of SAP on the agriculture sector are mixed. Some argue that SAP triggered significant supply responses from the rural economy in terms of a substantial increase in food and export crop production – the early years of SAP gave rise to significant improvements in non oil exports led by cocoa. Similar views are that it led to an expansion of rural incomes and a dramatic reduction in rural poverty with the incidence decreasing from 51 percent in 1985 to 46 percent in 1992 (World Bank, 2002). Others however observe that the intended objective of diversifying the productive base of the economy has not been achieved through structural adjustment (Shaib, Aliyu, & Bakshi, 1997).

The introduction of SAP in Nigeria did not differ considerably from the NDPs. It was aimed at restructuring and diversifying the economy's productive base and reducing the economy dependence on petroleum exports, eliminating distortion and rationalizing consumption and expenditure patterns, expanding non oil exports, etc. It made no provision for changes that could result from the continuous cultivation of agricultural lands.

3.6.4 Agriculture in Poverty Reduction Strategies

Recognizing the close interface between agricultural rural development and poverty alleviation, several targeted poverty alleviation programmes bear strong agricultural rural sector bias. The Directorate for Foods, Roads and Rural Infrastructure (DFRRI) established in 1986 aimed at developing rural and agricultural infrastructures including roads, agro facilities, electricity to improve rural productivity, employment and incomes. The National Directorate for Employment has since 1987 been implementing schemes to promote skills acquisition, job creation and enterprise development in agricultural and nonagricultural sectors. While the Peoples' Bank (established in 1989) aimed at

easing access to low cost credit in the informal sector including farmer groups and producer's associations, the Community Banking Programme established in 1991 was designed to promote community owned banking (savings and credit) among the grassroots including farmers and rural people. Also, women targeted poverty alleviation programmes emphasized agriculture and rural sector. The Better Life Programme (BLP) for Rural Women was established in 1987 to improve rural and agricultural women's incomes and welfare through productivity enhancing measures, enterprise development, skills and capacity development.

The Family Support Programme (FSP) was established in 1994 to promote women's productivity and incomes through easier access to micro credit. Nigeria's Draft Interim Poverty Reduction Strategy Paper (August 2003) incorporates agricultural and rural development as a main agenda of poverty reduction strategy. Currently, the National Poverty Eradication Programme (NAPEP) established in 2000 is implementing nation wide employment creation and enterprise development schemes in agricultural production, processing, marketing and agro based activities. However, agricultural components of the poverty alleviation programmes have had little impact due to poor linkages and lack of coordination with sector strategies and policy discontinuity. While incorporating agricultural and rural development as a key element of poverty reduction strategy, the Draft Interim Poverty Reduction Strategy Paper I PRSP anchors on the Nigerian Rural Development Sector Strategy developed in 2001, with an overarching goal of bringing about poverty reduction and enhanced food security through sustainable agriculture and rural development. The strategies defined in the IPRSP point to the following priorities and options:

a) promotion of rural productive farm and off-farm activities;
b) human resource development;
c) enhancement of rural infrastructure – physical, economic and social infrastructure and their maintenance by communities;
d) special programmes for target groups and/or development challenges, such as women, youth, children and HIV/AIDS; and
e) organization and mobilization of rural communities. In this context, an important future challenge is to clarify mechanisms for achieving pro poor growth in the agricultural and rural sector.

In Nigeria today, about 70% of her population are actively engaged in agriculture yet poverty is soaring high among the citizens, especially those dwelling in the rural areas. The reason for this is not farfetched as there can be no meaningful agricultural development when the issues of climate change mitigation and adaptation is not captured in any agricultural policy or development strategy aimed at combating poverty.

Agricultural production is declining as a result of climatic changes that are cutting across every continent, country, state, town and village. A strategy concerned with reducing poverty through agricultural development must carefully put in place measures to cope or mitigate the changing climate. Poverty reduction as a strategy designed to achieve the goals of agricultural policy cannot go far if all the measures that determine agricultural development are not adequately catered for. One of these measures includes climate change mitigation.

3.6.5 Nigeria's Key Agricultural Policy: The New Agricultural Policy - 2001

The New National Policy Thrust on Agriculture was adopted in March 2002. It covers a wide range of issues which affect and determine agriculture outcomes and states government policy on them (International Institute of Tropical Agriculture (IITA), 2005). The main features of the policy include the evolution of strategies that will ensure sufficiency and improvement of the level of technical and economic efficiency in food production; reduction in risks and uncertainties; unified and all inclusive extension delivery system; promotion of agro allied industries; provision of rural infrastructure, rural banking, primary healthcare, cottage industries, etc. A key aspect of the policy was that it assigned supportive roles to the government while investments in the sector are to be left to the private sector initiative (Government of Nigeria, 2006). The broad objectives include: attainment of self sufficiency in basic food commodities with particular reference to those which consume considerable shares of Nigeria's foreign exchange and for which the country has comparative advantage in local production; increase in production and processing of agricultural raw materials to meet the growth of an expanding industrial sector and increase in production and processing of exportable commodities with a view of increasing their foreign exchange earning capacity and further diversifying the country's export base and sources of foreign exchange earnings. Others are protection and improvement of agricultural land resources and preservation of the environment for sustainable agricultural

production; appropriate institutional framework, sustainable funding and effective coordination and monitoring (FMARD, 2001).

The new National Policy Thrust on Agriculture adopted 2002, has one of its policy features as reduction in risks and uncertainties. Also, some of its broad objectives include: (i) attainment of self sufficiency in basic food commodities, (ii) protection and improvement of agricultural land resources and preservation of the environment for sustainable agricultural production.

This policy on reduction in risks and uncertainties remains inexplicit; reduction in risk and uncertainties of what? In clear terms has the policy articulated on what areas of agriculture it intends to reduce risk and uncertainties. Though an objective noted the issue of preservation of the environment, it failed to highlight measures through which this objective will be achieved. To effectively cope with the menace of climate change, there is need for a careful plan of policy addressing measures on adaptation and mitigation. Indirect mention of measures on environment preservation is insufficient if the battle against climate change must be won.

3.6.6 Agriculture in National Economic Empowerment and Development Strategy (NEEDS)

The NEEDS targets: minimum annual growth rate of 6% per annum in agriculture; $3 billion in agricultural exports, a major component of which will be cassava by 2007; drastic reduction in food imports from 14.5% of total imports to 5% by 2007; development and implementation of a scheme of land preparation services to increase cultivable arable land by 10% annually and foster private sector participation through incentive schemes (NPC, 2004).

The policy framework embodies: providing the right policy environment and vigorously targeted incentives for private sector investment in the sector. The NEEDS as a strategy for achieving the goals of national agricultural policy set out to be a more focused strategy as it had goals it would attain by 2007. The policy framework had provision for government to create an agricultural sector that is responsive to the demands and realities of the economy; thereby reversing the trend of food importation, through a progressive programme for agricultural expansion; reduction of the food import bill to stem the rising trade imbalance as well as diversifying the foreign exchange earnings and striving towards food security and generate surplus for the export market. The government had

designed strategies through which it intends to achieve the goals of NEEDS. These are the various Presidential initiatives, which include the Presidential Initiatives on Cassava, Rice, Vegetable oil, sugar, livestock, tree crops and cereals. Under this initiative, Nigeria hopes to generate as much as N3 billion annually from the export of agricultural products; taking advantage of the various concessionary arrangements within the World Trade Organization, EU ACP, and the AGOA, New Partnership for Africa Development (NEPAD) and the huge market in the West African sub region

The policy thrust of NEEDS though seems achievable could be cut short due to its inability to capture the threat posed by the changing climate. This strategy aimed towards achieving the National Agricultural Policy with its beautiful conceptualizations for boosting food through presidential initiatives failed to factor in the vagaries of nature/weather as it undermines agricultural production. It failed to capture measures to mitigate climatic changes which would end up boosting agricultural production and overall economy development.

3.6.7 Agriculture in the Major Economic Policy-the 7 Point Agenda / NEEDS II

The agricultural and rural development policies and strategies currently are being pursued within the framework of the 7-point agenda and the successes and lessons of the National Economic Empowerment and Development Strategy (NEEDS), which was the Nigerian equivalent of a Poverty Reduction Strategy Programme (PRSP) launched in June 2004. The 7-point agenda, which was adopted by government in May 2007, is the broad policy priorities for implementing economic reforms and development programmes in Nigeria. The 7 point Agenda describes the key policy imperatives, directive principles and instruments in promoting sustainable economic growth for the achievement of the MDGs by 2015 and Vision 20:2020. The 7 point Agenda is being implemented within the enabling platform of the successes and lessons of precursor programmes NEEDS I and the experiences in the design of the NEEDS II. The main agricultural goals enunciated under the 7 point agenda include diversified economy, food security, employment generation, economic linkages, exports and poverty reduction. The 7 point Agenda acknowledges the oft mentioned challenges in Nigeria's agricultural development as follows: low

productivity, low quality of private sector investment, lack of domestic and international competitiveness, weak domestic policies and institutions, inadequate funding and lack of organized land titling and tenure. The issues are analogous to those identified under NEEDS II, as constituting critical gaps in the agricultural development process. Specifically, NEEDS II identifies the key challenges as follows: finance and access to credit, land reform, agricultural extension, commercialization of agricultural production and post harvest management, agricultural industry linkage, research and training, market oriented subsidies, appropriate technologies and entrepreneurship and agribusiness development. In addition, the NEEDS II stipulates the targets of agricultural progress as follows: 10% annual increase in crop production, 2.5% annual increase in livestock production, 8.0% annual increase in forestry and 9.0% annual increase in fishery production. Other targets include: reduce agricultural population in poverty by half each year; achieve 5% employment generation in the agricultural sector, generate up to $3 billion in agricultural exports by 2011; reduce food import from 5% of total imports to zero by 2011, increase cultivable arable land by 10% annually.

The 7 – point agenda, a strategy designed for implementing economic reforms and development programmes in Nigeria, seems to be one of the few strategies directed towards the actualization of the Nigerian agricultural policy that indirectly made provision for coping with climate changes. It raises issues that are similar to NEEDS 11 e.g. land reforms, agricultural production and post harvest developments etc. A silent passing notice of issues bothering on climate change is inadequate if Nigeria must attain self-sufficiency in food production and improvement in the overall well being of her citizens which need be of paramount interest to the government. This therefore means that concrete policy and strategies need to be developed if the rural farmer is to effectively cope/adapt to climate changes.

The National Food Security Programme (NFSP): Within the framework of the 7-point Agenda, the National Food Security Programme current base document was published in August 2008. According to the Federal Ministry of Agriculture and Rural Development, its objective is to "ensure sustainable access, availability and affordability of quality food to all Nigerians and for Nigeria to become a significant net provider of food to the global community". The key features of the

programme include providing a conducive environment for private sector involvement, encouraging large scale commercial farming with strategic linkages to small holder farmers, and significantly reducing post-harvest losses through adequate storage, processing and appropriate market outlets.

Comprehensive Africa Agricultural Development Programme (CAADP): Many ongoing and pipeline agricultural investments and interventions have linkages to CAADP pillars. The implementation of the CAADP initiative was further advanced with the inauguration of the technical committee on it in 2007. In 2008 further analytical work was carried out in order to select investments which can most contribute to halving poverty by 2015.

3.6.8 Environmental Policies in Nigeria

Environmental policies are very important for sustainable growth and development. Hence, the Federal Environmental Protection Agency (FEPA) produced a revised version of the national policy on the environment in 1999. The goals of National Policy on the Environment (www.nipc.gov.ng/.../The%20New%20Nigerian%20-Agricultural%20Policy.doc) is to achieve sustainable development in Nigeria, and, in particular, to: secure a quality of environment adequate for good health and well being;

a) conserve and use the environment and natural resources for the benefit of present and future generations;
b) restore, maintain and enhance the ecosystems and ecological processes essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;
c) raise public awareness and promote understanding of the essential linkages between the environment, resources and development, and encourage individual and community participation in environmental improvement efforts; and
d) co-operate in good faith with other countries, international organizations and agencies to achieve optimal use of trans-boundary natural resources and for an effective prevention or abatement of trans-boundary environmental degradation.

The goals of the national policy on the environment cover to a great extent the issue of preserving the environment. It clearly states strategies on how to ensure

that the environment is secured, conserved, restored and maintained; thereby leading to the maintenance of the ecosystems, and ecological processes of the environment. An important strategy towards achieving this goal is it inclusion of the private sectors, NGOs and the public in the implementation of strategies and actions aimed at achieving stated goals. It is evident that the policy on environment addresses the issue of climate change mitigation.

The future strategy and plans of the Nigerian government for creating and improving capacity for sustainable development are to:

a) develop a blueprint for environmental education and public awareness by 1998;
b) ensure that environmental education is a core ingredient of the educational system at the primary, secondary and tertiary levels of education by 1999;
c) make environment and development education available to people of all ages; involve school children in local studies on environmental health, including safe drinking water, sanitation, food and the environmental and economic impacts of resource use;
d) encourage all sectors of society, including industries, universities, governments, non- governmental organizations, and community organizations to train people in environmental management;
e) work with the media, theatre groups, entertainment and advertising industries to promote a more active public debate on the environment;
f) train decision-makers on the basic tenets of environment and sustainable programmes for different strata of the environment on a continuing basis;
g) develop and implement tailor-made environmental education and awareness programmes for different strata of the environment on a continuing basis; and
h) institutionalize environmental responsibility through regular competitions and awards such as cleanest village in each local government, cleanest local government in each State and cleanest State in the Federation, as well as the most environmentally-friendly industries on a sectoral basis.

The Nigerian Government, through the Federal Environment Protection Agency (FEPA) and other relevant agencies, has undertaken programmes to enlighten, educate, and raise awareness of the Nigerian populace through media (both print and electronic) campaigns on environmental issues. Identification, education, and training of officials that would form the core of the Environmental Education

Network nationwide are being undertaken. In addition, the FEPA has encouraged the establishment of Environmental Conservation Clubs in Secondary Schools. It has also collaborated with the Federal Ministry of Education through the National Educational Research and Development Council (NERDC) on the development of an Environmental Educational Master plan and Curricula for both the formal and informal educational system in Nigeria.

In 1993, the United Nations Development Programme (UNDP) offered to support the National Programme on Environmental and Natural Resources Management for Nigeria. The support focused essentially on capacity building in all programme areas identified. This is to enable the environmental agencies of the Government of Nigeria at both Federal and State level, NGOs, and local communities design, formulate, manage, implement, and sustain their own environmental protection programmes. Specifically, the four target objectives of the programme include strengthening National capacity for the formulation of environmental policies, legislation, and enforcement; increased awareness and conservation of the environment; preparing the National Agenda 21 and an action plan for its implementation; training of staff of FEPA, State Environmental Protection Agencies, and other National bodies to enable them to carry out their work programmes on a self-sustaining basis (www.nipc.gov.ng/.../The%20New%20Nigerian%20Agricultural%20Policy.doc).

The Nigerian government has adequately made provision for creating and improving capacity for sustainable development. In the above stated plans, mention was made of the all important factors of education and participation. The strategy recognizes the significance of educating people of all ages on environmental health and the participation of various institutions, NGOs in environmental management. These two strategies are keys in the fight against climate change. The need to create environmental health awareness among the people from an early time cannot be over emphasized. This will ensure conscious individual participation in reducing those human activities that are major contributors to climate change. The involvement and participation of different stakeholders highlight the need for a collective effort to effectively adopt strategies that will assist the teeming populace in coping with climate change. Also, it will give greater credence to mitigation to mitigation measures that will be identified.

3.7 A Review of Agricultural Policies in Sierra Leone

3.7.1 Colonial Period up to 1961

Apart from some narratives given about the rudimentary agricultural practices of the indigenous ethic groups of Sierra Leone, there is no written evidence as to the existence of a formal agricultural policy in pre-historic Sierra Leone. Formal agricultural practices and policy institutions seem to have started with the advent of the British colonial government; and even so, such institutions were not established until the 1900s. The British colonial government's agricultural policies were mainly policy prescriptions meant to tackle certain socio-political problems. Albeit a Department for Agriculture was established as early as 1911, the colonial government's agricultural policies laid much emphasis on the cultivation of export crops, particularly tree crops. This policy necessitated the construction of railway and feeder roads between 1896 and the 1920s to facilitate the transportation of agricultural produce (cocoa, coffee, palm kernel, ginger etc) from the provinces to Freetown, from where they were shipped overseas. Since local foodstuffs were not in high demand in Europe, colonial agricultural policies were bias against local foodstuff production (). The colonial era policy laid emphasis on forest conservation and timber production and exportation and therefore dissuaded farmers from upland cultivation (Alieu, 2005).

3.7.2 Immediate Post Independence Period up to Military Rule in 1967

Post independence agricultural policies introduced direct government intervention in rice production through the Sierra Leone Produce Marketing Board (SLPMB) as contained in the Government White Paper on Agriculture dated 1961. While the SLPMB was fully involved in the export crops sector, the Government-owned Rice Corporation actually cultivated about 590 hectares of lowlands in 1961. A remarkable achievement during this era however, was the establishment of the Njala University College to train agricultural staff at middle and senior levels, thereby developing the capacity of the agricultural extension services (Alieu, 2005).

3.7.3 Ten-Year Plan for Economic and Social Development: 1962 to 1971

The blueprint for the country's development at independence was the 'Ten-Year Plan for Economic and Social Development' (1962-1971). This document highlighted two major problems of the agriculture sectors:

(a) low productivity despite the fact that the sector employed majority of the population and
(b) the instability of the export market.

To address this condition the Plan proposed to diversify the agriculture sector rather than one dependent on primary produce, and at the same time increase export for foreign exchange. The Plan anticipated spending 7.7% of the country's capital expenditure on agriculture. However, although the Plan considered the pursuance of agricultural development as a major plank of the country's economic strategy, the government's economic policies in the first decade after independence seemed to have shifted emphasis from agricultural crop production to industrialization. Industrialization was seen as the engine of growth to kick-start the rest of the economy for national development and agricultural policies therefore simply became conduits for the enhancement of industrialization ()

3.7.4 The National Development Plan: 1974 – 1978

The National Development Plan of 1974 to 1978 was similar to that of the Ten-Year Plan for Economic and Social Development in aspiration but different in scope and content. The main trust of the Plan regarding agricultural development was to increase productivity of the sector and income from it thereby improving the living standard of the rural population through the integrated agricultural development projects. Although the plan indicated a great attempt to re-shape the country's development process, the international economic situation by then was unfavourable and the allocation of limited national resources unfortunately did not favour agriculture as the productive sector. Like the ISI, the government neglected the agriculture sector and instead concentrated on infrastructural development, tourism and electrification. A second National Development Plan was developed for the country (1983-1985) but it was never formally adopted because of adverse economic conditions and donor neglect (http://www.fao.org/docs/up/easypol/forum/31//31_REVIEW_OF_PAST_AGRICULTURAL_POLICIES_IN_SIERRA_LEONE_-_FINAL%201%20.pdf).

3.7.5 The Integrated Agricultural Development Projects (IADPs)

The agriculture sector faced serious setbacks in the late 1960s to mid 1970s; institutional capacity and farmers' confidence suffered. Partly as an attempt to revive the sector government policy focused on support for small scale

agriculture and this stimulated support for the Integrated Agricultural Development Projects (IADPs). The IADPs like the ISI, was a policy prescription sanctioned by international agencies like Food and Agricultural Organization (FAO), the World Bank, United States Agency for International Development (USAID), etc. The broad objectives of these projects were: to improve the living standards of the people by securing their basic needs and to make the rural communities more productive and less vulnerable to economic depression and the oil shocks of the time (Lea and Chaudhri, 1983).

The IADP was a very ambitious plan covering most aspects of the agricultural sector; road infrastructure, credit for farmers, animal husbandry, cash crop production, rice cultivation etc. However, these projects were limited to specific locations within the country and because they were mainly donor-dependent, the projects ended when donor funds were exhausted.

3.7.6 The Structural Adjustment Programmes

It became quite clear that the international donor support which the government relied upon for its economic activities was not forth-coming until and unless the Structural Adjustment Programme (SAP) with the conditions attached to it were fulfilled. The country agreed to implement the Structural Adjustment Program (SAP) in its bid to please the donor community and to stabilize the economy. This programme saw the removal of subsidies from gas, rice, electricity, an end to price control and government's incentives to farmers; and the influx of grains and semi-processed agricultural products brought about by the open market conditionality. The little support government received for agriculture was skewed towards export crop production to help the country service its foreign debts and bring in much needed foreign exchange. However this had little economic impact because international prices for most of the export crops (e.g. cocoa) had declined and local farmers could not get the required returns on their produce ().

3.7.7 The Green Revolution Programme

The Green Revolution Programme (GRP) was aimed at making the agriculture sector more productive after years of neglect. The GRP like that of the IADPs was elaborate in scope and objectives covering almost all aspects of the agriculture sector. The estimated cost of the GRP was slated at Le 380,329,367.00 of which the Sierra Leone government was expected to provide Le 30,650,827.00 and the bulk of the project finance was expected to come from foreign sources. The GRP

policy content appeared good for the agriculture sector but to have tied its financial support mainly to donor funding was a serious policy miscalculation. Western donor assistance to Sierra Leone at this time was contingent upon the government's willingness to fully implement the SAP, and this meant the removal of direct government support for such agricultural projects like the GRP ().

3.7.8 The Current Development Policies -The Food Security Policy: 2007 to Date

The Sierra Leone's Food Security Policy (FSP) came through a presidential proclamation in 2002, asserting that "no Sierra Leonean should go to bed hungry by 2007 (The Agriculture Sector of Sierra Leone). At the official end of resettlement, there was an urgent need for increased food production both for domestic consumption and export. The FSP is therefore based on the following pillars:

a) Agricultural Intensification which underscores the need of cultivating improved varieties through appropriate agronomic practices, including the use of fertilizers and pesticides to ensure increased yields;
b) Crop Diversification which promotes the cultivation of improved varieties of other crops other than rice through sensitization and awareness raising of their nutrient value to reduce the dependence and demand for rice;
c) Natural Resource Conservation which encourages the prudent use of water and watershed resources in an effort to increase agricultural land resources; and
d) Food Safety Nets which provide food aid support to farmers and their dependants during hunger seasons to prevent them from eating seed rice and vulnerability to sicknesses.

