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CLIMATE CHANGE RISK MANAGEMENT CAPACITY OF NIGERIAN FARMERS

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Abstract
Climate is the primary important factor for agricultural productivity. Climate Change and variability is a major risk for agricultural production, and is bringing with it alterations in climatic risks patterns. The impact of climate change has potential to undermine development achievements and threaten the food security of millions of people, especially in Nigeria where more than 70% of rural farmers are dependent on rain-fed agriculture for their livelihood. Changes in rainfall pattern, temperature, relative humidity, and soil fertility are the key climate risks faced by Nigerian farmers who must be supported in preparing themselves for the changing situations and taking the steps that will improve their ability to protect their livelihoods. Awareness raising, capacity-building processes and risk management will assist policymakers in assessing the effectiveness of different types of risk protection tools. This paper provides a rigorous, yet accessible, description of risk and risk management tools and strategies that can be adopted to cope with varying weather conditions with an overall aim of enhancing food security.
Keywords: Climate change, agricultural risk, weather forecast, agricultural production insurance and risk management.

Introduction
The enterprise of agriculture is a means by which more than 70% of rural farmers in Nigeria earn their livelihood employing over 65 percent of the population. The agricultural sector is a high risk industry that is vulnerable to natural disasters and impacts of climate change due to its dependence on weather over which the farmer has little or no control. Risks faced by farmers are numerous and varied, and are specific to the country, climate, and local agricultural production systems. The inherent biophysical nature of agricultural and livestock systems combined with various external stimuli makes it vulnerable to multiple sources of risk. These sources emanate from both the production environment, as well as from the market, technological and social environments that characterizes agriculture. Further, the nature of risk in the production environment is complicated by interaction between these multiple sources of risk. This interaction will ultimately influence the overall exposure to risk as well as choice of avenues for risk management. Modelers and decision-makers must be cognizant of the multiple facets of the agricultural risk environment for efficient decision making.

Climate change is already taking place, and further changes are inevitable. Developing countries like Nigeria, and particularly the poorest people in these countries, are most at risk of these changes. The impacts result not only from gradual changes in temperature and sea level but also, in particular, from increased climate variability and extremes, including more intense floods, droughts, and storms. These changes are already having major impacts on the economic performance of developing countries and on the lives and livelihoods of millions of poor people around the world. Climate change is projected to increase the number of droughts and floods. Coupled with sea level rise, this will affect food security, the productivity of commercial agriculture, commodity exports, health, and energy. Crop production will be seriously affected, with yields falling in most parts of Africa. People will lose their livelihoods, and communities and countries will suffer economically (DFID, 2004). In Nigeria not much attention has been given to the risks associated with a changing climate, and many strategies, programs, and projects have also failed to take into account the risks of natural hazards under current climate conditions. Even as various governments have made substantial investments to foster economic development and poverty alleviation, their efforts are frequently diluted or even erased by the effects of natural disasters. Some of the damages from these natural hazards are unavoidable, as it is neither feasible nor economical to strive for protection against all risks, but many damages and casualties simply result from poor planning. Even worse, the well-intended rapid reconstruction efforts after a disaster often recreate the same vulnerabilities that allowed the hazard to cause such havoc in the first place.

This paper reviews Agricultural risks with specific reference to climatic risks arising from climate change, its effects on the economy, people in general and the farmers in particular. The instruments available for climate risk management in agriculture and the micro-level practices for adapting to climate change that are available to small-scale farmers in Nigeria have also been reviewed. Particularly, the review looks at practices that boost small-scale farmers' resilience or reduce their vulnerability to observed or expected changes in climate. The necessity for risk management tools and strategies are nowadays greater than ever in a context of deteriorated climate conditions, the