The Ministry of Agriculture and Food Security has taken tremendous strides in recent years to achieve these policy goals and objectives. The challenge is in bid to meet and surpass the government PRSP agricultural targets. Meanwhile, targets for rice, cassava and sweet potatoes were well achieved in 2005 (see table 3), but much need to be done to meet other targets and projections considering the population growth rate of 1.9%.

Table 3: Comparing Target and Actual Production (MT) for the First Year of PRS Implementation

Crop	2005 Target	2005 Actual	Difference	Target 2006	Target 2007
Rice	540,000	552,000	12,000	875,000	1,290,000
Cassava	1,935,221	2,287,060	351,839	2,100,000	2,300,000
Sweet Potato	160,856	191,498	30,642	185,368	203,905
Groundnut	95,684	167,200	71,516	110,265	121,292

Source: Ministry of Agriculture, Sierra Leone.

According to Morlai *et. al.*, (2010) recent estimates reveal that in:

i. 2007 population is projected to be 5.2 million for which 486,700 MT of milled requirement (60% of sufficiency ratio) is needed.
ii. 2008 population is projected to be 5.3 million for which 496,100 MT of milled requirement (75% of sufficiency ratio) is needed.
iii. 2009 population is projected to be 5.4 million for which 505,400 MT milled equivalent (85% of sufficiency ratio) is needed.
iv. 2010 population is projected at 5.5 million for which 514,800 MT milled equivalent (100% sufficiency ratio) is needed.
v. 2011 population is projected at 5.6 million for which 524,200 MT milled equivalent (110% sufficiency ratio) is expected.
vi. 2012 population is projected at 5.7 million for which 533,500 MT milled equivalent (120% sufficiency ratio) is expected.

For such projections / targets to be met, robust and appropriate science (research), technology and innovation (STIs) need to be adopted. Fortunately, the science and technology policy is already in existence in Sierra Leone; what is needed however is harmonization of the policy with all agricultural strategies to be implemented in the country. The STI policy cuts across all development priorities with the objective of spurring national development and poverty reduction.

3.7.9 The Nexus between Sierra Leone's STI Policy and Food Security Policy

Morlai *et. al.*, (2010) noted that agriculture, food security and agro-allied industries form the top-most priority in the science and technology policy,

suggesting that they have the potential to increase output on crop, livestock and marine resources with the emphasis on fish, and diversified food sources. The objectives gear towards the PRSP and other national targets on food self-sufficiency and food security in the country. This implies that science and technology should be applied if PRSP policy objectives are to be achieved. Specifically the S & T Policy objectives for food self-sufficiency and food security are to:

a) stimulate economic production of crops, animals and fisheries and encourage prudent intensification and diversification of products;
b) develop and promote appropriate land use practices and
c) upgrade, popularize and rationalize production of farm tools and implements and improve local agricultural practices.

Morlai *et. al.*, (2010) further observed that areas such as environment, whose ignorance can militate against efforts to reduce climate change impacts, are also emphasized in the S&T policy in Sierra Leone. In particular, the policy seeks to complement national environmental policy objectives that tend to enhance environmental quality. Hence the S&T policy specifically seek to:

a) Provide ways in which S&T would be applied to reduce levels of environmental degradation and pollution;
b) Encourage proper environmental management in urban and rural areas;
c) Encourage the use of environmental-friendly and economically viable technologies in natural resource exploitation and development;
d) Monitor regularly environmental quality using recent techniques in S&T;
e) Collect and make available technical scientific data for national decision-making on resource use and conservation;

Considering the large number of indigenous farmers, who are basically poor and who live on less than US$1.00/day, bye-passing the traditional technological Knowledge would also undermine efforts to meet food self-sufficiency targets (Morlai et. al., 2010). Frantic effort is seen in the S&T policy formulation, as it tends to capture indigenous technology by suggesting upgrading and modernizing such technology so that it can better serve the needs of the society. The policy aims at:

a. increasing the productivity of surviving indigenous technology through the infusion of modern scientific and technological methods;

b. increasing appeal, popularity and affordability of indigenous technologies nationwide; and
c. encouraging the development of labour and cost saving devices using local materials and internally generated indigenous knowledge.

3.7.10 Linkages between the Food Security Policy and External Development Agendas

The FSP has strong synergy with other national development programmes like the NRS, PRSP and Vision 2025. For instance Pillar 2 of the PRSP creates the bases for the FSP by providing a roadmap for the attainment of a viable agriculture sector. More importantly, the FSP has donor support partly due to its synergy and entry point into other international and regional development agendas. For instance the government's overall objective as exemplified by the FSP is to reduce hunger and malnutrition and accelerate the attainment of the Millennium Development Goals (MDGs), especially MDG 1: the eradication of extreme poverty and hunger and the halving of poverty by 2015. Also, Pillar 2 of the PRSP: pro-poor sustainable growth for food security and job creation is aligned to MDG 1. Similarly, all of the Pillars of the New Partnership for Africa's Development (NEPAD) as contained in the Comprehensive Africa Agricultural Development Programme (CAADP) are indicated in the sectoral policy briefs of the FSP. For instance the National Resource Conservation policy under the FSP is given priority because of its direct link with NEPAD's advocacy for the increase of agricultural land through proper water management processes. The linkage between the FSP and the other development agendas has increased support for the food policy programmes and possibly government and donor commitment to the development of the agriculture sector.

It is evident from the review above that the government of Sierra Leone has made conscious effort to address the issue of climate change lately. However, from the colonial period to 2006, all formulated policies bordered around food and cash crop production. The closest policies that one may consider has any semblance of a policy on climate change are the agricultural policies of the colonial era, but it is quite clear that the colonial government only encouraged the cultivation of tree crops that possessed economic value.

Other policies in recent time that tried to address the issue of climate change could be seen under the food security policy and ST&I policy. These policies have

as their third and second pillars, the conservation of natural resource and appropriate land use practices which encourage the prudent use of water and watershed resources in an effort to increase agricultural land resources.

3.8 Review of Agricultural Policies on Climate Change and Food Security in Liberia

3.8.1 Poverty Situations and Food Security Policies in Liberia

Liberia is richly endowed with natural resources notably rubber, iron ore, timber, diamonds, and gold. The country benefits from fertile soils and favourable climatic conditions for the production of palm and coffee, among other products. Liberia also has large hydropower potential. Unfortunately, Liberia remains one of the least developed countries with a Human Development Index of 0.276 (1999) declining from 0.311 (1996). The Gross Domestic Product (GDP) of current market prices is estimated at US$43796 million (2003) with a per capita income of US151.02 (Millennium Development Goals, 2004).

Liberia's political instability and recent civil war caused destruction of livelihoods, infrastructure, productive capacity and financial resources. Past mismanagement of natural resources fueled and sustained civil conflicts (Republic of Liberia, 2006). In 2001, about 86% of the rural population was poor and 80% were subsistence farmers leading to an increase in rural to urban migration. About 80% of the population is unemployed and nearly three quarters of them live on less than 1 dollar per day (European Union, 2006).

According to Tefft (2005) an estimated 1.3 million of Liberia's 3.5 million people are living in poverty, of which 48 percent are living in extreme poverty. Poverty is higher in the rural areas, where about 73 percent of the population is poor. The Comprehensive Food Security and Nutritional Survey (CFSNS) conducted in March 2006 revealed that about 40 percent of households in rural and semi/urban Liberia are food insecure. The figure reached as high as 28 percent in areas most affected by war and displacement. The report stated that the underlying causes of food insecurity include low agricultural production capacities and limited economic access to food. This can mainly be attributed to the lack of access to safe drinking water (Koiwue and Bedini, 2009). Tefft (2005) further noted that children are vulnerable as a result of food insecurity. In 1997, an estimated 14.8 percent, and in 2000, an estimated 8 percent of children under the age of five were

underweighted. The situation seems to be getting worse, as the 2007 Liberia Demographic and Health Survey (LDHS) shows that 39 percent of children under age of 5 are stunted, and one-fifth of children are severely stunted. This indicates chronic malnutrition. About 70 percent of rural households rely on food from their own farms or gardens as compared to 5 percent in the urban area. Given the impact of the war, coupled with the week supporting environment, it is unlikely that Liberia will attain the benchmarks of the World Food Summit, or the Millennium Development Goal (MDG) goal of food security (World Bank, 2008).

Prior to the civil conflict, agriculture accounted for approximately 40 percent of GDP. In 2007 GDP was US$725 Million of which agriculture accounted for 66 percent (UNDP, 2006). Agricultural activities are still considerably reduced and food insecurity is worsening. Imports of agriculture produce continue to increase, as compared to export, putting a strain on foreign currency needed for other essential goods and services. Low productivity of land and labour, shifting cultivation and low livestock production remain the main characteristics of traditional farming in Liberia (World Bank, 2008).

According to Republic of Liberia (2008), the national "Food Security and Nutrition Strategy", developed by the government in collaboration with the UN World Food Programme (WFP) and Food and Agriculture Organization (FAO), identifies how the government will coordinate itself to tackle chronic hunger - a challenge across the region but particularly in Liberia where 14 years of war gutted infrastructure and left massive poverty and malnutrition. The WFP document on Liberia says the underlying causes of food insecurity are low agricultural production, low purchasing power and limited absorption capacities due to lack of safe drinking water and sanitation. The latest market review shows that outside Monrovia the market system functions poorly, largely due to bad roads, limited transportation and lack of functioning institutions.

The strategy also covers "nutrition security", which includes improving access to basic services like health care and a sanitary environment as much as improving diets and also provides a framework for collaboration so as to ensure that food is available in sufficient quantities for all Liberians (Republic of Liberia, 2008).

Even before the civil crisis, successive governments initiated strategic policies for the development of the agricultural sector. The goal has always been food

sufficiency and food security. For example, Operation Production, Self Sufficiency in Food Production, and the Green Revolution were national strategies of the Tubman, Tolbert, and Doe Governments, respectively. The Taylor Government also established a two phase approach to rehabilitate the agriculture sector contained in the National Reconstruction Program (1998 - 2000), and the five year National Reconstruction and Development Program (2001 – 2006) (Republic of Liberia, 2007).

The Poverty Reduction Strategy (PRS), the present development agenda by the government, for the next three years (2008 – 2011) sets out its agenda for agriculture and food security in Liberia (USAID, 2010). The central goal for agriculture during the PRS period is to revitalize the sector in order to contribute to inclusive and sustainable economic development and growth, food security and nutrition, employment and income, and poverty reduction. The Government plans to expand agricultural production by 3.2 percent per annum during the first two years of the PRS (Republic of Liberia, 2008).

According to World Bank (2008), in early 2008, the Government endorsed a national strategy for Food Security and Nutrition, within the wider framework of the Government's Poverty Reduction Strategy and is aimed at:

I. enhancing food availability by addressing production, processing and marketing constraints of small farmers and maintaining predictable and stable food imports;
II. improving access to food, through enhancing opportunities for employment and increased incomes and improving infrastructure so that Liberians have better physical access to food; and
III. promoting better food utilization and improving nutritional status, through better prevention and more systematic monitoring of malnutrition, as well as supplementary and therapeutic feeding actions aimed at young children and pregnant and lactating mothers.

In response to the global food price crisis, and guided by the framework of the national Food Security and Nutrition Strategy, the Government took fiscal measures to ensure adequate supply of rice; promoting increases in domestic production by distributing inputs, capacity building and the introduction of new technologies at production and post-harvest levels, with a focus on smallholder producers; and expanding social protection mechanisms for vulnerable groups,

such as employment generation schemes, school feeding and nutritional interventions (Koiwue et. al, 2009).

According to the Republic of Liberia report (2008) to realize the above growth in the agricultural sector, the government has earmarked three strategic objectives. Firstly, developing more competitive, efficient and sustainable food and agriculture value chains and linkages to market; secondly, striving to improve food security and nutrition, especially for vulnerable groups, including lactating women and children under five; and thirdly, strengthening human and institutional capacity. The role of women will also be expanded in the agricultural value chain.

3.8.2 Liberia Agricultural Policy

An agricultural policy has also been drafted, and is being validated, within the context of the PRS and the Millennium Development Goals (MDG). Koiwue et al. (2009) noted that it outlines specific policies and strategies that will revitalize and strengthen the agriculture sector within five years, beginning 2008. The policy seeks to establish operational, legal, and institutional framework to ensure efficient development, utilization and management, monitoring and conversation of country's water resources for agriculture. The rehabilitation of previously established swamps to increase rice production will be pursued. The total cost for food and agriculture under the PRS is US$38.7 million (USAID/Liberia, 2009).

Under the agricultural policy, a mechanism will be put in place to monitor climate change situation to ensure that agricultural activities in Liberia do not contribute to such changes, and undermine effort aimed at poverty alleviation, food security and environmental protection. The Government is working in collaborative partnership with the donor community in order to accomplish its goals for the agricultural sector (USAID, 2010).

To overcome pervasive structural impediments and a poor policy environment that have undermined agricultural growth and development (i.e. low yields, depleted infrastructure, weak capacity and poor market linkages), the government of Liberia adopts a pro-poor approach to raising productivity, strengthening institutions, and making markets work for households and communities through commercialization and private sector initiatives such as out-grower schemes (Republic of Liberia, 2008).

According to World Bank (2008) the government of Liberia has further defined four major program thrusts for the period 2010-2015 as follows:

1. Land and Water Resources Development
2. Food and Nutrition Security
3. Competitive Value Chains and Market Linkages
4. Institutional Development

The Government of Liberia confirmed its commitment to promoting long term social and economic development to reduce poverty and achieve food and nutrition security as specified in Food and Agricultural Policy Strategy (FAPS). These national policy and strategy frameworks seek to achieve agricultural sector objectives through the provision of an enabling environment, the development of the private sector supported by an active state, trade openness and continued maintenance of an enabling environment, particularly security and macroeconomic stability. It will endeavor to ensure effectiveness and efficiency in achieving the 6% Comprehensive African Agricultural Development Programme (CAADP) growth target over the next 5 years. It is committed to working towards fulfilling the Maputo Declaration of the Heads of State and Government of the African Union in 2003 of allocating at least 10% of their national budgets to the agricultural sector within this period (Republic of Liberia, 2008).

While working to ensure maximum effectiveness and efficiency of utilization of natural resources in the agricultural sector so as to improve food security and reduce the adverse effect of climate change, in line with its broader efforts to strengthen public financial management, Tefft, (2005) noted that Government of Liberia is cognizant that increased budgetary support and improvement in the absorptive capacity of agricultural institutions will not be sufficient to achieve and sustain the required transformation of the agriculture sector.

Hence, additional demonstration of the government's will to utilize agriculture as the key entry point and vehicle for climate change mitigation and poverty reduction will therefore be required.

Restructuring of key institutions such as the ministry of agriculture and state-owned corporations will also be undertaken to focus limited public resources on policy development, coordination, regulation and provision of essential services,

and to ensure maximum participation of rural communities and households in decisions that affect their lives. The International Monetary Fund (IMF) and Government of Liberia (2008) report noted that the government is committed to dialogue, coordination, mutual review, and accountability mechanisms and modalities of the ECOWAP/CAADP processes.

3.8.3 Environmental policies

Liberia is endowed with abundant natural resources. These served for giving impetus for the nation's development efforts since the opening of its market through the Open Door Policy in the early 1950's (Wiles, 2005). Additionally, these natural resources remain the fundamental endowment from which the population derives their livelihood. Nevertheless, in the process of exploiting these resources to meet social and economic needs, adequate care has not been taken to guard against the depleting of the resources and its resultant effects on food security and climate change. This is primarily due to the lack of a policy statement and a legal framework to direct activities and actions. This has given rise to a host of problems, including deforestation, soil degradation, biding to desertification and mismanagement of solid and liquid waste as well as other problems such as an increase in charcoal production as the next alternative energy source, which has worsened the food security situation in the area and climate change.

Liberia is party to some treaties and laws and a member of international and regional organizations for global protection of the environment and sustainable use of natural resources. According to Drakenberg and Dahlberg (2008), Liberia had existing policies and laws regulation, but these laws have not been implemented. Such existing policies related to food security and climate change are:

1. The Natural Resource Law of Liberia Code of Law of 1956.

Chapter 1-4 of Title 24 of the Natural Resources Law of the Liberian Code of Law of 1956 are the modification of the forest Act of 1953 entitled “an Act for the Conservation of forests of Liberia” and the 1957 Supplementary Act for the conservation of the forest of Liberia that incorporated some of the forest and wildlife rules and regulations of 1954. The 1953 Act established the Bureau of Forest Conservation whose program's initial policies and primary objectives included the establishment of “a permanent forest estate, made up of reserved area, upon which scientific forestry could be practiced.” The function of the

Bureau was to create and administer Government Forest Reserves, Native Authority, Communal Forest, Communal Forests and National Parks; to enforce all laws and regulations for the conservation of forests and the development of their resources; and to carry out a program for wise use and perpetuation of the forest, recreational, fish and wildlife resources of the country (Chapter 1, Section 3).

2. An act creating the Forestry Development Authority (1976)
This Act repeals all previous forest related laws in Liberia, in effect, chapter 1-4 of the 24 of the Natural Resource Law of Liberia Section (1); establishes Forestry Development Authority (FDA). However, this act was amended in 1988 by the addition of eight new sections to the FDA Act of 1976 that deal mostly with forest utilization agreement, fees, permits, etc.

3. Timber concession agreement (1973) revised 1988
This is the FDA's detailed and comprehensive document for granting forest utilization concession. It covers among other things the terms of the concession, operations of the concessionaire, rights and obligation of the concessionaire and a forest management plan that governs logging methods, timber harvesting, reforestation, construction of logging road and scaling.

However, it was after Liberia's participation in June of 1992, at the United Nations Conference on Environment and Development (UNCED), in Rio de Janeiro, Brazil, awareness about environmental protection gained some momentum in some circles (United Nations Environmental Programme (UNEP), 2004). Prior to 1992 there was hardly any mention of environment in Liberia, except for considerations about the need to conserve the natural resources, primarily forest and wildlife.

The Republic of Liberia ratified the United Nations Framework Convention on Climate Change (UNFCCC) on November 5, 2002 and as a signatory to the Kyoto protocol, Liberia is committed to fulfilling its obligation for reducing greenhouse gas emission into the atmosphere (UNDP, 2004). As a small country, Liberia is also a small contributor to global warming, nevertheless, the sensitivity of the country to the impacts of the impending global and regional changes – on the one hand, and its commitment to the protection of the global environment – on the

other hand, dictate the integration of national policy with international agreements (European Union, 2006).

The Environment Protection and Management Law was adopted in November 26, 2002. The law provides for the protection and management of the environment as well as the sustainable use of Liberia's natural resources. It provides the framework for formulation, reviewing, updating and harmonizing all environment-related sectoral laws. This means the amendment and/or repeal of all laws that are in conflict with the framework legislation (UNEP, 2004). Further, the Law is intended as a comprehensive coordinating legal framework, to be implemented through collaboration between the Environment Protection Agency and line ministries and agencies (in the case of forest resources, the FDA), local authorities and the public. The Law anticipates stand-alone, sector-specific statutes, rules and regulations to facilitate implementation (USAID, 2006).

The National Environmental Protection Policy (2003) aims at promoting sustainable development and the general welfare of the state through conservation and judicious use of the national biological resources. The policy recognizes the need for conservation of biodiversity both in and out of protected areas and therefore seeks to adequately protect human, flora, fauna, and their biological communities and habitats against harmful impacts such as climate change and food insecurity, as well as to preserve the biological diversity. It further calls for the enactment or promulgation of environmental legislation and regulations for sound environmental management (UNEP, 2004).

The policy also emphasizes the need for the conduct and mainstreaming of environmental impact assessment in all necessary environmental activities in order to curtail any adverse impact on the environment. It recognizes Environmental Impact Assessment (EIA) as a useful tool to facilitate the integration of environmental concerns in decision-making process (UNEP, 2004). Additionally, the policy requires formulation of public hearing programs of all developmental initiatives that may impact on the environment prior to execution of such undertaking.

However, World Bank (2007) noted that the Government of Liberia performs limited activities if any regarding environmental impact assessment. Therefore, it is not aware of the negative impacts, which could culminate annual losses that

could amount to several million United States Dollars, which could be equivalent to a significant percentage of the total GDP. The magnitude and pervasiveness of the losses impose a strong case for taking effective action to reduce the losses. This could be achieved through sound environment policy, an environment protection and management law, and an environment protection agency.

3.9 The Innovation System Perspectives

Innovation system approach emerged in the mid 1980s as a Schumpeterian perspective that drew significantly from the literature on evolutionary economics and system theory (Speilman, 2005). However, more comprehensive description was first set forth by Lundvall (1985) and applied to national comparisons of innovation system by Freeman (1987 and 1995), Nelson (1988 and 1993) and Edquist (1997) with empirical application focusing primarily on national industrial policy in Europe, Japan and several East Asia countries that were experiencing rapid industrialization during the 1980s. Metcalfe (1995) and Roseboom (2004) further confirmed that the concept of innovation system was first mentioned in the industrial literature in the late 1980s and later entered into the vocabulary of national and international policy makers in the industrialized world. In recent times the concept is gradually spilling into policy making circles in developing countries.

The Innovation System thinking represents a significant change from the conventional linear approach to research and development. It provides analytical framework that explore complex relationships among heterogeneous agents, social and economic institutions, and endogenously determined technological and institutional opportunities. It demonstrates the importance of studying innovation as a process in which knowledge is accumulated and applied by heterogeneous agents, through complex interactions that are conditioned by social and economic institutions (Agwu , Madukwe & Dimelu, 2008). According to Tugrul and Ajit (2002) it is not a simple aggregation of organizations as portrayed by some views, but a group of agents who operate like an invisible orchestra characterized by coherence, harmony and synergy. It is an interactive learning process in which enterprises/agents in interactions with each other, supported by organizations and institutions play key roles in bringing new products, new processes and new forms of organizations into social and economic use (Francis, 2006). The above definitions point to the three essential elements of innovation system namely:

1. The organizations and individuals involved in generating, diffusing, adapting and using knowledge.
2. The interactive learning that occurs when organizations engage in generating, diffusing, adapting and using new knowledge and the way in which this leads to innovation (new products, processes or services).
3. The institutions (rules, norms, conventions, regulations, traditions) that govern how these interactions and processes occur.

The concept of innovation system is built on several assumptions and integrates current trends in development in the analytical framework. They include the followings:

a. Innovation takes place everywhere in the society and therefore bringing the diffuse element of a knowledge system and connecting them around common goals should promote economic development.
b. Innovation is an interactive process and is embedded in the prevailing economic structure and this determines what is to be learnt and where innovation is going to take place.
c. Innovation includes development, adaptation, imitation and the subsequent adoption of technology or application of new knowledge.
d. Innovation takes place where there is continuous learning and opportunity to learn is a function of the intensity of interactions among agents.
e. Heterogeneous agents are involved in innovation process, and formal research is a part of the whole innovation processes.
f. Linkages and/or interaction among components of the system (knowledge generating, transfer and using agents) are as important as direct investment in R and D.
g. Institutional context rather than technological change drives socio-economic development.
h. In addition to technical change and novelty, innovation includes institutional, organizational and managerial knowledge.

Speilmen (2005) reported that analysis of innovation system may focus on the study of the system at different spatial (local, regional, national) at different sectoral levels (agriculture, environment) in relation to a given technological set (biotechnology, Information and Communications Technologies (ICTs)), focus on the material (particular goods or services) and temporary dimension that studies how relationships among agents change over time as result of knowledge flow.

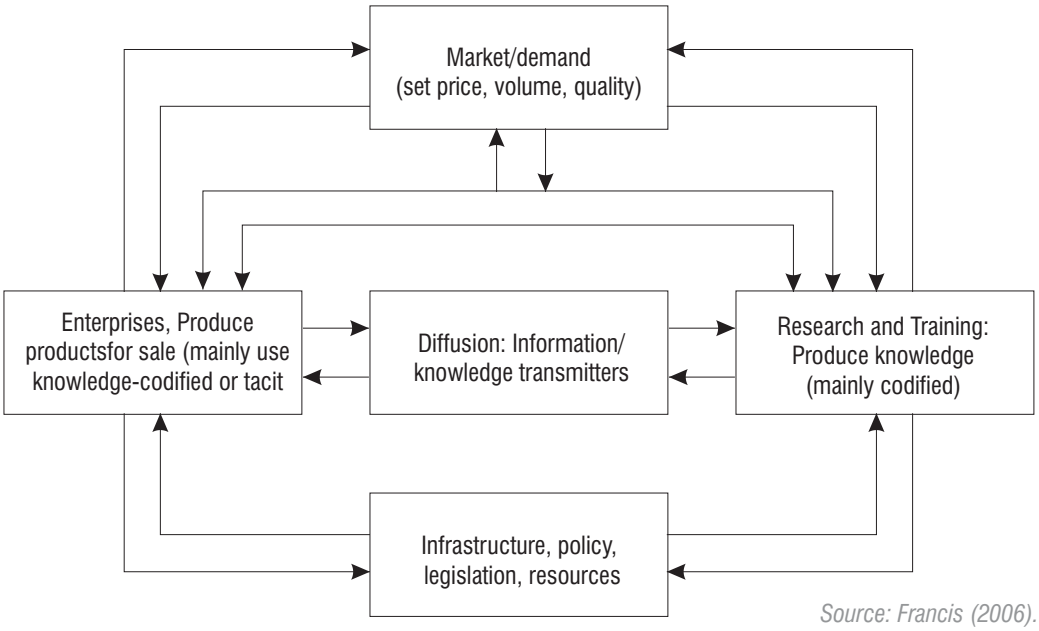
Empirically, the application of the innovation system approach at different analytical dimensions such as local, national, regional, sectoral and others have been advanced in literature. For instance, its early application started with introducing the concepts such as institutional learning and change, and the relationships between innovation and institutional context in which innovations occur. According to Speilmen (2005), studies by Johnson and Segura Bonilla (2001), Clark, Sulaiman % Naik (2003) and Hall and Yoganand, (2001, 2002) introduced innovation system to the study of developing countries agriculture and agricultural research systems. At the national and regional level the concept was adopted in sub-Saharan Africa by Samberg (2005), Roseboom (2004), Chema, Gilbert and Roseboom (2003), Peterson, Gijsbera and Wilks (2003), and Hall and Yoganand (2004), in Latin America by Vieira and Hartwich (2002) and in India by Hall et al (1998). Generally, most of its application across countries focused on institutional arrangements in research and innovation. For example Hall et al. (2002) emphasized on public-private interactions in agricultural research in India; and in south Asia and sub-Saharan Africa. Kangasmemi (2002) focused on producers organizations. Other scholarly studies focused on technologies opportunities, for example zero tillage cultivation survey in Argentina conducted by Ekboir and Parallada (2002) which revealed social, and economic change that encouraged the diffusion of zero-tillage cultivation.

3.9.1 Application of Innovation System Concept to Agriculture and its Relevance

In the last decade, economic and technology strategies have shifted from national agricultural research system (NARS) to agricultural knowledge, and information system, (AKIS) and more recently to agricultural innovation system (AIS). The national agricultural research system perspective emerged in the late 1980s and tends towards linearity in movement of knowledge from known source (formal research) and flowing to some end users (the farmers). It further recognizes the public good nature of agricultural research, the role of the state in fostering technology change, and assumed that the social and economic context of technological change is exogenous and unchanging. By 1990s agricultural knowledge and information system (AKIS) evolved as a more sophisticated and less linear approach. Contrary to the focus of the NARS, it emphasizes linkages between research, education and extension in generating and fostering technological change. AKIS, however, is limited in its ability to conduct analysis beyond the nexus of the public sector and to consider the heterogeneity among

agents, the institutional context that conditions their behaviours and the learning processes that determine their capacity to change (Speilman, 2005). In general, the system projects agricultural research system as the epicenter of innovation as opposed to the multiple knowledge bases put forward in innovation system perspective. The agricultural innovation system (AIS) comprises a far broader set of actors than the traditional agricultural research, extension and education agencies. Innovation takes place throughout the whole economy, and not all innovations have their origin in formal S & T nor are they all exclusively technical. This new perspective places more emphasis on the role of farmers, input suppliers, transporters, processors and markets in the innovation process. While each of the three system concepts has its own strengths and weaknesses, they can be seen as interlinked and cumulative: NARS focuses on the generation of knowledge, AKIS on the generation and diffusion of knowledge, and AIS on the generation, diffusion, and application of knowledge.

Agricultural innovation system evolved directly from the concept of national innovation system with the sectoral level as the unit of analysis. Adapting the various definitions of innovation system, agricultural innovation system is defined as a set of agents that jointly and/or individually contribute to the development, diffusion and use of agriculture-related new technologies and that directly and/or indirectly influence the process of technological change in agriculture (Tugrul and Ajit, 2002). The organizations include research institutes, training and education institutions, credit institutions, policy and regulatory bodies, private consultants / NGOs, farmers, farmers' associations and public services delivery organizations. It emphasizes agricultural innovations and goes beyond previous knowledge system concepts by incorporating the goals of current reform measures, such as political decentralization, public sector alliances with the private sector, enabling private sector participation in advancing consensus approach to development and promoting demand-driven services. Besides, it captures the intricate relationships between diverse actors, processes of institutional learning and change, market and non-market institutions, public policy, poverty reduction and socioeconomic development. Figure 3 shows the possible linkages and relationships among diverse actors in an agricultural innovation system.



Source: Francis (2006).

Figure 3: Elements of Agricultural Science Technology and Innovation (ASTI).

By adopting an AIS perspective, bigger issues come into focus than when adopting a more limited NARS or AKIS concept. By starting at the knowledge-application end, the question of why farmers innovate or why they don't becomes a major issue for debate and research. What are the constraints that hold them back? Is it the prices in the market, for example, or the lack of (or lack of access to) technology? Are farmers passive recipients of technology or do they actively search for innovations? What are the roles of input suppliers, cooperatives, traders, processors, NGOs, and government-extension services in technology diffusion? What are the relative strengths and weaknesses of each diffusion channel? How can they be improved and what can be done to reach more farmers? In answering these questions, we may learn that the most critical bottleneck is not the lack of available technology, but whatever prevents other factors from playing their often-far-more-crucial role. Hall and Yoganand (2002) highlighted that applying innovation system to agriculture in developing countries may provide the following features:

a) It focuses on innovation as its organizing principles. Here the concept of innovation is used in its broad sense as the activities and processes associated with the generation, production, distribution, adaptation and use of new technical, institutional, organizational and managerial knowledge.

b) Conceptualizes research as part of the wider process of innovation and extends its tentacle to identify actors and their scope, and the wide set of relationships in which research is embedded.
c) Recognize the importance of both technology producers and technology users and acknowledge that their roles are both context specific and dynamic.
d) It recognizes that the institutional context of the organizations involved (and particularly the wider environment that governs the nature of relationships) promotes dominant interests and determines the outcome of the system as a whole.
e) It recognizes that innovation systems are social systems. It therefore focuses not only on the degree of connectivity between different elements but also on the learning and adaptive process that make systems dynamic and evolutionary.
f) Matches better with the non-linear interactive concept of innovation.
g) It is more holistic including the final step (application) in the innovation process and incorporates ideas from various disciplines.
h) It stresses the importance of linkages among different actors.
i) It is only a framework for analysis and planning and can draw on a large body of existing tools

Nonetheless, scholars have expressed concern as to the relevance of national innovation system concept for agriculture in developing countries. Issues raised include the fact that transplanting the insight from innovation studies in developed countries is against the evolutionary character of the national innovation system, which argues that innovation process and systems are context specific and historically determined. In contrast however, Johnson and Segura-Bonilla (2001) reporting from their experience in Central America favourably argues for the suitability of national innovation system for agriculture in developing countries buttressing the following points:

1) The national innovation system concept help to concentrate on what we believe is important in development as it takes departure in learning capabilities and focuses on innovation processes and their role in development.
2) It has a broad explanation of innovation as based on both research and in every day routine economic activities and in both high-tech and low-tech sectors.

3) Its growth factors are interacting and feeding upon each other. An interaction between firms, organizations and the public sector is the essence of the concept.
4) Institutions and production structures matter.
5) It is a flexible approach, which for example can direct emphasis on local, national, regional systems and their mutual interdependence.
6) Finally, it is an inherently comparative approach and compares the anatomy and changes of different innovation systems.

In addition, Speilman (2005) argued that innovation system perspective on agriculture is critical to shifting socio-economic research beyond technological change "induced" by the relative prices of land, labour and other production factors in agriculture; beyond the concept of linear technology transfers from industrialized to developing countries, from advanced and international research centres to national systems as engine of change. Speilman (2005) thus concluded that the application of innovation system analytical framework to agriculture is embedded within the wider context of institutional change, change process, and answers certain questions that the linear, conventional research and systems are unable to address.

In other words, the innovation system approach offers a more holistic, multidisciplinary and comprehensive framework for analyzing innovation processes for climate change adaptation and food security, as well as the roles of science and technology actors and their interactions because of its emphasis on wider stakeholder participation, linkages and institutional context of innovation and processes. Whilst climate change is presenting specific additional challenges to development, it cannot be addressed in isolation. Unless concrete and urgent steps are undertaken to reduce vulnerability and enhance adaptive capacity of poor people, and unless these actions are integrated in national strategies for poverty eradication and sustainable development, it may be difficult to meet some MDGs by 2015.

4. Methodology

4.1 Area of Study

The study was carried out in three west African countries, namely: Nigeria, Sierra Leone and Liberia.

NIGERIA

Nigeria is a federal constitutional republic comprising thirty-six states and one Federal Capital Territory. The country is located on the Gulf of Guinea, and has a total area of 923,768 km2 (356,669 sqmi) and shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north (Wikipedia, 2009). Nigeria is an important centre for biodiversity. It is widely believed that the areas surrounding Calabar, Cross River State, contain the world's largest diversity of butterflies. Nigeria's Delta region, home of the large oil industry, experiences serious oil spills and other environmental problems.

When dividing Nigeria by climatic regions, three regions, the far south, the far north, and the rest of the country emerge. The far south is defined by its tropical rainforest climate, where annual rainfall is 60 to 80 inches (1,524 to 2,032 mm) a year (). The far north is defined by its almost desert-like climate, where rain is less than 20 inches (508 mm) per year. The rest of the country, everything in between the far south and the far north, is savannah, and rainfall is between 20 and 60 inches (508 and 1,524 mm) per year.
(http://www.uni.edu/gai/Nigeria/ Background /Standard5.html).

However, according to Federal Government of Nigeria report on drought management (FGN,1999), the Nigeria landmass of 923,766 km2 is divided into seven ecological zones. This classification is based on the similarity of climatic

elements and the type of vegetation that can be supported. These ecological zones are the mangrove swamp, rainforest, montane forest /grassland, derived savannah, guinea savannah, Sudan savannah and the Sahel savannah. The mangrove swamp and rainforest zones, and part of derived savannah zone are found in the southern part of the country. These zones are characterized by high rainfall intensity, long wet season, dense vegetation, rugged topography and temperature range of 26 – 28ºC and small farm holdings. Flood and water erosion are the major problem of crop production in these zones. A sizeable hectare of agricultural land and farmer's properties are lost yearly to water erosion in the eastern part of the country. Maize, cassava, yam and vegetables are the major crops grown in these zones.

Conversely, the savannah zone (Derived, Guinea, Sudan and Sahel savannah) is located in the northern part of the country. This region is characterized by short wet season and long dry season, high annual temperature (average) of the range 28 – 32ºC, few scattered trees and grasses, gentle slope and large farm holdings. Maize, sorghum, millet, wheat, rice, cowpea, pepper and onion are the major crops that thrive in savannah. The limiting factor to crop production in this region is water; this is because of short wet season that often commences in June and ends in September.

The montane forest/grassland zone is located in the high altitude areas of the country. This zone includes Jos Plateau, Adamawa and Obudu mountains. The zone is known for low average annual temperature (20 – 23ºC) all year round, moderately high rainfall and rugged topography. Montane forest/grassland is exceptionally suitable for maize, exotic vegetables (carrot, cabbage, cucumber and lettuce among others). The mountainous nature of this zone, cold weather and low concentration of oxygen are the obstacles to crop production. With the exception of the montane region, the length of wet season (days) and temperature increase from the coast to the hither land. In this categorization no state of the federation can boast of one ecological zone. A state may have up to three ecological zones. The seven ecological zones are explained below.

Mangrove Swamp Forest: This zone is characterized by a bimodal rainfall distribution. The zone has an average annual temperature and rainfall of 26ºC and 2503mm respectively. There is hardly a month without rainfall. The mangrove swamp vegetation is a hydromorphic forest type characterized by an entangled

dense growth of stems and aerial roots. The most common specie of this vegetation is the raffia palm (Sowunmi and Akintola, 2010). The better drain areas support maize oil palm trees and big trees like Iroko (Chlorophora exceisa). Limiting factors to agricultural production include waterlogged soil, rugged topography and leaching as a result of excessive rainfall. A substantial land area of states such as Lagos, Delta, Rivers, Cross River, Akwa Ibom and Calabar are within this zone. The Fig. 4 shows the vegetation map of Nigeria.

Fig. 4: Vegetation Map of Nigeria

Tropical Rainforest: This zone like the mangrove swamp zone has a bimodal rainfall distribution but with less intensity. There is a distinct dry and rainy seasons. The zone has an average annual rainfall and temperature of 1489 mm and 26.5ºC respectively. Tropical rainforest zone accounts for a great number of plant species. The lower layer vegetation is most dense with abundance of herbs, shrubs and some grasses. The top layer accounts for valuable economic trees such as Mahogany, Iroko, Obeche among others. The zone has a high density of human population with agriculture as primary occupation of the people. The zone is known for the cultivation of maize, cassava, vegetables, yam, oil palm etc. Problem of agriculture in the zone are rugged topography and bush burning which predisposes soil to erosion (Sowunmi and Akintola, 2010).

The Montane Forest/Grassland: The montane zone is located in the high altitude areas of the country like Jos Plateau, Mandara, Adamawa Mountain and Obudu Plateau. The zone is characterized by low average annual temperature (21.5ºC). The average annual rainfall is 1450mm. The montane zone vegetation is covered with grass at the top and base, while forests cover the slopes, favoured by moisture-laden wind. The zone has a great potential for the cultivation of maize, wheat, carrot, cabbage and other exotic vegetables but the mountainous nature of the zone prevents commercial farming.

Derived Savannah: This zone is found immediately after the tropical rainforest zone. It is the transition between the tropical rainforest and guinea savannah zones. The average annual rainfall and temperature are 1314mm and 26.5ºC respectively. The zone is covered with scattered trees and tall grasses. Maize, cassava, yam and rice are the major crops grown in this zone. The savannah in general has an enormous potential for food production in the country. Bush burning and erosion as a result of over grazing by animal especially cattle constitute a major problem to agricultural production in the zone.

Guinea Savannah: The Guinea Savannah, located in the middle of the country, is the most extensive ecological zone in Nigeria, covering near half of the country. Guinea savannah zone has a unimodal rainfall distribution with the average annual temperature and rainfall of 27.3ºC and 1051.7mm respectively. It extends from Ondo, Edo, Anambra and Enugu States in the south, through Oyo State to beyond Zaria in Kaduna State. It is a belt of mixture of trees and tall grasses in the south, with shorter grasses and less trees in the north. The Guinea savannah, with its typically short trees and tall grasses, is the most luxuriant of the savannah vegetation belts in Nigeria(Sowunmi and Akintola, 2010). The zone is characterized by low rainfall and long dry period, which call for alternative water supply (irrigation) to enhance full utilization of the zone potential in agricultural production.

Sudan Savannah: The Sudan savannah zone is found in the northwest stretching from the Sokoto plains in the west, through the northern sections of the central highland. It spans almost the entire northern states bordering the Niger Republic and covers over one quarter of Nigeria's total area. The low average annual rainfall of 657.3mm and the prolonged dry season (6-9 months) sustain fewer trees and shorter grasses than the Guinea savannah. It is characterized by

abundant short grasses of 1.5 - 2m and few stunted trees hardly above 15m. It is by far the most densely human populated zone of northern Nigeria. Thus, the vegetation has undergone severe destruction in the process of clearing land for the cultivation of important economic crops such as cotton, millet, maize and wheat. This is in addition to devastation due to animal husbandry, especially cattle rearing, which is greatly favoured in this belt because the area is relatively free from tsetse fly. The trees of the Sudan savannah include the acacia, the sheabutter, baobab and the silk cotton. Fig. 2 show the rainfall distribution map.

Sahel Savannah: This is the last ecological zone that supports maize cultivation with proximity to the fringes of the fast-encroaching Sahara desert. It is located in the extreme northeastern part of the country, close to Lake Chad, where the dry season lasts for up to 9 months and the total average annual rainfall is hardly up to 700mm. It is characterized by very short grasses of not more than one metre high located in-between sand dunes. The area is dominated by several varieties of the acacia and date palms. The Lake Chad basin, with its seasonally flooded undulating plains, supports a few tall trees. At the same time, the drainage system of rivers and streams into the Lake Chad basin has favoured irrigation, without which cultivation would be virtually impossible. The increasing aridity in the area accounts for the progressive drying up of the Lake Chad.

SIERRA LEONE

The Republic of Sierra Leone is a country bordered by Guinea in the north, Liberia in the southeast, and the Atlantic Ocean in the southwest. Sierra Leone covers a total area of 71,740 km2 (http://encarta.msn.com/encyclopedia_761563681/Sierra_Leone.html). The national capital Freetown sits on a coastal peninsula, situated next to the Sierra Leone Harbor, the world's third largest natural harbour. The climate is tropical, with two seasons determining the agricultural cycle: the rainy season from May to November, and a dry season from December to May, which includes harmmattan, when cool, dry winds blow in off the Sahara Desert and the night-time temperature can be as low as 16 °C (60.8 °F) (Blinker, 2006). Logging, mining, slash and burn, and deforestation for land conversion have dramatically diminished forested land in Sierra Leone since the 1980s. Until 2002, Sierra Leone lacked a forest management system due to a brutal civil war that caused tens of thousands of deaths. Deforestation rates have increased 7.3% since the end of the civil war. The Republic of Sierra Leone is composed of three provinces: the Northern Province, Southern province and the Eastern province

and one other region called the Western Area. The provinces are further divided into 12 districts, and the districts are further divided into chiefdoms, except for the Western Area. The country is divided into four agro –climatic regions, namely, Coastal Plains, Rainforest, Savannah Woodland and Transitional Rainforest/Savannah Woodland. The four agro-climatic regions are explained below.

Coastal Plains. Agro-climate of this region is dominated by proximity of the sea, strongly temperature regimes, humidity and rainfall. The boundary of the region is approximated and taken to coincide with the specific drainage and edaphic characteristics. The coastal plains covers an area of some 11,000 km2 or about 15% of the land surface of Sierra Leone and is comprised of estuarine swamps, alluvial plains, beach ridges and coastal terraces. The dominant factor influencing the agricultural utilization of this region is the exceptionally high rainfall and an excess of precipitation over evapo-transpiration demands, exposing the region to excessive leaching, prolonged flooding and swampy conditions. An average water budget account for the region shows that there is some 2,100 mm of surplus rainfall which together with the seasonal flooding reflects the extreme conditions of humid environment. There are distinct contrasting periods of the year generally referred to the rainy and dry seasons. The average duration of rain-fed growing period averages some 260±10 days. The dry season therefore averages some 105 days, but for specific agricultural purposes it could be extended for several weeks to include comparatively dry periods of the rainy season in November and December. Temperature is however not a limiting factor for crop growth in this region. Major crops grown include Cabbage, Carrot, Lettuce and Potato Leaves. Fig 5 shows the Agro-climatic Regions of Sierra Leone.

Rainforest. The ecologically important characteristic of the region is a unimodal distribution of annual rainfall resulting in the high reliability of moisture supply to vegetation. However, the receipt of annual rainfall is much in excess of evapo-transpiration demands and consequently about half of the annual precipitation (1460mm) finds its way to ground water or runoff resulting in stream and river flow. The distribution of rainfall is prolonged, lasting from the beginning of May to the end of November, a rise in the level of ground water table occurs and may adversely affect draining conditions particularly in the lower parts of the topography. Another agronomical important aspect of this large climatic water

supply is its effect on soil nutrients and land management. The drainage is poor in some areas, especially where there is low elevation- nutrients are all taken away from the forest. The major crops grown here are both perennial and annual, but the most common types are perennials (plantation). Cassava, Yams, Rice, Foliage crops, Maize, Cabbage, Carrot and Lettuce are major crops found in this region.

Fig 5: The Agro-climatic Regions of Sierra Leone

Savannah Woodland. This covers about 30% of Sierra Leone, and extends from the interior lowland to the interior plateaus of the north and northwest. Rainfall and water surplus are slightly lower than the other agro-climatic regions. The region is characterized with unique less luxuriant savannah vegetation, and has a dry season that lasts for about 100-130 days. There is also a serious annual water deficit. Wild fire, crop cultivation and overgrazing were also identified as the major biotic influences producing this type of agro-climatic zone. Poor drainage, shallowness and infertility are the main edaphic influences. These two factors, result in the establishment of savannah mosaic landscape, which consists mainly of deciduous woodland tree species and grasses. The rainy season starts about mid-April to January. This result is suitable for annual crop production. Average growing period is about 255 days. Rainfall is unimodal. There is large water surplus in humid condition resulting to environmental stress for the arable crops. This produces pests, diseases, weeds, leaching of nutrients, risk of flooding and soil erosion. Dry season experiences a high water deficit (about 500 ml). At times

dry season prolongs between 160-170 days. Irrigation technology is therefore important. Since there is a marked water supply in the rainy season and water deficit in the dry season, there is a need to conserve water in the rainy season for dry seasons. Groundnut, Cowpea, Maize, Millet, Sorghum, Beans, Rice, Cocoa, Banana, Oil Palm, Rubber, Pineapple, Sisal, Cassava, Yams and Sugar Cane are major crops grown in this zone.

Transitional Rainforest/Savannah Woodland. This shares similar characteristics with the rainforest and savannah woodland agro-climatic regions. Major crops grown include Coffee, Cocoa, Citrus, Banana, Avocado, Oil Palm, Cassava, Yams and Rice.

LIBERIA

Liberia is located on the south-western coast of Africa. It is bound by Sierra Leone to the northwest, Guinea to the north, Ivory Coast to the east and northeast and the Atlantic Ocean to the south. The country can be divided into three topographical regions.

a) The coastal belt of undulating plains characterized by tidal creeks, shallow lagoons and swamps.
b) The plateau which rises slowly from the plain between 200 metres (656 feet) and 750 metres (2,461 feet) and is covered in forests as well as grasslands.
c) A mountainous area that is densely forested and reaches Mt. Nimba, the country's highest point. Other mountain groups include the Wologisi Range, Bomi Hills and the Niete Mountains.

The country has a total land Area of 111.369 sq km (43,000 sq miles) and seven major rivers, the Mano, Loffa, St. Paul, Farmington, St. John, Cess and Cavalla which all flow into the Atlantic (CIA World Fact Book, 2005). Liberia is dominated by flat to rolling coastal plains that contain mangroves and swamps. Those plains slope into a rolling plateau and rainforest-covered hills central, and into relatively low mountains in the northeast. Fig. 6 shows the map of Liberia.

Liberia has a tropical climate with two wet seasons in the southeast and one wet season from May to October for the rest of the country. The climate is characterized by constant high temperatures and abundant rainfall. Annual mean temperature is 77,5 degree (22.5 degree). Annual mean temperature is 77,5 degree (22.5 degree). High humidity is common during the wet season and the

prevailing winds are the NE and SW Monsoons as well as the Harmattan which is a dust laden wind from the Sahara Desert. Tornadoes are also common during the wet season. Average annual precipitation in Monrovia is 4,150 mm (163 inches) and average temperature ranges are from 22 degrees Celsius (72 degrees Fahrenheit) to 27 degrees Celsius (81 degrees Fahrenheit) all year. According to USAID Report (1999) Liberia has four distinct agro-ecological zones (AEZ), each having its unique and vegetation determined by rainfall pattern, altitude/topography, and temperature. The four major AETs are: (a) Coastal Plains; (b) Upper Highland Tropical Forest; (c) Lower Tropical Forest; and (d) Northern Savannah.

Fig. 6: Map of Liberia

Coastal Plains(AEZ, I): Coastal Plains are found along the coast running inland, covering Montserrado, Cape mount, Bomi, Margibi, Bassa, and Rivercess counties. Vegetation is swampy along rivers and creeks, mangroves, scattered patches of both low and high hushes and a savannah belt(with various types of grasses) running up to 15 miles (25km) in to the interior of the country. The coastal plains begin at sea level and extend to heights of 100-ft(30m) inland. The coastal plains are characterized by very high levels of rain fall, ranging from 178 to 182

inches (4450-4550mm). High humidity of 85%-95% occurs in the coastal plains, and these causes, which cause the temperature, feel higher. The coastal plains also experience wider temperature ranges and longer sunshine hours.

Upper highland Tropical Forest (AEZ II): This area covers Upper Cape Mount, Lofa, Bomi, Margibi, Bong, and Rivercess and most of Nimba. This zone covers the agricultural belt of Liberia, which composes the plateaus and mountain ranges located behind the rolling hills. The plateaus (tablelands) run up to an elevation of 1000ft. (300m) above sea levels. The Mountain ranges (Mano and Gbi) are found at elevations up to 2000ft (600m). The Northern Highlands is composed of the Wologisi range with elevation of up to (1350m) in Lofa, and the Nimba range with elevation of 4540ft.(1385m). Vegetation in the Upper Highland Tropical Forest is Semi-deciduous forest and transition zone of secondary forest (low bush), high broken forest, and high closed forest. Rainfall within this zone is characterized by a bi-model rainfall, subdivided with a short dry spell of two weeks in July/August. Annual average rainfall is 115 inches (2900mm) from Lofa to Nimba, and ranges from a low of 65 inches (1625 mm) in Bong County, to maximum of 128 overall. The variation in temperature throughout the region is about 5OF. This zone is excellent for cocoa and coffee production.

Lower Tropical Forest Zone (AEZ III): This zone is the mid-altitude rolling hills composed of valleys, hills and numerous water courses found mainly in Sinoe, Maryland, Grand Kru, Grand Gedeh and parts of Nimba counties. Vegetation is mostly evergreen rainforest found mainly in the south-eastern part of the counties named above. Within this zone average rainfall goes from 120 inches (300mm) in Maryland to 164 inches (4100mm) in Sinoe. The region experiences greater length of dry spell and two distinct peaks of the rainy season.

Northern Savannah Zone (AEZ IV): This zone is found only in Northern Lofa and Northern Nimba. It consists of dense elephant grass (grows up to 10ft.) with scattered trees and patches of forest. The zone is characterized by high elevation with average rainfall between 30 inches and 70inches (USAID Report, 1999).

4.2 Population and Sample Size

The population for this study included all types of farmers and organizations considered as major stakeholders in the field of agriculture/ food security and climate change issues in the three countries. The organizations include research

institutes, training and education institutions, credit institutions, policy and regulatory bodies, private consultants / NGOs, farmers' associations and public services delivery organizations.

Respondents for this study were selected through a multistage sampling technique. In the first stage, thirteen states (namely: Abia, Adamawa, Brono, Cross Rivers, Delta, Enugu, Imo, Kogi, Ondo, Oyo, and Plateau states), were selected from the seven agro-ecological zones in Nigeria; In Sierra Leone, six districts (namely: Freetown Peninsula, Kailahun, Bo, Koinadugu, Moyamba and Free Town Coastal Plain districts) were selected from the four agro-climatic regions, while seven counties (namely: Nimba, Bong, Lofa, Grand Bassa, Margibi, Grand Cape Mount and Grand Gedeh) were selected from the four agro-climatic regions, in Liberia.

In the second stage, using the delineation by the different states' Agricultural Development Programmes (ADPs), two agricultural zones were randomly selected from each state giving a total of 26 agricultural zones in Nigeria. From each of the selected zones, 25 farming households were randomly selected for interview. This gave a total of 650 framing households from Nigeria. In Sierra Leone, a sample size of 70 farming households were randomly selected from each of the six districts giving a total of 420 households; while in Liberia 60 farming households were randomly selected from each of the counties surveyed, giving a total of 420 farming households.

The sample of farming households for this study was selected through a combination of strategies that recognized the social component of indigenous knowledge and practices. Criteria used for selection included age (for historical insight on indigenous knowledge), framing experience and interest. In all, a total of 1,490 farming households were interviewed. However, 1,424 (624 from Nigeria); (400 from Sierra Leone) and (400 from Liberia) completely filled interview schedules were used for analysis.

On the other hand, data were collected from a total of two hundred (200) respondents from various organizations, covering research institutes, training and education institutions, credit institutions, policy and regulatory bodies, private consultants / NGOs, farmers' associations and public services delivery organizations in Nigeria, Sierra Leone and Liberia. However, only 164 completely

filled questionnaires, consisting of 124 from Nigeria; 20 each from Sierra Leone and Liberia, respectively, were used for analysis.

4.3 Data Collection Technique

Tools of participatory research namely: structured questionnaire, semi structured interview schedule, key informant interviews and focus group discussions (FGDs) were used in data collection. These instruments contained both open ended and semi structured questions.

The organization questionnaire was divided into five sections. Section A of the questionnaire dealt on the organization's profile; information about the organization were collected. Section B identified the manpower and training needs of the organizations; while section C revealed the various sources through which the respondents sought for funds. Section D of the questionnaire tried to ascertain the intensity and trend of collaborations and networks among the organizations; while section E looked at the performance of the various systems as regards the major problems encountered in climate change innovations dissemination and food security issues, as well as the state of the domestic environment with regard to supporting agricultural development.

Section A of the interview schedule elicited the farmers' profile; information concerning the respondents was collected. Section B identified the manpower and training needs of the farmers; while section C sought for information on the various available sources of funds to the farmers. Section D determined the respondent's awareness and knowledge of climate change phenomenon. Section E focused on the perceptions of respondents on the causes of climate change. Section F of the interview schedule sought for information on various innovative climate change adaptation measures used by respondents. Section G sought to identify the problems farmers encountered in adapting to the changing climate, while Section H looked at the food security issues as it affects the respondents. Section I sought to elicit information on the intensity and trend of collaborations and networks with other stakeholders in the last five years. Section J sought to ascertain the performance of the farmers as regards climate change adaptation.

4.4 Measurement of Variables

Section A of the instruments elicited information on characteristics of the farming households and the nature of the organization. Variables measured under this section were: age (in years); years of farming experience (in years); sex; marital status; household size; ownership structure of farm and organization; main areas of focus in farming; available extension activities on climate change; types of organizations; main purpose of the organizations and thematic area of focus.

Section B of the farmer and organization questionnaire identified the available manpower and areas of specialization of respondents. Respondents were asked to name their highest academic qualification and areas of interest. Respondents were asked if they have had any specialized training on climate change and/or whether their organizations provided opportunities for staff training on climate change adaptation by ticking against a response option of "Yes" or "No". Respondents were also asked to indicate by ticking the appropriate response to show if their manpower strength was "Decreasing=1", "Remained the same=2" or "Increased=3" over the last five years.

Section C of the two sets of instruments showed the available sources of finance to the respondents. Respondents were asked to give the percentage of their budgets that comes from the listed sources: Government, Self generated, Private sector, Donor funded etc. They were also asked to indicate how contributions from the different funding sources have changed over the past five years by ticking against "Decreasing=1", "Remained same=2", "Increasing=3". They were also asked to indicate the percentage of their budget that goes to solving climate change/food security issues.

Section D of the farmers' interview schedule and organization questionnaire determined the respondent's awareness and knowledge of climate change phenomenon and elicited information on the intensity and trend of collaborations and networks in the last five years available to the organizations. Respondents were asked to indicate if they have heard of climate change and if climate change affects their farming activities by ticking on a response option of "Yes" or "No". They were also asked to give a description of their understanding of the concept of climate change. To ascertain the direction of change with regard to some climate phenomena on farming activities over the past five years, a three point Likert-type scale was used. Each respondent was required to indicate his/her

responses by ticking any of the options namely “Decreasing”, “Remained the same” or “Increasing”. Values assigned to these options were 1, 2 and 3; these were summed to obtain 6.0 which was divided by 3 to obtain a mean score of 2.0. Factors with mean scores of less than 2.0 were regarded as not showing any sign of change, while those with mean scores of above 2.0 were regarded as showing some changes in the past five years.

Sections D and I of the organization and farmers' instruments respectively, sought to elicit the availability of overseas and / or local collaborators and whether these collaborations covered the issues of food security/climate change. Respondents were asked to indicate the existence of collaborations by ticking “Yes” or “No”, they were also asked to indicate the main areas of available collaborations. The intensity of collaboration was measured on a five point Likert-type scale of “None”, “Weak”, “Average”, “Strong” and “Very strong”, with nominal values of 1, 2, 3, 4 and 5, respectively. These values were added to obtain 15, which was further divided by 5 to get a value of 3.0, which was regarded as the mean. Collaborations with mean scores of less than 3.0 were regarded as showing weak intensity while those with mean scores of greater or equal to 3.0 were regarded as showing strong intensities. Respondents were also asked to indicate how collaborations with the various organizations have changed over the past five years. To measure this trend, each respondent was required to indicate his/her responses by ticking any of the options namely “Decreasing”, “Remained the same” and “Increasing”. Values assigned to these options were 1, 2 and 3; these values were summed to obtain 6.0 and was divided by 3 to obtain 2.0 which was regarded as the mean. Collaborations with mean scores of less than 2.0 were regarded as showing decreasing intensities over the past five years with, while those with mean scores of above 2.0 were regarded as showing increasing intensities over the past five years.

Sections E and J of the farmers' interview schedule as well as section E of the organization questionnaire focused on the perceptions of respondents on the causes of climate change and also looked at the performance of the various systems as it regards to climate change adaptation. Respondents were asked to tick “Yes” or “No” options if they introduced new crop, farm tool, information, markets for products etc., within the past 10 years. A list of different sources of information on climate change and food security was provided and the respondents were asked to indicate their major sources of information. Also, the

respondents were asked to indicate the quality of information they received on a 5 point Likert – type scale. The values were summed up to get 15.0 which was later divided by 5 to give a mean score of 3.0. Any response option lower than 3.0 was not regarded as a source of information on climate change and food security issues while responses greater than or equal to 3.0 were taken as sources of quality information. Respondents were also required to rate the present domestic environment in the country in terms of its support for climate change adaptations and food security on a 5 – point Likert- type scale. Again, government support systems with less than 3.0 scores were regarded as weak supports / efforts while responses with options greater than 3.0 were taken as strong domestic supports.

Section F looked at different innovative climate change adaptation measures used to combat the climate change. Respondents were asked to state different approaches they used to combat pests and diseases attack, and measures they took to improve on their crop and livestock productions. Then a list of different adaptation measures (use of resistant varieties, increase weeding, planting of trees, out migration etc) was provided and the respondents were asked to indicate by ticking under the appropriate column any of the measures they have been using in the past five years.

Section G of the interview schedule sought to elicit information on problems encountered by the farmers in adapting to the effects of climate change. Respondents indicated the extent to which variables like lack of information, low awareness level, low institutional capacity etc., acted as constraints to climate change adaptation. A three point Likert –type scale with response options of, to a very serious, serious, and not serious scaled 3 to 1 was used to ascertain the level of seriousness of the different constraints listed.

Section H elicited information on food security issues as they affect the respondents. The respondents were asked to show the frequency at which they had difficulties in meeting the food needs of their households and the number of times they fed in a day by ticking under the correct options as provided.

4.5 Data Analysis

Data relating to organizations and farmers' profile, manpower and specialization as well as sources of finance were summarized using percentages and mean scores. Awareness and knowledge of climate change phenomenon among the

respondents, perceived causes of climate change and different adaptation measures used by framers were analyzed using percentages and mean scores. Also, mean scores and trend analysis were used to summarize information on manpower trend, financing trend, budgetary trend climate change trend and intensity of collaborations among key stakeholders in the climate change /food security innovation system in the last five years. Percentages and mean scores were also used to analyze the major sources of information on climate change and food security as well as the quality of these sources. Both mean scores and exploratory factor analysis procedure were used to analyze the problems encountered by farmers in adapting to the effects of climate change. First of all, to determine the possible constraints as perceived by the respondents, the respondents' mean scores were summarized such that those variables with mean scores greater than 2.0 were regarded as a “possible constraints”. Exploratory factor analysis procedure using the principal factor model with iteration and varimax rotation was further employed in grouping the constraint variables into major constraint factors for policy implication. In factor analysis, the factor loading under each constraint (beta weight) represent a correlation of the variables (constraint areas) to the identified constraint factor and has the same interpretation as any correlation coefficient. However, only variables with loadings of 0.40 and above {(10% overlapping variance, Comrey, (1962)} were used in naming the factors.

5. Results & Discussion

The findings of the study are presented under the following headings:

1. Farmers' Demographics and available Extension Activities in Nigeria, Sierra Leone and Liberia
2. Manpower and Specialization (Training, experience and skills) of surveyed Enterprises
3. Sources and Trends of Enterprise funding over the past five years
4. Perceived Trend of Climate Change Phenomenon in Nigeria, Sierra Leone and Liberia
5. Perceived Causes of Climate Change
6. Innovative Climate Adaptation Measures used by Farmers
7. Problems Encountered by Farmers in Adapting to the Effects of Climate Change
8. Respondents' Perception of Household Food Security Issues
9. Intensity and Trends of Collaboration among key actors in the Climate Change and Food Security Innovation System
10. Performance of the System on the basis of Innovation Generation
11. Sources of Information on climate change, food security measures and innovations
12. Respondents' Perception of Domestic Environment support for Climate Change Adaptation and Food Security

5.1. FARMERS' DEMOGRAPHICS AND AVAILABLE EXTENSION ACTIVITIES IN NIGERIA, SIERRA LEONE AND LIBERIA

Age

Entries on Table 4 show that in Nigeria, 31.8% of the rural households fell within the age range of 40-49 years, 20.7% were within 20-20 years, in Sierra Leone, 30.4% were within 40-49 years, 24.9% fell in the range of 50-59 years. However, in Liberia, 28.0% were within the age ages of 40-49 years. The mean ages of respondents in the three countries were (x=47.00, = 44.71 and =42.99) for Nigeria, Sierra Leone and Liberia respectively. This indicates that the respondents were predominately in their middle age and hence are in their high productive stage.

Sex

Data on Table 4 show that in Nigeria, Sierra Leone and Liberia respectively, that 81.4%, 76.5% and 66.9% of the respondents were males. These reveal that more males dominated in agriculture in the three countries than females.

Marital status

Entries in Table 4, further reveal that 82.4%, 82.8% and 87.1% of the rural households interviewed in Nigeria, Sierra Leone and Liberia, respectively, were married. About 9% for (Nigeria and Sierra Leone) and 5.4% were single. This findings show that there are more married couples who engage in agriculture in the three countries.

Household size

Table 4 shows that about 82% of the respondents in Nigeria, 73% in Sierra Leone and 68% in Liberia had household size between 1-10 persons. While 16.0%, 18.9% and 14.5% for Nigeria, Sierra Leone and Liberia respectively, had household size between 11-20 persons. The average household size is 7persons in Nigeria and 8 persons each in Sierra Leone and Liberia. Large household size is a common phenomenon in most rural African communities. Having many household members is an advantage in terms of support in farming activities.

Ownership structure of farm

Entries on Table 4 further reveal that the ownership structure of farms in Nigeria,

Sierra Leone and Liberia respectively (94.7%, 95.5% and 99.7%) was basically family/private ownership system.

Main area of farm focus

The main areas of farm focus for the three countries under study were crops (94.5%, 98.5% and 98.3%) for Nigeria, Sierra Leone and Liberia respectively. The remaining 5.3% for Nigeria, 2.5% for Sierra Leone and 1.7% for Liberia were directed into livestock production. This indicates that crop production is the predominant agricultural activity in these countries.

Years of farming experience

Data on Table 4 further show that respondents in Nigeria (33.7%), Sierra Leone (38.5%) and Liberia (28.8%) had years of farming experience between 11-20 years. Respondents who had years of farming experience between 1-10 years for Nigeria, Sierra Leone and Liberia respectively, were 26.2%, 30.1% and 46.7%. The mean years of farming experience for respondents in the three countries were (=21.55, =17.62 and =15.04). This means that the respondents have been practicing agriculture for a long period of time and could therefore be said to have gained some level of experience as regards changes in the climate as it affects their farming activities.

Table 4: Socio–economic characteristics of rural households surveyed in the three countries

Socio-economic characteristics	Nigeria Percentage	Mean	Sierra Leone Percentage	Mean	Liberia Percentage	Mean
Age(years)						
20-29	6.6		14.4		15.1	
30-39	20.7		18.6		26.9	
40-49	31.8	47.00	30.4	44.71	28.0	42.99
50-59	21.4		24.9		18.1	
Above 60	19.6		11.7		11.9	
Sex						
Male	81.4		76.5		66.9	
Female	18.6		23.4		33.1	
Marital status						
Single	9.6		9.0		5.4	5.4
Married	82.4		82.8		87.1	87.1
Divorced	2.4		2.8		3.7	3.7
Widowed	5.6		5.5		3.7	3.7
Ownership structure of farm						
Family/private	94.7		95.5		99.7	
Foreign owned	0.8		0.8		0.3	
Government	2.3		3.5			
Joint venture	2.2		0.2			
Main area of farm focus						
Crops	94.7		98.5		98.3	
Livestock	5.3		2.5		1.70	
Size of farm						
Small size	78.1		99.7		99.7	
Medium size	29.8		0.3		0.2	
Large size	2.1					
Household size (person)						
1-10	81.5		73.0		67.8	
11-20	16.0	7	18.9	8	14.5	8
Above 21	2.5		8.1		17.7	

5.1.1 Available Extension Activities on Climate Change and Food Security

Figure 7, shows that only 22.6% of the respondents in Nigeria noted that there are available extension activities on climate change through the use of demonstration/training on the use of adaptive measures (e.g. mulching) to cushion the effects of climate change. About 25% of the respondents in Nigeria asserted that there are advisory services on how to manage the farm in order to reduce the effect of climate change; while 26.2% of them reported that there are awareness creations on the effects/consequences of climate change from extension activities.

In Sierra Leone and Liberia, only 2.2% and 14.3% of the respondents respectively noted that there are extension activities with regard to visiting sites that are undergoing changes due to variations in the climate. Only about 3% and 7% of the respondents from Sierra Leone and Liberia reported that there are awareness creations on the effects/consequences of climate change through extension activities in the two countries. It can be inferred from the above, that there seem to be more extension activities on climate change in Nigeria than in Sierra Leone and Liberia. However, the data reveals that there were little or no public shows on changing climate; excursion to locations showing neither varying climate situations nor field days where discussions on effect of climate change were done in any of the countries. This call for the need for extension to work closer with research institutions and famers to build synergy that will lead to quicker development of new adaptation technologies on climate change.

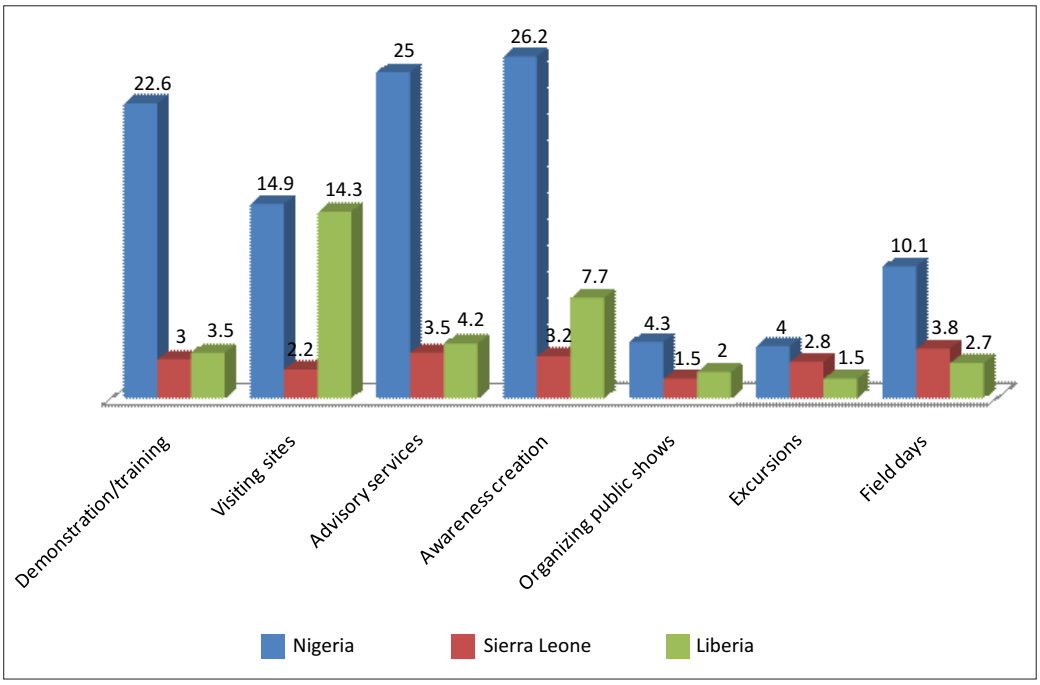


Figure 7: Respondents' reported extension activities on climate change in three countries

5.2 MANPOWER AND SPECIALIZATION (TRAINING, EXPERIENCE AND SKILLS) OF SURVEYED ENTERPRISES IN NIGERIA, SIERRA LEONE AND LIBERIA

5.2.1 Enterprise Manpower and Specialization in Nigeria, Sierra Leone and Liberia

Educational Qualification

Entries on Table 5 show that about 59% of the respondents in Sierra Leone, 38% of Liberian respondents and 14% of respondents from Nigeria had no formal education. The table further shows that 27.5%, 22.8% and 31.6% of the respondents from Nigeria, Sierra Leone and Liberia respectively completed secondary school while, 17.5% of the Nigerian respondents, 0.2% and 0.7% of respondents from Sierra Leone and Liberia had university education. On a general note, the data show that respondents from Nigeria were more literate than respondents form the other two countries.

Possession of Specialized Training on Climate Change Adaptation and/or Food Security Issues

From Table 5, it is evident that only 1.8% of respondents from Nigeria, 2.5% of respondents from Sierra Leone and 0.7% of respondents from Liberia possessed special training on climate change adaptation and food security issues. It can be inferred from the above findings that majority of the respondents across the three countries possessed no special training on climate change adaptation and on food security issues.

The Table further reveals that only about 2% of family members or farm workers from Nigeria, 1% from Sierra Leone and 0.2% from Liberia possessed a specialized training on climate change adaptation and food security issues. On provision of opportunities for training for staff or family members on climate change adaptation, 3.0% of respondents in Nigeria noted to have provided such opportunities, while 0.2% of respondents from both Sierra Leone and Liberia agreed to have also provided such opportunities for training. The implication for this is that there is so much work to be done by all stakeholders involved in climate change adaptation measures, if the issue of food security is be achieved for the teeming population across Africa and the world at large.

5.2.2 Trend in Manpower Structure within the Farms over the Past Five Years

Data in Table 6 and Figure 8 show a positive growth in the manpower strength of farms in Nigeria over the past five years, while Liberia had a positive growth up till 2008 and a downward trend in the 2009. However, Sierra Leone have had an unstable manpower trend (both upward and downward trend) over the past five years. The data on the Table further show that the manpower structure in the farms are dominated by farm labourers followed by management staff, with technical staff being the least in most cases.

Table 5: Trend i manpower structure within the farms over the past five years

	Nigeria	Sierra Leone	Liberia
Training, experience and skills			
Highest academic qualification			
No formal education	14.3	59.0	37.5
Primary school	17.3	14.8	20.5
Secondary school	27.5	22.8	31.6
Certificate Course / Diploma	23.5	3.2	9.6
University education	17.5	0.2	0.7
Years of farming experience			
1-10	26.2	30.1	46.7
11-20	33.7	38.5	28.8
21-30	18.7	23.0	15.1
Above 31	21.4	8.7	9.4
Mean farming experience	21.55	17.62	15.04
Do you have specialized training in Climate Change adaptation and /or food Security issues			
Yes	1.8	2.5	0.7
No	98.2	97.5	99.3
Do any members of your family or farm workers have specialized training in Climate Change adaptation and /or food Security issues			
Yes	2.2	1.0	0.2
No	98.8	99.0	99.8
Does your farm provide opportunities for training staff / family members			
Yes	3.0	0.2	0.2
No	97.0	99.8	99.8

Table 6: Distribution of rural households by training, experience and skills possessed

Manpower Trend	2005			2006			2007		
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Management	1.32	2.13	1.12	1.37	2.05	1.16	139	2.05	1.21
No. of Technical staff	0.85	0.00	1.21	0.84	0.00	1.21	0.96	0.00	1.25
No. of labourers / family members	1.89	2.19	1.36	1.92	2.01	1.40	1.80	2.17	1.58
Overall mean	**4.06**	**4.32**	**3.69**	**4.13**	**4.06**	**3.77**	**4.15**	**4.22**	**4.04**

Manpower Trend	2008			2009		
	A	**B**	**C**	**A**	**B**	**C**
Management	1.43	1.98	1.24	1.46	1.99	1.25
No. of Technical staff	0.98	0.00	1.36	1.01	0.00	1.28
No. of labourers / family members	1.86	2.15	1.71	1.91	2.27	1.72
Overall mean	**4.27**	**4.13**	**4.31**	**4.38**	**4.26**	**4.25**

A: Nigeria

B: Sierra Leone

C: Liberia

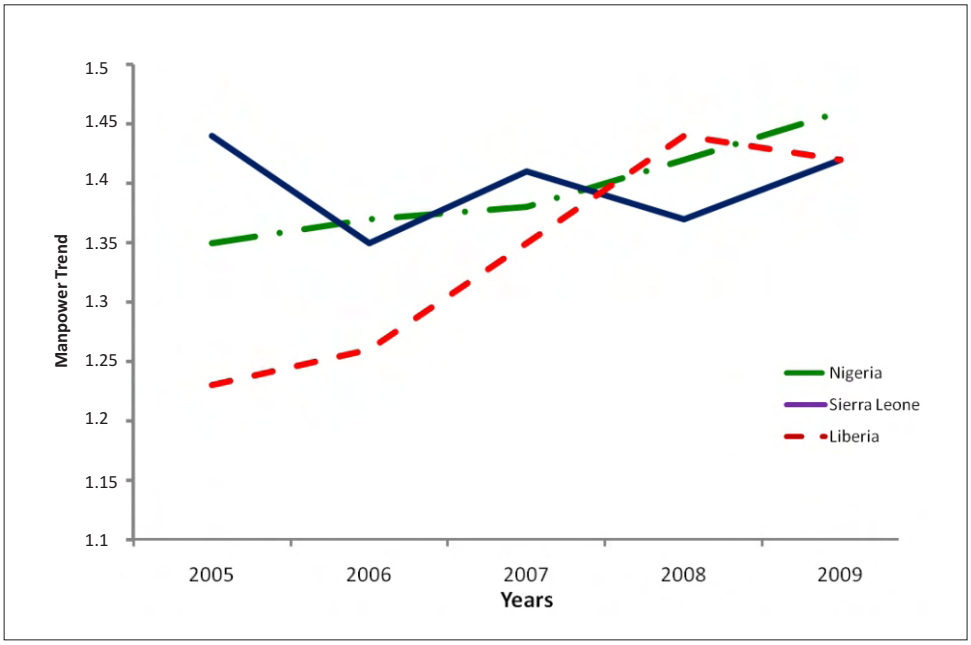


Figure 8: Trends in manpower structure of farms in Nigeria, Sierra Leone and Liberia over the past 5 years.

5.3 SOURCES AND TRENDS OF ENTERPRISE FUNDING IN NIGERIA, SIERRA LEONE AND LIBERIA OVER THE PAST FIVE YEARS

5.3.1 Trends in enterprise funding from self generated sources in Nigeria, Sierra Leone and Liberia

Data in Figure 9 show that Sierra Leone has the highest level of investment in farms from self generated sources over the past four years, while Liberia has the lowest level of investment from this source. However, Nigeria has had an unstable flow of funds from self generated sources with 2006 and 2008 being the lowest over the past five years.

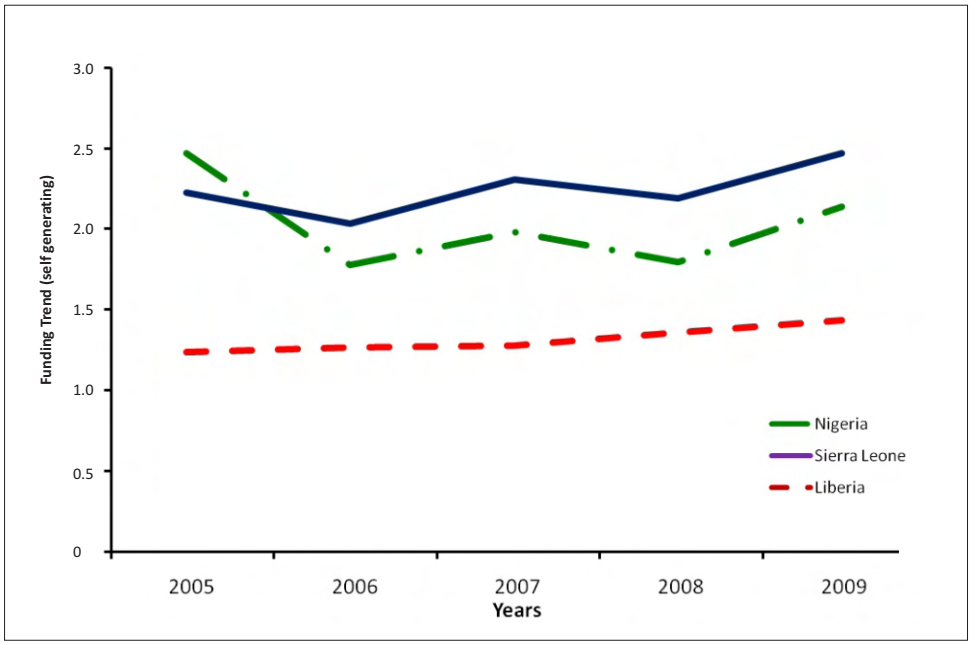


Figure 9: Funding trends form self generated sources in Nigeria, Sierra Leone and Liberia

5.3.2 Trends in enterprise funding from government (subsidies) in Nigeria, Sierra Leone and Liberia

Figure 10 shows that farmers in Sierra Leone and liberia percieved funding from government (subsidies) to be stable over the past five years, though at a higher level in Sierra Leone than Liberia. However, tha data from Nigeria shows an unstable government support for the enterprises over the past five years, with the lowest being in 2006 and 2008, but suppasing the funding in the other two countries towards the end of 2009.

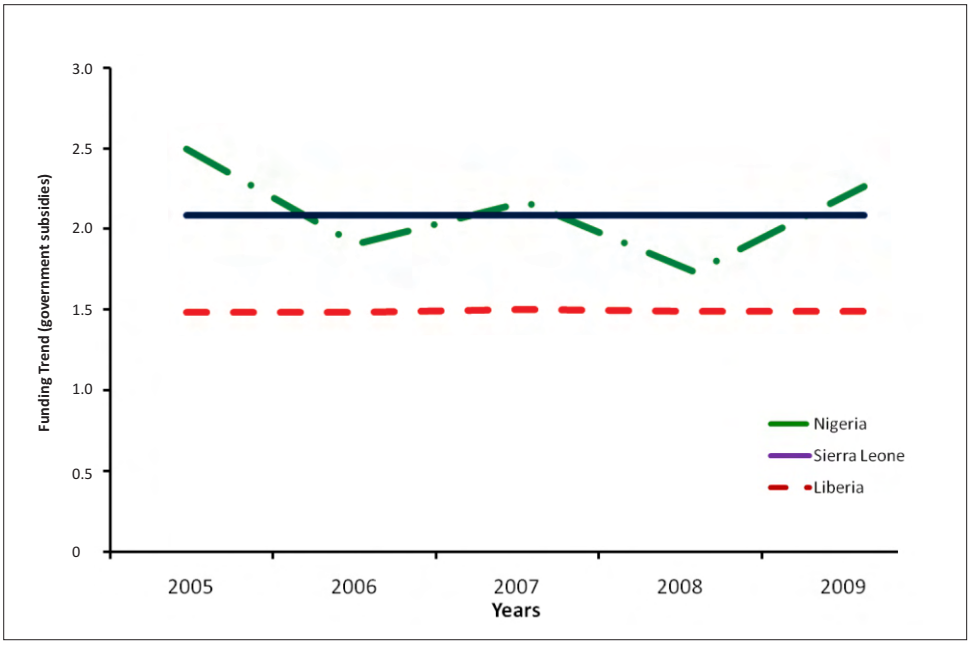


Figure 10: Trends in enterprise funding from government (subsidies) in Nigeria, Sierra Leone and Liberia

5.3.3 Trends in enterprise funding from private sector (loans) in Nigeria, Sierra Leone and Liberia

Data in Figure 11 shows the trend in enterprise funding from the private sector in form of loans received for investment in the farms. The data show that Nigeria seem to have higher volume of inflows from the private sector in support of enterprise investments, however there seem to be fluctuations in the inflows, which recorded the lowest support in 2006. On the other hand, data from Sierra Leone and Liberia shows a more stable financial inflow from the private sector over the past five years, with Sierra Leone having a higher level of financial support than Liberia between 2005 and 2009.

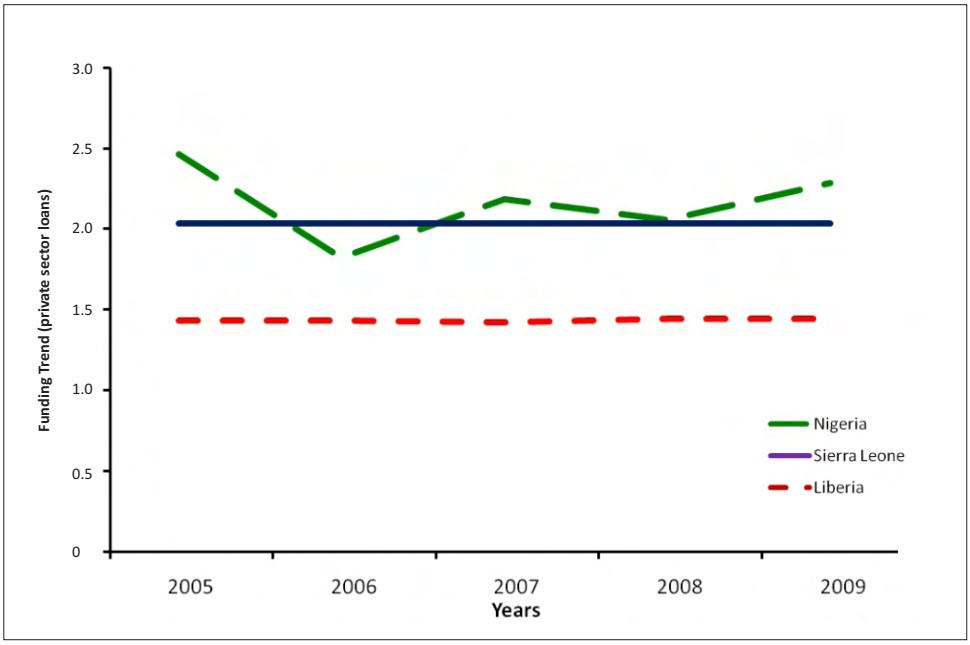


Figure 11: Trends in enterprise funding from private sector (loans) in Nigeria, Sierra Leone and Liberia

5.3.4 Trends in enterprise funding from donor sources in Nigeria, Sierra Leone and Liberia

Figure 12 shows that Nigeria had higher level of financing from donor sources than Sierra Leone and Liberia over the past five years, except for 2006. The data also show that Sierra Leone and Liberia had a more stable financial inflow from donor source over the past five years, with Sierra Leone having a higher level of financial support than Liberia between 2005 and 2009.

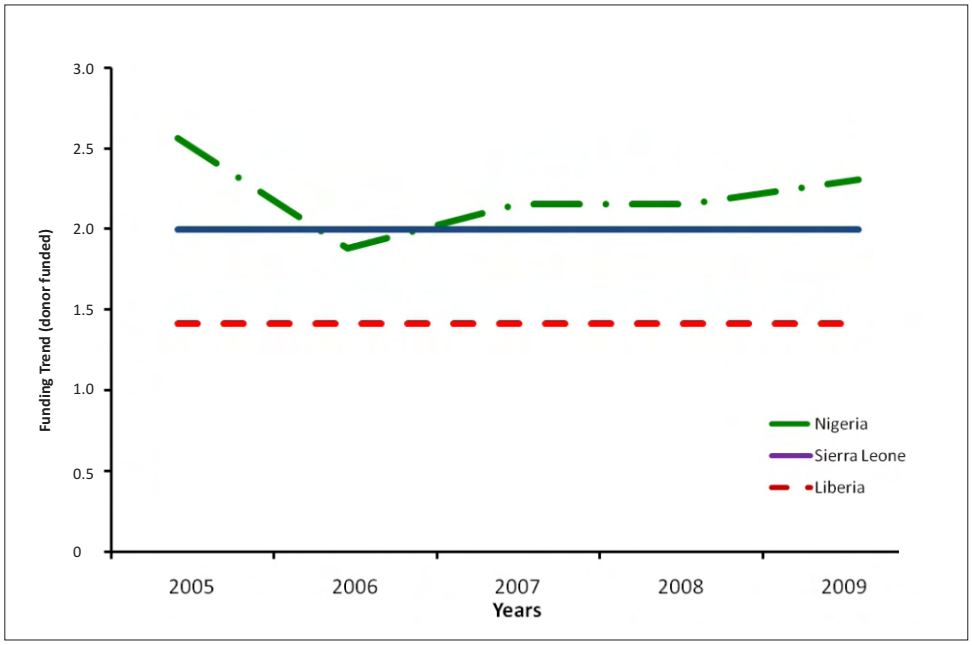


Figure 12: Trend in enterprise funding from donor sources in Nigeria, Sierra Leone and Liberia

5.4 PERCEIVED TREND OF CLIMATE CHANGE PHENOMENON IN NIGERIA, SIERRA LEONE AND LIBERIA

5.4.1 Uncertainties on the onset of farming season

Data in figure 13 shows that Liberia have had an increasingly higher level of uncertainties in the onset of farming seasons than Sierra Leone and Nigeria since 2006 arising from a combination of the following factors: unusual early rains that are followed by weeks of dryness; erratic rainfall pattern; delay in the unset of rains; long period dry seasons; long period of rainfall in some areas; short period of rainfall in some areas and reduced period of harmattan. On the other hand data from Nigeria and Sierra Leone show a relative stability in the onset of farming seasons, even though the farmers experienced a delayed shift in the onset of farming seasons in these countries in the past few years, mainly due to delayed and erratic onset of rains.

Adaptation to climate change requires that farmers and / or communities first notice that the climate has changed, and then identify useful adaptations measures and implement them (Maddison, 2006).

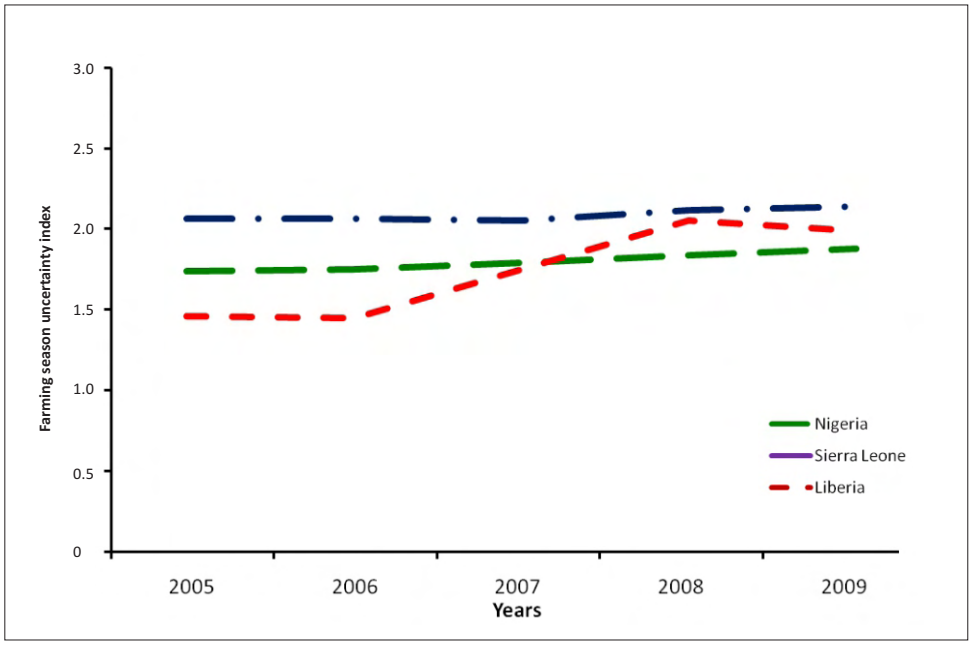


Figure 13: Perceived trend in uncertainties on the onset of farming season in Nigeria, Sierra Leone and Liberia.

5.4.2 Extreme weather events

Data in Figure 14 show that Liberia has the highest level of increase in the trend of extreme weather events occasioned by thunderstorms, heavy winds, flooding , heavy rainfall and erosion, among other weather conditions since 2006. Rural households in Sierra Leone also perceived a slight increase in the extreme weather events since 2006 and at the same time has a higher extreme weather event than Nigeria over the past 5 years. On the other hand, data from Nigeria reveal a relatively stable weather condition up till early 2007 and an upward trend in extreme weather condition between 2007 and 2008. However, they perceived a downward trend in extreme weather conditions between 2008 and 2009.

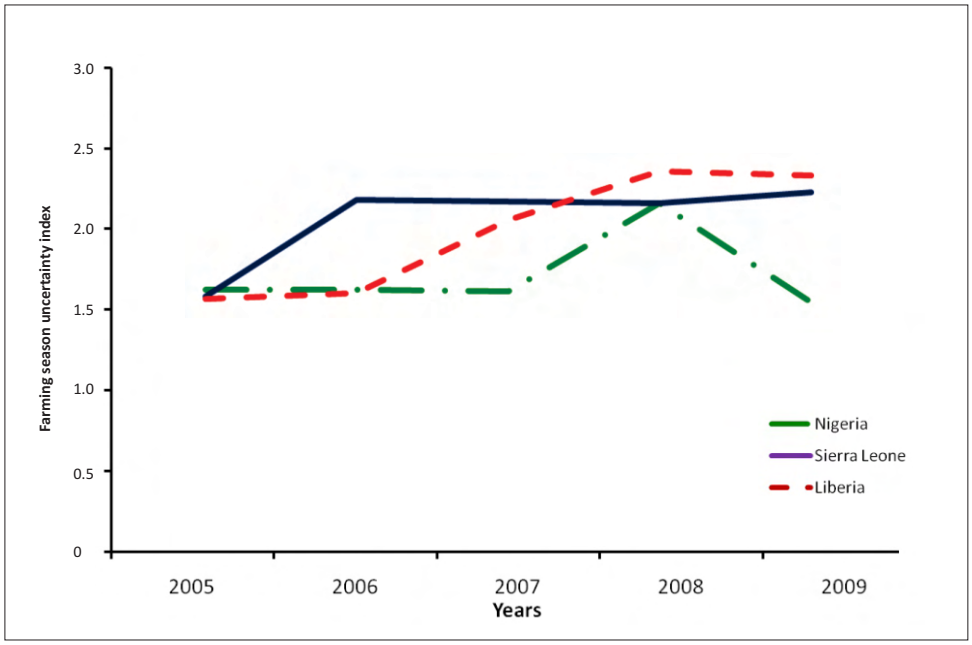


Figure 14: Perceived trend in extreme weather events in Nigeria, Sierra Leone and Liberia.

5.4.3 Farming Problems

Figure 15 reveals a perceived increase in the trend of farming problems (including disease incidence, weed infestation, soil infertility, over flowing/ drying up of streams / rivers, low farm yields and landslides) in Liberia between 2006 and 2009, than in Nigeria and Sierra Leone. On the other hand, data from Nigeria and Sierra Leone show a stabilized trend in farming problems over the past five years, with Sierra Leone showing a higher level of problems than Nigeria across the years.

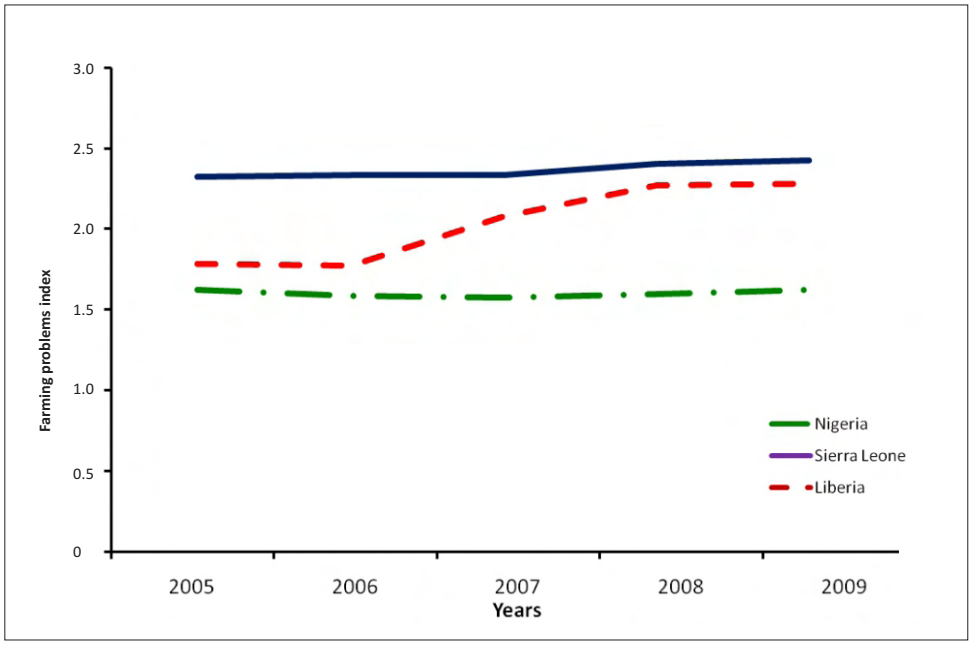


Figure 15: Perceived trend in farming problems in Nigeria, Sierra Leone and Liberia.

5.5 PERCEIVED CAUSES OF CLIMATE CHANGE

Entries on Table 7 show that respondents from Nigeria perceived burning of fossil fuel by industries (x=3.24), use of generator to generate electricity by many households (=3.02), gas flaring from oil companies (=3.21), burning of fossil fuel from vehicles, machines (motorcycles) (=3.05), gases released from industries (=3.29), high temperature due to the depletion of ozone layer (=3.39), emission of green house gases (e.g. methane) (=3.07) and crude oil spillage (=3.04) as major causes of climate change. This finding is in agreement with Lohnman (2006), who opined that climate change is closely associated with the burning of oil, coal or gas.

Field evidence from Nigeria shows that gas is flared continuously in the oil producing communities of the Niger Delta region of Nigeria (Figure 16), which daily leads to the release of the greenhouse gases which are responsible for the changing climate. This perceived situation can be attributed to carelessness of oil industries in oil spillage, natural gas flaring, over exploitation of natural resources, extensive dam construction, and unfavourable farm practice methods found in the area. As majority of the people living in the Niger Delta are farmers and fishermen, the environmental and social consequences of climate change is putting livelihoods at serious risks. Unfortunately, the deadline to put an end to gas flaring in Nigeria has been postponed from 2008 to 2009 and then 2011.

Other perceived causes of climate change in Nigeria include bush burning (=3.04), cutting down of trees (=2.88), and over grazing of farmland by livestock (=2.64). This result is also in agreement with the fact that burning of coal, oil and natural gas, as well as deforestation and various agricultural and industrial practices, are altering the composition of the atmosphere and contributing to climate change (www.gcrio.org).

Figure 16: A site of gas flaring at Escravos, Warri Delta state Nigeria

Respondents from Sierra Leone perceived the use of firewood for cooking (x=2.66), bush burning (=3.09), cutting down of trees (=3.10) and swamp rice production (=2.56) as major causes of climate change in Sierra Leone. On the other hand, respondents from Liberia perceived the following as causes of climate change: burning of firewood for cooking (=2.86), over grazing of farmland by livestock (=3.10), use of excess chemical in farmlands e.g. fertilizer, herbicides etc (=3.12), swamp reclamation (=3.10) and swamp rice production (=3.39).

The implication of this finding is that human activities are to a large extent the major causes of climate change as most of their industrial or agricultural activities lead to increase concentrations of green house gases in the atmosphere.

Table 7: Mean scores of perceived causes of climate change in Nigeria, Sierra Leone and Liberia

	Nigeria		Sierra Leone		Liberia	
Perceived causes of climate change	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Burning of fossil fuel by industries	3.24*	0.89	1.96	1.13	1.76	0.61
Use of generator to generate electricity by many households	3.02*	0.82	1.86	1. 05	2.28	0.76
Gas flaring from oil companies	3.21*	0.82	1.86	1.07	2.02	0.77
Burning of firewood for cooking	2.17	1.01	2.66*	1.09	2.86*	0.99
Bush burning	3.04*	0.83	3.09*	1.13	2.31	0.88
Burning of fossil fuel from vehicles, machines (motorcycles)	3.05*	0.78	1.85	1.07	2.15	0.83
High use of irrigation which changes the amount of water going into and out of a given location	2.20	0.85	1.63	0.91	3.16*	0.79
Cutting down of trees	2.88*	0.89	3.10*	1.15	1.68	0.66
Over grazing of farmland by livestock	2.64*	0.9 2	2.44	0,96	3.10*	0.87
Gases released from industries	3.29*	0.80	1.90	1.11	2.00	0.73
High temperature due to the depletion of Ozone layer	3.39	0.87	2.41	1.10	1.90	0.89
Use of excess chemical in farmlands e.g. fertilizer, herbicides, pesticide etc.	2.49	0.96	1.69	1.01	3.12*	0.91
Emission of green house gases (e.g. CO_2, methane)	3.07*	0.93	1.77	1.02	1.92	0.96
Swamp reclamation	2.31	0.84	1.58	0.77	3.10*	0.81
Swamp rice production	2.17	0.83	2.56*	1.24	3.39*	0.71
Crude Oil spillage	3.04*	0.92	1.83	1.10	2.01	0.88

5.6 INNOVATIVE CLIMATE ADAPTATION MEASURES USED BY FARMERS OVER THE PAST FIVE YEARS

Entries on Table 8 revealed the adaptation measures been used by farmers in the three countries. In Nigeria, the identified measures included: mulching (74.1%), increased weeding of cultivated areas (63.9%), increased use of fertilizers, seeds (57.0%), intensive manure application (53.0%), planting of trees (23.3%), and use of resistant varieties (38.7%). Other measures were processing to minimize post – harvest loss (51.8%), expansion of cultivated land areas (26.3%), use of chemicals: herbicides, pesticides (55.3%), change in timing of land preparation (30.1%), changes in planting dates (38.0%), practicing zero/ minimum tillage (38.5%), changes in harvesting dates (30.0%), multiple cropping (planting of many crops in the same piece of land) (42.9%) and mixed farming (crop and animal production) (29.4%) construction of drainage systems (26.3%), planting of early maturing crops (30.8%) and prayers for God's intervention (58.1%).

In Sierra Leone, the adaptation measures were cultivating in wetlands/river valley e.g. Fadama (45.6%), expansion of cultivated land areas (27.6%), increased use of fertilizers, seeds (60.0%), increased weeding (62.2%), movement to a different site (51.8%), changes in planting dates (40.4%), multiple cropping (planting of many crops in the same piece of land) (49.1%), relay cropping – planting and harvesting in succession (39.8%), intercropping – main crops planted with subsidiaries at low densities (42.4%), prayers for God's intervention (70.0%) and planting of early maturing crops (41.1%).

While in Liberia, the adaptation measures been used by the respondents were expansion of cultivated land area (27.6%), increased weeding (47.8%), movement to a different site (47.8%), multiple cropping (planting of many crops in the same piece of land) (37.2%) and prayers for God's intervention (60.6%).

Table 8: Mean percentage distribution innovative climate change adaptation measures used by farmers over the past five years

Innovative climate adaptation measures as used by farmers	Nigeria	Sierra Leone	Liberia
Ground water harvesting	11.9	37.6	18.1
Mulching / use of cover crops	74.1	5.4	5.0
Cultivating in wetlands / river valleys (e.g. Fadama)	17.8	45.5	14.9
Construction of drainage systems	26.3	12.9	8.1
Planting of trees	23.3	4.9	3.7
Use of resistant varieties	38.7	5.0	5.0
Processing crops to minimize post-harvest losses	51.8	15.7	4.3
Expansion of cultivated land area	26.3	44.3	27.6
Increased use of fertilizers, seeds	57.0	60.0	11.6
Intensive manure application	53.0	20.0	5.0
Increased weeding	63.9	62.2	74.4
Use of chemicals: herbicides, pesticides etc	55.3	10.0	11.3
Moved to a different site	19.1	51.8	47.8
Change in the timing of land preparation activities	30.1	10.3	18.7
Changes in planting dates	38.0	40.4	21.8
Practicing zero / minimum tillage	38.5	4.5	3.4
Changes in harvesting dates	30.0	36.4	15.8
Multiple cropping (planting of many crops in the same piece of land)	42.9	49.1	37.2
Mixed farming (crop and animal production)	29.4	9.7	7.7
Relay cropping-planting and harvesting in succession	14.2	39.8	2.9
Intercropping - main crops planted with subsidiaries at low densities	19.0	42.4	14.7
Decreasing animal stock	11.9	0.7	1.9
Change from animal production to crop production	8.4	0.2	1.7
Prayers for God's intervention	58.1	70.0	60.6
Planting of early maturing crops	30.8	41.1	3.8

5.7 PROBLEMS ENCOUNTERED BY FARMERS IN ADAPTING TO THE EFFECTS OF CLIMATE CHANGE

Entries in Table 9 show that the three countries under study encountered similar problems in their efforts to adapt to the negative effects of climate in the various countries. The constraints experienced in Nigeria, Sierra Leone and Liberia respectively, included: poor access to information relevant to adaptation (x= 2.60, 2.88 and 2.77), lack of financial resources (= 2.50, 2.87 and 2.62), poor/low extension services (= 2.48, 2.78 and 2.58) and lack of access to weather forecasts (= 2.04, 2.67 and 2.51). The problems imposed by information lack, and poor extension services in the three countries point to the fact that there could be limited extension activities on climate change adaptation in the three countries. There is need therefore to have an enduring system through which information can be disseminated, as information exist currently at the global levels on measures of adapting to the changing climate.

Other problems encountered in the three countries respectively, were: high cost of improved crop varieties (=2.42, 2.77 and 2.08), absence of governments policy on climate change (=2.35, 2.66 and 2.35), non availability of credit facilities (=2.49, 2.30 and 2.38), limited knowledge on adaptation measures (=2.28, 2.64 and 2.52) and poor response to crises related to climate change by the governments agencies and interest groups (=2.36, 2.52 and 2.26).

Further problems included: non availability of processing facilities (=2.17, 2.03 and 2.00), inadequate knowledge on how to cope adequately (=2.21, 2.50 and 2.22) and high cost of farm labour (=2.38, 2.17 and 2.04). These findings reveal some level of disconnect among the major stakeholders across the three countries under study. The findings also show that the respondents have very limited knowledge on effective adaptation measures to combat the negative challenges of climate change. This means that more efforts should be channeled by the government of the three countries in putting in place appropriate policies on climate change. Again, research should build up more adaptation measures so that the respondents can be exposed to a variety of options on adaptation as best suits their environment.

Table 9: Mean scores on problems encountered by farmers in adapting to the effects of climate change

Problems encountered in adapting to the effects of climate change	Nigeria		Sierra Leone		Liberia	
	Mean	S.D	Mean	S.D	Mean	S.D
Poor access to information source relevant to adaptation	2.60	0. 60	2.88	0.36	2.77	0.45
Type of land tenure system practiced in my area	2.00	0.67	1.75	0.79	1.42	0.68
Ineffectiveness of indigenous strategies	1.98	0.76	2.52	0.74	1.38	0.59
Traditional beliefs/ practices does not allow me to use the adaptive strategies	1 .67	0.76	1.45	0.69	1.28	0.56
Lack of financial resources	2.50	0.54	2.87	0.37	2.62	0.54
Poor/low extension services	2.48	0.66	2.78	0.48	2.58	0.51
Lack of access to weather forecasts	2.04	0.76	2.67	0.57	2.51	0.56
Limited access to improved crop varieties	2.24	0.65	1.87	0.83	2.18	0.74
Lack of access to improved livestock breeds	2.23	0.79	2.23	0.80	1.99	0.87
High cost of improved crop varieties	2.42	0.58	2.77	0.47	2.08	0.72
Non-availability of storage facilities	2.01	0.74	1.97	0.85	1.93	0.85
Absence of government policy on adaptation	2.35	0.62	2.66	0.59	2.35	0.58
Non-availability of credit facilities	2.49	0.62	2.30	0.78	2.38	0.68
Limited knowledge on adaptation measures	2.28	0.68	2.64	0.67	2.52	0.56
Poor response to crises related to climate change by the governments agencies and interest groups	2.36	0.66	2.52	0.72	2.26	0.75
Risk of adaptation	1.95	0.71	2.49	0.77	2.09	0.57
High cost of fertilizers and other inputs	2.41	0.58	2.75	0.49	1.72	0.79
High cost of irrigation facilities	2.43	0.65	2.73	0.55	1.71	0.87
Non-availability of farm inputs	2.00	0.76	1.95	0.85	1.80	0.62
Non-availability of processing facilities	2.17	0.71	2.03	0.86	2.00	0.82
Inadequate knowledge of how to cope	2.21	0.67	2.50	0.72	2.22	0.68
Non-availability of farm labour	2.01	0. 74	1.56	0.66	1.63	0.61
High cost of farm labour	2.38	0.60	2.17	0.74	2.04	0.53

5.7.1 Factor Analysis of Constraints

The data were further subjected to exploratory factor analysis in order to group the constraints variables for policy implications. The result of the rotated component matrix showing the extracted factors, based on the response of respondents is shown in Table 10. The results show that three constraint factors were extracted based on the responses of the respondents. Only variables with loadings of 0.40 and above (10% overlapping variance; Comrey, 1962) were used in naming the factors. Factors 1, 2 and 3 were named institutional problems, traditional factors and government failures, respectively, on the basis of the

different variables that loaded high when problems encountered by respondents from Nigeria were examined.

Factors which loaded under institutional problems (Factor 1) include: high cost of improved crop varieties (0.41), non-availability of storage facilities (0.57), absence of government policies on adaptation (0.58), poor response to crises related to climate change by government agencies and interest groups (0.68), high cost of fertilizer and other inputs (0.60), non-availability of processing facilities (0.78), inadequate knowledge on how to cope (0.68), non-availability of farm labour (0.71) and high cost of farm labour (0.71). respondents; ignorance of the availability of policies on climate change is an indication that the government has to intensify efforts to ensure that appropriate policies on climate change are enacted and awareness of these policies created among the general populace. This will provide and carter for the rural poor who bear the brunt of the damages caused by climate change. Also, the non availability and high cost of farm labour portrays the need for increased in mechanization of agricultural processes.

Factors that loaded under government failures include: poor access to information source relevant to adaptation (0.71), lack of financial resources (0.65), poor/low extension services (0.80), lack of access to weather forecasts (0.66) and limited access to improved crop varieties (0.74). Irregularities of extension services discourage farmers as it brings about inconsistencies and lack of follow up on previously disseminated information. Limited access to improved crop varieties is a government problem. Interactions during the FGDs reveal the absence of weather information from meteorological stations to the general public.

Factors that loaded under traditional factors included: type of land tenure systems (0.82), ineffectiveness of indigenous strategies (0.65) and lack of access to improved livestock breeds.

With regards to Sierra Leone, factors 1, 2, and 3 were named production problems, institutional problems and government problems respectively. The factors that loaded under production problems included: type of land tenure system practiced in the area (0.79), limited access to improved crop varieties (0.77), lack of access to improved livestock breeds (0.54), non-availability of

storage facilities (0.78), non-availability of credit facilities (0.60), non-availability of farm inputs (0.82) and non-availability of processing facilities (0.79).

Factors that loaded under institutional problems were: ineffectiveness of indigenous strategies (0.75), lack of financial resources (0.52), poor/low extension services (0.80), lack of access to weather forecasts (0.73), absence of government policy on adaptation (0.7.0) and limited knowledge on adaptation measures (0.78).

Factors that loaded under government factors included: high cost of improved crop varieties (0.45), poor response to crises related to climate change by government agencies and interest groups (0.55), high cost of fertilizers and other inputs (0.70) and non availability of farm labour (0.54).

For Liberia, factors 1, 2 and 3 were named information / financial problems, traditional problems and government problems respectively. Factors that loaded under information problems were limited access to improved livestock breeds (0.87), high cost of improved crop varieties (0.81),lack of financial resources (0.72), poor / low extension services (0.48), limited access to improved crop varieties (0.78), non availability of credit facilities (0.81), limited knowledge on adaptation measures (0.58), poor response to crises related to climate change by government agencies and interest groups (0.88), high cost of irrigation facilities (0.88), non availability of processing facilities (0.93) and inadequate knowledge on how to cope (0.71). These findings further point to the need to have an enduring system of information dissemination in the rural communities. This need falls within the purview of the extension workers whose prerogative it is to disseminate information to farmers/rural people aimed at increasing their knowledge level on relevant matters as it affects them.
Factors that loaded under traditional problems included type of land tenure system practiced in the area (0.84), traditional beliefs/practices does not allow farmers use adaptive strategies (0.70) and high cost of farm labour (0.66).

Factors that loaded under government problems were lack of access to weather forecasts (0.73) and absence of government policies on adaptation (0.54).

Table 10: Factor analysis of problems encountered by farmers in adapting to the effects of climate change

Problems	Nigeria			Sierra Leone			Liberia		
	1	2	3	1	2	3	1	2	3
Poor access to information source relevant to adaptation	0.15	0.71	0.13	-0.18	0.28	-0.06	0.35	0.18	-0.28
Type of land tenure system practiced in my area	0.03	0.07	0.82	0.79	-0.21	-0.03	0.22	0.84	0.02
Ineffectiveness of indigenous strategies	-0.12	0.33	0.65	-0.21	0.75	0.24	0.43	0.76	-0.13
Traditional beliefs/ practices does not allow me to use the adaptive strategies	0.20	0.25	0.34	0.19	-0.29	-0.02	0.22	0.70	0.16
Lack of financial resources	0.12	0.65	0.39	0.03	0.52	0.06	0.72	-0.00	0.19
Poor/low extension services	0.17	0.80	-0.01	0.03	0.80	0.32	0.48	0.36	0.15
Lack of access to weather forecasts	0.19	0.66	0.06	-0.04	0.73	0.26	0.10	0.04	0.73
Limited access to improved crop varieties	0.13	0.74	0.23	0.77	-0.12	-0.17	0.78	0.05	0.32
Lack of access to improved livestock breeds	-0.03	0.23	0.72	0.54	-0.02	-0.08	0.87	-0.10	0.06
High cost of improved crop varieties	0.41	0.37	0.36	0.17	0.35	0.45	0.81	0.18	-.07
Non-availability of storage facilities	0.57	0.26	0.10	0.78	-0.06	0.09	0.86	-0.03	0.54
Absence of government policy on adaptation	0.58	0.40	-0.06	0.02	0.70	0.27	0.39	0.35	0.54
Non-availability of credit facilities	0.51	0.23	0.48	0.60	0.32	-0.18	0.81	0.05	0.12
Limited knowledge on adaptation measures	0.52	0.46	-0.01	-0.11	0.78	0.10	0.58	0.05	-0.00
Poor response to crises related to climate change by the governments agencies and interest groups	0.68	0.26	-0.02	-0.37	0.31	0.55	0.88	.023	0.26
Risk of adaptation	0.43	-0.05	0.60	-0.47	0.23	0.55	-0.17	0.42	0.40
High cost of fertilizers and other inputs	0.60	0.12	0.4	-0.29	0.16	0.70	0.58	0.40	0.38
High cost of irrigation facilities	0.37	-0.16	0.8	-0.02	0.42	0.58	0.88	0.14	-0.17
Non-availability of farm inputs	0.81	0.03	0.12	0.82	-0.12	0.16	0.15	0.40	0.58
Non-availability of processing facilities	0.78	-0.02	0.16	0.79	-0.12	0.09	0.93	0.01	-0.03
Inadequate knowledge of how to cope	0.68	0.23	-0.01	-0.15	0.44	0.59	0.71	0.29	0.35
Non-availability of farm labour	0.71	0.07	0.17	0.23	-0.30	0.54	-0.44	0.70	0.14
High cost of farm labour	0.71	0.16	0.17	0.15	0.07	0.35	-0.19	0.66	0.25

1 = Nigeria; 2 = Sierra Leone; 3 = Liberia

5.8.1 Problems of Satisfying Household Food Needs

Figure 17 shows that rural households in Nigeria (32.3%), Sierra Leone (33.5%) and Liberia (28%), sometimes have difficulties in satisfying family food needs. About 20% of households in Nigeria perceived seldom problems in satisfying family food needs; in Sierra Leone and Liberia respectively, 20% and 27% of the rural households noted that they perceived problems seldomly in meeting family food needs. Only 27.7%, 1.4% and 15.1% of the respondents in Nigeria, Sierra Leone and Liberia respectively reported that they have never experienced or perceived problems in meeting their household family food needs. It can be inferred from the above findings, that rural households across the three countries have difficulties in meeting their food needs.

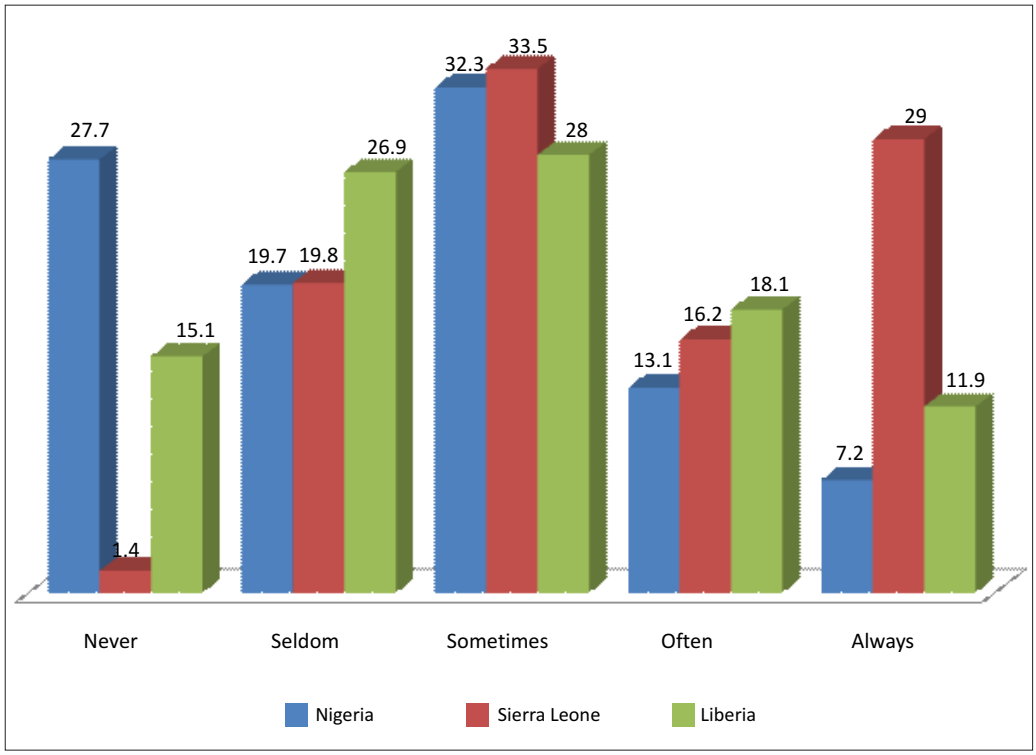


Figure 17: Percentage distribution of rural households by their perceived abilities to satisfy family food needs in Nigeria, Sierra Leone and Liberia

5.8.2 Number of Times Household Feed in a Day

From Figure 18, it is evident that majority (75.8%) of the respondents in Nigeria fed at least three times per day, in Sierra Leone more of the rural households noted that they fed twice (67.2%) per day; while the respondents in Liberia noted that they fed once (40.0%) and twice (50.6%) per day. This shows that on the average, the rural respondents in the three countries were not feeding adequately on daily basis.

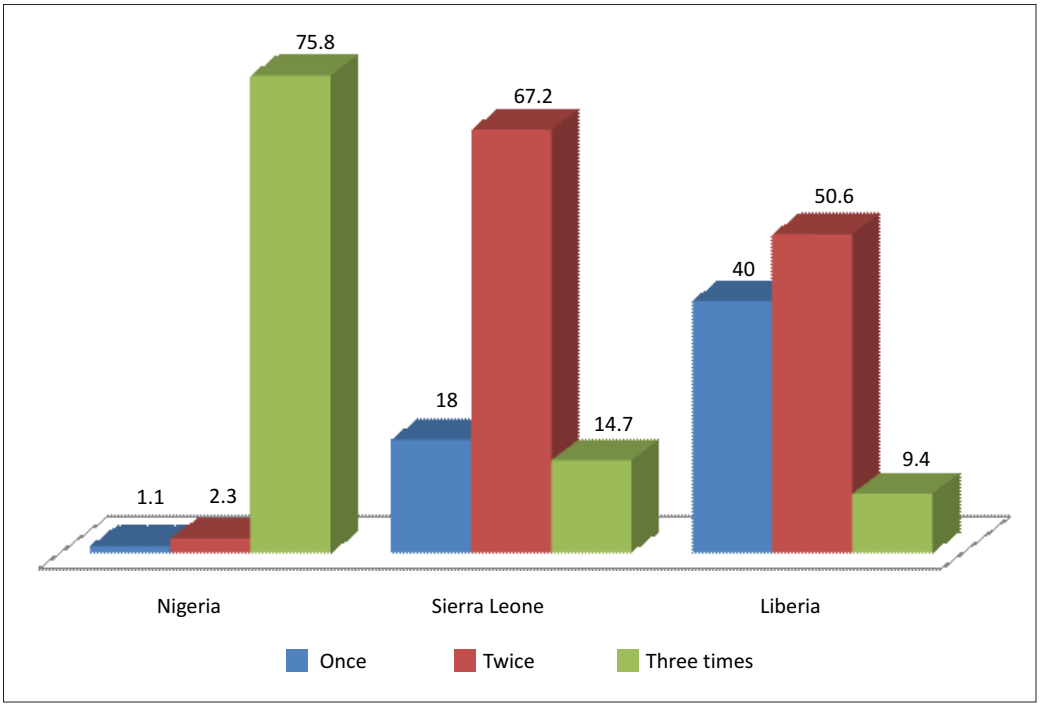


Figure 18: Distribution of rural households by number of times eaten per day

5.8.3 Respondents' Perception of Household Current Food Situations

From Figure 19, it is evident that majority of the respondents from Nigeria (21.4%), Sierra Leone (24.5%) and Liberia (25.9%) perceived the current household food situations as a little worse than what it was previously. About 23% of respondents from Nigeria noted that the situation has remained the same, while 34% of rural households from Sierra Leone and 21% from Liberia noted also that the situation has not changed. Only 23.5% of rural households from Nigeria perceived their current situation to have improved a little better than it was previously. Respondents from Sierra Leone and Liberia respectively (33.8% and

21.2%), noted that there has also been a little improvement on their current food situation over time. This means that on an average note in the three countries under study, there have not been many changes in their current food situations. In order to beef up food security issues and self sufficiency in terms of food production in these countries, there is need to invest more in agricultural production so that the teeming populations food needs can be met appropriately.

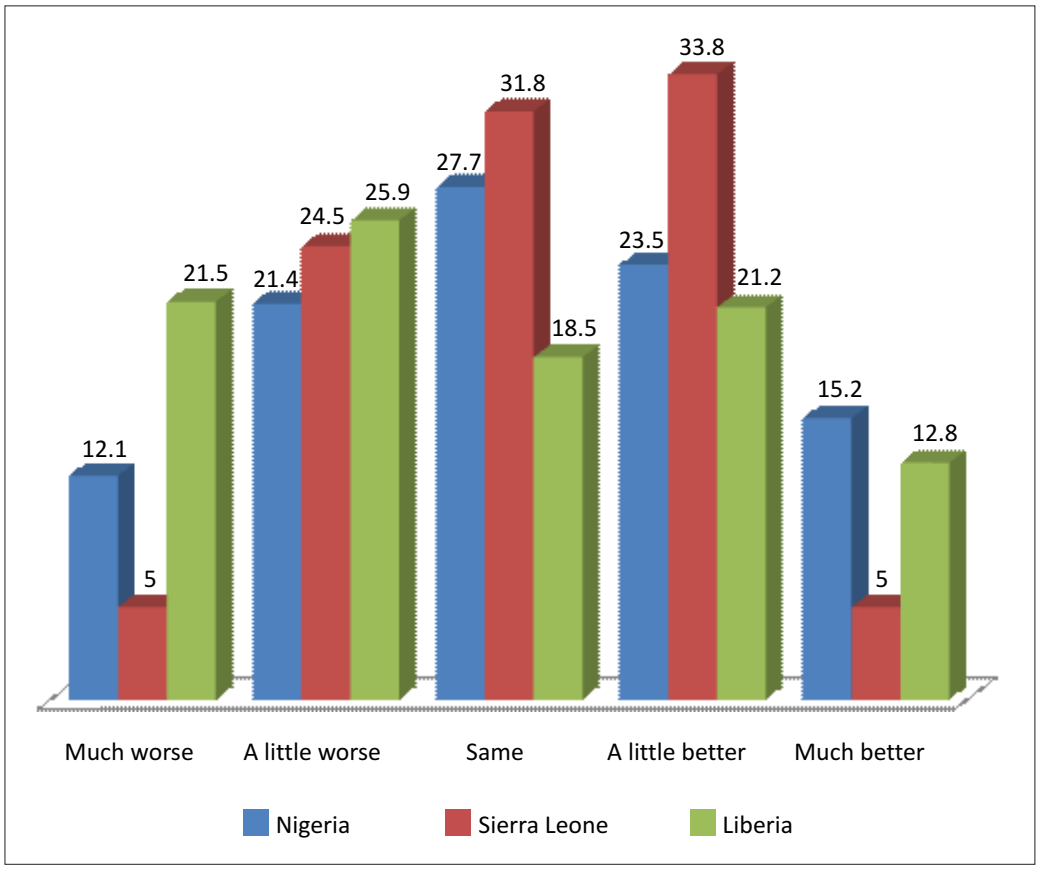


Figure 19: Distribution of respondents by perceived household current food situation in Nigeria, Sierra Leone and Liberia

5.9. INTENSITY AND TRENDS OF LINKAGES/COLLABORATION AMONG KEY ACTORS IN THE CLIMATE CHANGE AND FOOD SECURITY INNOVATION SYSTEM

5.9.1 Existence of Local and Overseas Collaborations in the Climate Change and Food Security Innovation System in Nigeria, Sierra Leone and Liberia

Data in Figure 20 indicated the non – existence of overseas linkages / collaboration in the area of climate change and food security among majority of the rural households across the three countries. The presence of local collaboration was higher in Nigeria (11.0 percent) than in Sierra Leone (2.0 percent) and Liberia (3.2 percent). Collaboration among actors in the climate change and food security innovation system is essential for relevance, capacity building and increase innovative performance of the actors and the system in general. The extent of collaboration also suggests the level of involvement in climate change and food security activities.

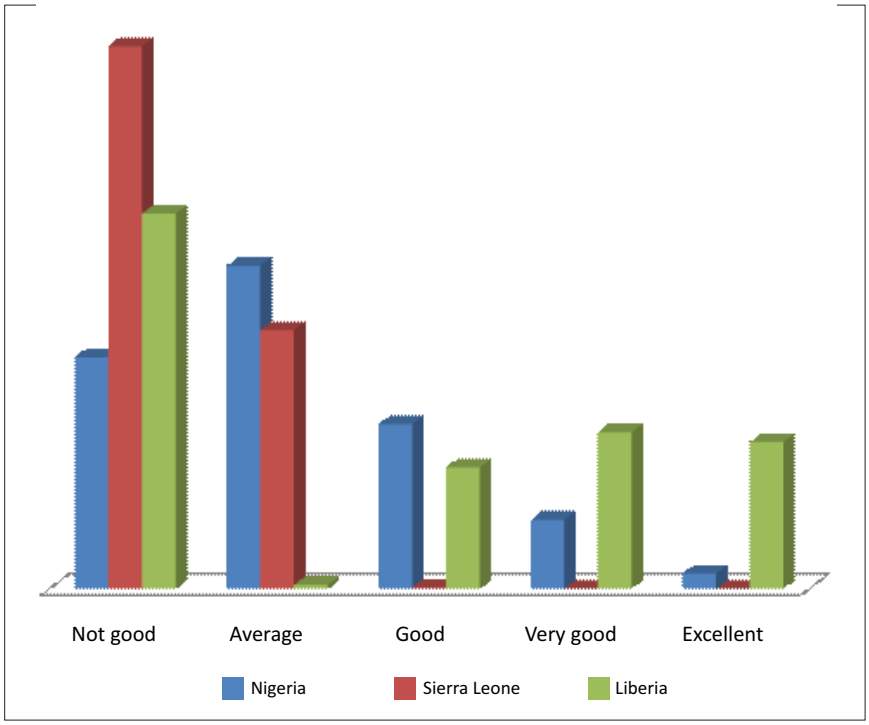


Figure 20: Farmers' reported existence of local and overseas collaborations on climate change and food security in Nigeria, Sierra Leone and Liberia

5.9.2 Intensity of Linkages/Collaborations between Farmers and other Actors in the Climate Change and Food Security Innovation System in Nigeria, Sierra Leone and Liberia

Data on Table 11 reveal that the intensity of linkages / collaborations existing among actors in the enterprise domain, in the three countries, outweighs that with other domains, with higher collaborations existing among the small-scale farmers and famers' associations. Nigeria tends to have higher linkages / collaborations among the actors in all the domains followed by Liberia in three out of the four major domains, while Sierra Leone only showed a higher intensity than Liberia in the area of linkage with policy makers. Collaboration among actors in the climate change and food security innovation system is essential for relevance, capacity building and increase innovative performance of the actors and the system in general. The extent of collaboration also suggests the level of cohesion and/or involvement of the different actors in climate change and food security activities.

Table 11: Mean scores of intensity of linkages/collaborations between farmers and other actors in the climate change and food security innovation system

Collaborating Actors	Nigeria		Sierra Leone		Liberia	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
R &D Agencies Domain						
National agricultural research organization (e. g. NIHORT, FIIRO, NRCRI, IAR, etc.)	2.14	1.17	1.07	0.25	1.09	0.34
Regional agricultural research organization / network	1.36	0.66	1.07	0.25	1.13	0.44
International agricultural research organization / network (e.g. IITA)	2.21	1.46	1.05	0.22	1.05	0.22
Universities	1.89	1.29	1.09	0.34	1.21	0.42
Overall mean	**1.90**	**1.15**	**1.07**	**0.27**	**1.12**	**0.36**
Policy Makers Domain						
National agricultural research council	1.42	0.62	1.14	0.35	1.06	0.30
Policy makers	1.66	1.13	1.19	0.39	1.21	0.41
Standard setting body (e. g. NAFDAC, SON, etc.)	2.06	1.06	1.03	0.18	1.01	0.09
Overall mean	**1.71**	**0.94**	**1.12**	**0.31**	**1.09**	**0.27**
Enterprise Domain						
Small – scale Farmers	2.93	1.08	1.19	0.38	1.42	0.70
Medium – large scale farmers	2.69	1.40	1.17	0.39	1.14	0.44
Farmers Association	2.88	1.35	1.22	0.44	1.25	0.70
Agricultural cooperatives	2.37	1.09	1.22	0.44	1.19	0.49
Financing/ credit/ venture capital	2.44	1.38	1.03	0.17	1.02	0.15
Input suppliers e.g. Seed companies	2.00	1.09	1.03	0.18	1.03	0.17
Agricultural machinery suppliers	1.41	0.69	1.05	0.23	1.04	0.30
Agricultural produce marketers	2.39	1.21	1.09	0.25	1.18	0.48
Consumers of agricultural products	2.81	1.32	1.08	0.21	1.18	0.54
Overall mean	**2.44**	**1.18**	**1.13**	**0.30**	**1.16**	**0.44**
Extension Agencies Domain						
Extension agencies (e. g. ADPs including private extension services)	1.98	1.17	1.12	0.37	1.25	0.46
Federal / State Ministries of Agriculture	1.84	0.91	1.11	0.39	1.33	0.47
Federal / State Ministries of Environment	2.10	1.12	1.05	0.22	1.28	0.45
Overall mean	**1.97**	**1.07**	**1.09**	**0.33**	**1.29**	**0.46**

5.9.3 Linkage Trends between Farmers and R & D Institutions in the Climate Change and Food Security Innovation System in Nigeria, Sierra Leone and Liberia

Figure 21 shows the perceived linkages existing between farmers and research and development institutions between 2005 and 2009 in the three countries. The data reveal a perceived increase in the trend of linkage between the farmers and the R & D institutions in Nigeria between 2007 and 2009, with a linkage index of more than 2. On the other hand, data from Sierra Leone and Liberia show a stabilized trend in their linkage with R &D institutions over the past five years (with

linkage index of less than 2 each), with Sierra Leone showing a higher intensity of linkage than Liberia.

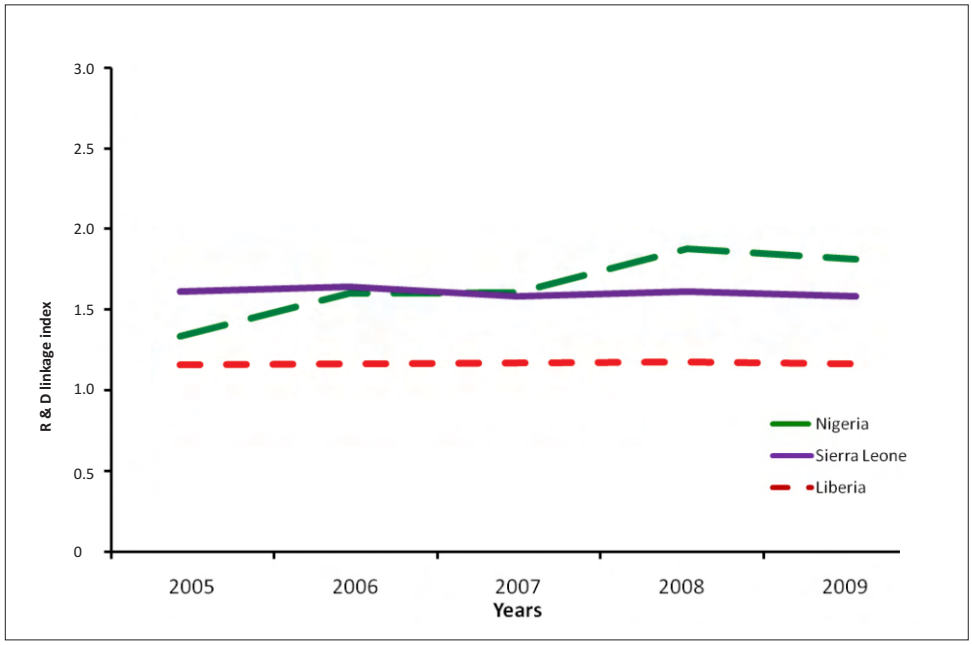


Figure 21: Percieved trend of linkage between farmers and R &D institutions in Nigeria, Sierra Leone and Liberia

5.9.4 Linkage Trends between Farmers and Policy making bodies in the Climate Change and Food Security Innovation System in Nigeria, Sierra Leone and Liberia

Data in Figure 22 show the linkage trend between farmers and policy making bodies in the different countries. The Figure shows a low linkage index of less than 2 for all the countries. However, data from Nigeria show an unstable trend between 2005 and 2008, with an upward trend since 2008. On the other hand, data from Sierra Leone and Liberia reveal a more stable linkage between the farmers and policy making bodies, with Sierra leone having a higher colllaboration intersity than Liberia.

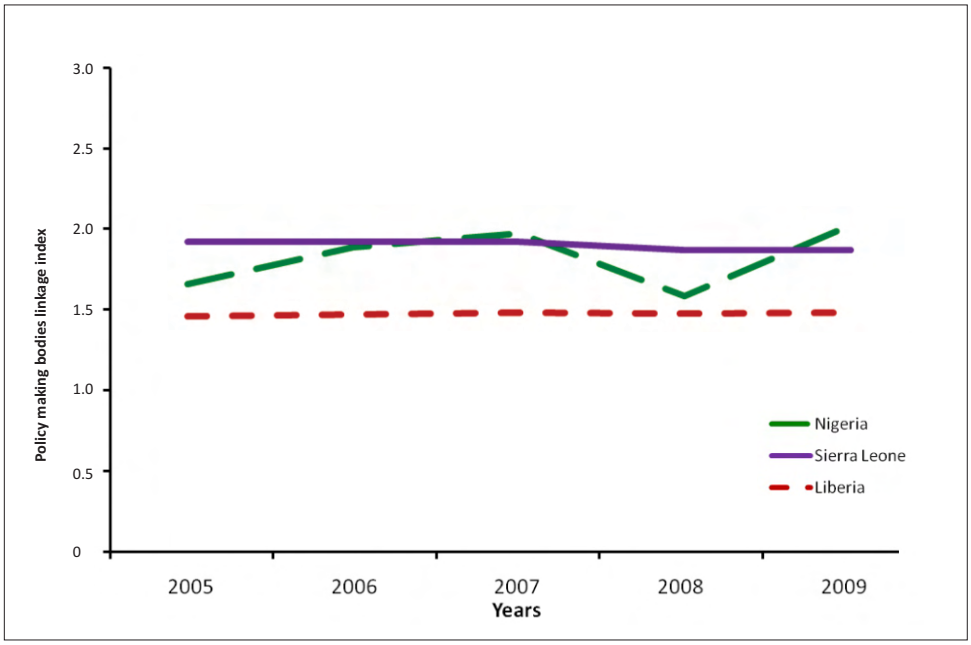


Figure 22: Perceived trend of linkage between farmers and policy making bodies in Nigeria, Sierra Leone and Liberia

5.9.5 Linkage Trends among actors within the enterprise domain in the Climate Change and Food Security Innovation System in Nigeria, Sierra Leone and Liberia

Data in Figure 23 show the linkage trend among key actors (which include Small – scale farmers, medium – large scale farmers, farmers association, agricultural cooperatives, financing/ credit/ venture capital, Input suppliers, agricultural machinery suppliers, agricultural produce marketers and consumers of agricultural products) within the enterprise domain. The data reveal a higher linkage index among these actors than with other actors in the climate change and food security innovation system across the three countries. The data also show an increasing linkage trend among these actors in Nigeria than in Sierra Leone and Liberia, with Sierra Leone showing a higher linkage intersity trend than Liberia.

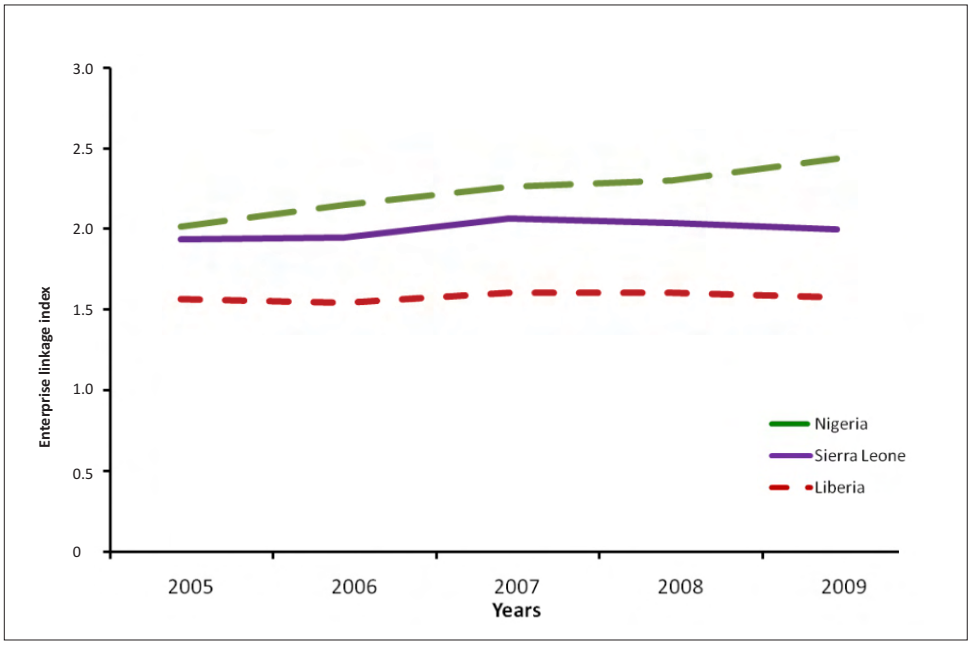


Figure 23: Perceived trend of linkage among actors in the enterprise domain in Nigeria, Sierra Leone and Liberia

5.9.6 Linkage Trends between Farmers and Technology Delivery Institutions in the Climate Change and Food Security Innovation System in Nigeria, Sierra Leone and Liberia

Figure 24 shows the linkage trends between farmers and the technology delivery institutions across the three countries. The data reveal an incresing higher linkage index (of more than 2) between farmers and the technology delivery institutions in Nigeria than in Sierra Leone and Liberia. On the other hand, data from Sierra Leone also shows an uneven increasing linkage trend over the past five years, with Liberia showing a more stable linkage trend between the farmers and technology delivery insitutions. The linkage index between farmers and the technology delivery insitutions in Sierra Leone and Liberia was less than 2.

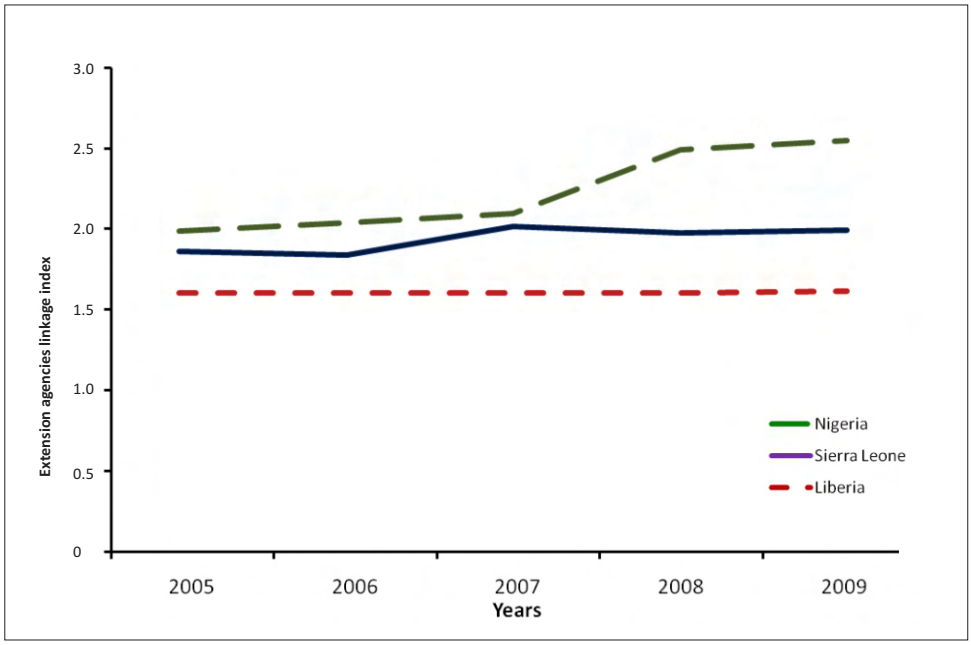


Figure 24: Linkage trends between farmers and technology delivery services in Nigeria, Sierra Leone and Liberia

5.10 PERFORMANCE OF THE SYSTEM ON THE BASIS OF INNOVATION GENERATION

Figure 25 reveals the types of innovation generated by enterprises over the past ten years in Nigeria, Sierra Leone and Liberia. In Nigeria, it is evident that new improved crop varieties / livestock breeds (38.5%), new information (25.2%), new markets for products (16.1%) and upgrading of machinery were the innovation generated over the past ten years. In Sierra Leone, the innovations generated included new markets for products (16.1%) and upgrading of machinery (13.3%). For Liberia, it is evident that over the past ten years, virtually nothing has been done in the area of generating innovations by the enterprises. From this findings, it is clear that innovations are been very poorly generated across the countries under study. Efforts should be channeled by the relevant government bodies e.g. Ministries of Agriculture, Research organizations etc to ensure that innovations are generated always so that the gap between the use of primitive methods in agricultural production and use of improved methods as found in other developed parts of the world can be bridged.

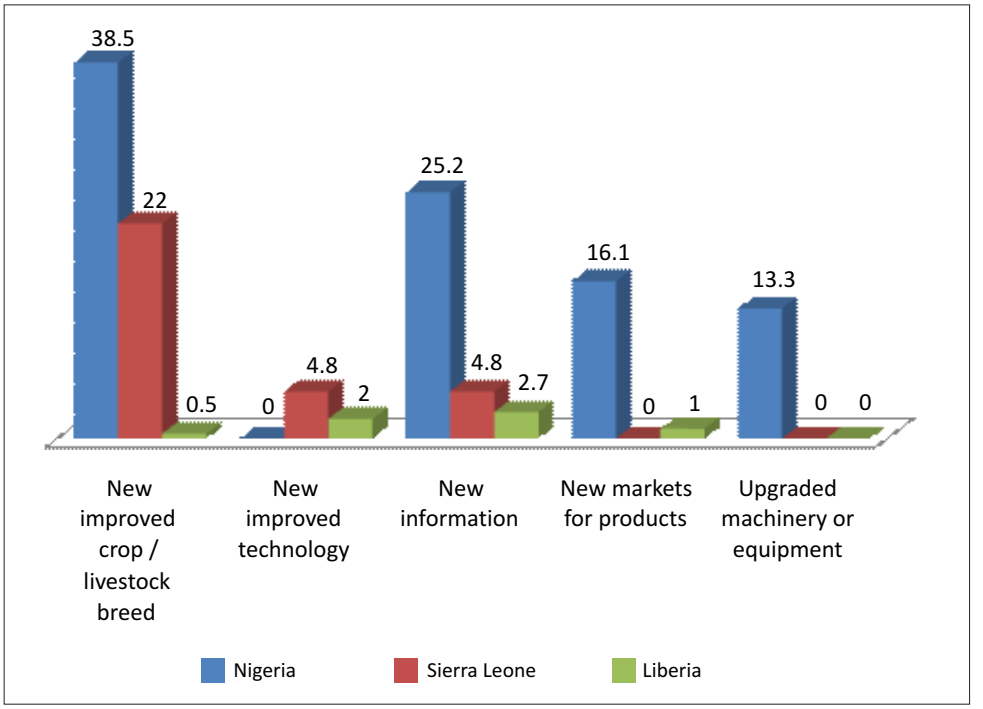


Figure 25: Types of innovations generated by enterprises over the last ten years in Nigeria, Sierra Leone and Liberia

5.11 SOURCES OF INFORMATION ON CLIMATE CHANGE, FOOD SECURITY MEASURES AND INNOVATIONS

Information on Table 12 showed the respondents sources of information on climate change and food security measures. The mean score on sources of information by respondents from Nigeria and Sierra Leone showed that they sourced information from radio (x=3.02, 3.44); those who got information on climate change and food security measures in Sierra Leone through television were (=3.06). In Nigeria, respondents noted that they sourced information from other farmers (=3.08); in Sierra Leone, respondents reported also that they sourced information from government researcher (=3.38) and Ministries of Agriculture (=4.02).

The available sources on information from respondents in Liberia revealed under utilization of the available sources of information. Also, the available sources of information on climate change and food security measures and innovations from respondents in Nigeria and Sierra Leone reveals limited usage of the identified sources of information. A possible reason for this could be that the information disseminated over time is limited in usage to respondents needs or that the message is being communicated using a wrong channel. The appropriate means of disseminating information should be employed and messages that are beneficial to solving particular problems as it regards climate change and food security measures should be disseminated to farmers efficiently and in a timely manner.

Table 12: Sources of information on climate change food security measures, new/improved varieties, products, technologies, services and markets

Sources of information	Nigeria		Sierra Leone		Liberia	
	Mean	SD	Mean	SD	Mean	SD
Radio	3.02*	0.95	3.44*	1.31	2.66	1.28
Television	2.74	1.10	3.06*	1.12	1.49	1.05
Other Farmers	3.08*	1.17	2.84	0.92	2.10	1.13
Meetings / seminars / trade fairs	2.98	1.34	2.76	1.30	1.83	1.14
Extension Officers	2.44	1.45	2.64	0.81	1.68	0.92
Government Researchers	2.43	1.39	3.38*	1.77	1.50	0.81
Input suppliers e.g. seed, fertilizer companies	2.71	1.34	1.00		1.40	0.58
University	2.74	1.52	1.00		1.59	0.83
Internet	2.44	1.43	1.00		1.36	0.81
Ministries of Agriculture	2.63	1.42	4.20*	1.88	1.70	0.92
Ministries of Environment	2.45	1.47	1.00		1.78	0.93

5.12 RESPONDENTS' PERCEPTION OF DOMESTIC ENVIRONMENT SUPPORT FOR CLIMATE CHANGE ADAPTATION AND FOOD SECURITY

5.12.1 Respondents' Perception of Farms Ability to Adapt to Changes in the Local or International Environment

Figure 26 reveals the respondents' perception on their farms ability to adapt to changes in their environment. Respondents from the three countries (Nigeria, Sierra Leone and Liberia respectively) noted that the ability of their farms to adapt to climate changes was not good (28.8%, 67.5% and 46.7%). On the average, 40.2%, 32.2% and 0.5% of the farmers from Nigeria, Sierra Leone and Liberia respectively agreed that their farms can adapt to these changes. This findings show that farms in these countries have very limited capacities to adapt to changes in the environment. This could probably be done to absence of policies on climate change or limited adaptive measures to the changing climate. There is need therefore to strengthen if any, existing policies on climate change adaptation and mitigation and to also reposition research institutes in the search for innovative adaptive measures to climate change effects.

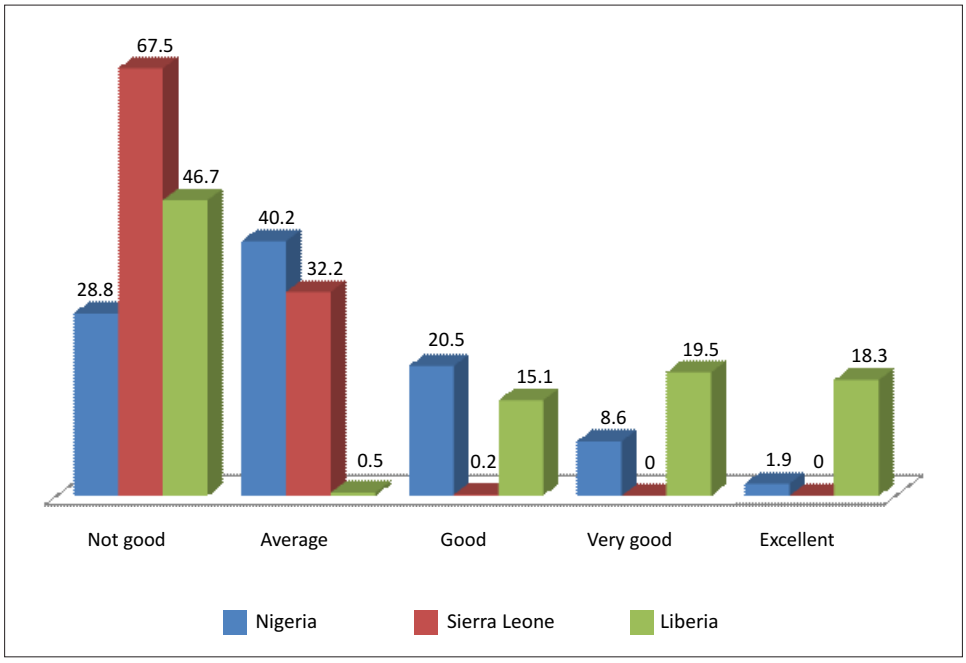


Figure 26: Percentage distribution of respondents by perceived ability of farms to adapt to change environment

5.12.2 Farmers Perception on Domestic Support for Climate Change Adaptation and Food Security in Nigeria, Sierra Leone and Liberia

From Table 13, it is evident that the respondents from the countries under study perceived domestic environments support for climate change adaptation and food security to be poor. The reason for this may be due to absence of mitigation measures and policies on climate change that carter for the rural poor in the fight against the dangerous consequences of climate change.

Table 13: Farmers' perception of domestic environment support for climate change adaptation and food security in West Africa

Statements	Nigeria		Sierra Leone		Liberia	
	Mean	SD	Mean	SD	Mean	SD
Government incentives for innovation	1.73	1.06	1.16	0.44	1.18	0.41
Availability of trained and experienced scientists	1.76	1.07	1.18	0.48	1.34	0.53
Local universities responsiveness to needs of the sector	1.60	1.23	1.15	0.65	1.19	0.39
National R & D organizations responsiveness to needs of the sector	1.39	0.78	1.07	0.26	1.06	0.27
Standard setting bodies and laboratory infrastructure	1.44	0.90	1.10	0.37	1.02	0.14
Intellectual property protection to support innovation	1.50	0.99	1.14	0.43	1.01	0.11
Availability of financing / venture capital	1.51	0.90	1.23	0.57	1.02	0.20
Information and telecommunication infrastructure	1.79	1.07	1.34	0.73	1.10	0.35
State of power supply	1.49	0.74	1.26	0.61	1.01	0.10
State of water supply	1.72	1.01	1.30	0.60	1.04	0.11
Road, rail, air and sea communication infrastructure	1.63	0.92	1.24	0.55	1.34	0.30
Supportive polices for science and technology and agriculture	1.61	0.98	1.16	0.48	1.07	0.68
Marketing infrastructure and supportive policy	1.59	0.94	1.12	0.37	1.24	0.35

6. Summary & Conclusion

6.1 Summary

Based on the findings of the study, the following conclusions were made:

1. The available extension services on climate change and food security in the countries under study show that work done with regards to climate change adaptation is very limited.
2. Respondents across the three countries possessed no special training on climate change adaptation and on food security issues.
3. There was a positive growth in manpower strength of farms in Nigeria and Liberia; this was majorly dominated by farm labourers.
4. The level of investment in farms from self generated income sources in Sierra Leone and Liberia show an increasing trend over the past five years.
5. There was a unstable source of government funding over the past five years in Sierra Leone and Nigeria.
6. On private sector funding of enterprises, there was a more stable financial inflow in Sierra Leone and Liberia than in Nigeria which had a higher volume of finance inflow but with fluctuations.
7. Nigeria had higher level of financing through donor funding sources than Sierra Leone and Liberia, though Sierra Leone and Liberia had more stable finance inflow from donor sources.
8. Farmers from the three countries noted that they experienced delayed shift in onset of farming seasons due to delayed and erratic onset of rains.
9. Though Liberia had the highest level of increase in the trend of extreme weather events, the farmers perceived that there was a downward trend in extreme weather conditions between 2008 and 2009.
10. Farmers in Liberia were experiencing more farming problems than those in Nigeria and Sierra Leone.

11. Farmers from the three countries noted that human activities are largely the main causes of climate change. These human activities were tree felling, cooking with firewood, burning of fossil fuels etc.
12. Adaptive measures been used in the three countries include: increased weeding, increased use of fertilizers, changes in planting dates and prayers for God's interventions.
13. From the respondents, it is clear that similar problems were being encountered in their various efforts to adapt to the changing climate. These problems are poor access to relevant information, poor/low extension services, lack of financial resources etc.
14. Respondents perceived food situations in their various countries not to have changed considerably. This is evident in the number of times they fed on daily basis, which was mainly twice in Sierra Leone and Liberia.
15. There was perceived non-existence of overseas linkages/collaborations in the area of food security and climate change issues.
16. There was an increase in linkage between farmers and the R&D institutions in Nigeria, and a more stable trend in Sierra Leone and Liberia.
17. Liberia had a more stable linkage between farmers and technology delivery institutions.
18. The performance of systems based on innovations generated is poor as there scarcely evidence to show work been done.
19. The sources of information on climate change for Nigeria and Sierra Leone farmers were radio, television, other farmers and Ministries of Agriculture.
20. Respondents' farms ability to adapt to the changing climate was regarded as not good.
21. Respondents noted that the domestic environments support for climate change adaptation and food security issues were poor.

6.2 Conclusion

In essence, the future development of the agricultural sector in the three countries, if not properly managed can further escalate climate change with the resulting negative impacts of reduced availability of cultivated land, decreased crop yields and food insecurity. Intense farming methods using fossil fuels, commercial fertilizers and pesticides and requiring high consumption of water can lead to increased atmospheric concentration of greenhouse gases (GHGs) with consequences of sea-level rise, and migration of population due to environmental stresses.

The development challenges are enormous for any country coming out of a protracted civil conflict. Sierra Leone and Liberia are no different. This document, in reviewing the acts and policies relating to agriculture, food security and climate change in Nigeria, Sierra Leone and Liberia, as well as the agricultural innovation system framework underscores the importance of the Government of to play a leadership role in establishing a vision and strategy for the reconstruction and development of the agriculture and food sector, environmental sector as well as the ministries of science and technology.

To play this role, the Government will first need to evolve (in mind and in action) from an implementation agency to one focused on coordination, facilitation, regulation and evaluation. In addition to reorienting its mission to one focused on the provision of key public goods, the government will be challenged in the immediate future to serve as a bridge between managing short-term safety net activities and developing a long term vision and strategy for food security and climate change issues.

In recognizing that the various sectors represent the primary opportunity for broad-based growth, the needed improved food security and climate change mitigation and adaptation, Government needs to be a catalyst in mobilizing actions to address the main structural constraints in the various sectors, while at the same time assuring that the basic needs of vulnerable groups are met. But it cannot do it alone. Given the complexity of the existing socio-political situation as well as the tremendous lack of financial and human resources for development in these countries, it will be imperative for the different Governments to work collaboratively with other stakeholders so as to secure the future of their citizens---there lies the importance of the Agricultural Innovation System Framework.

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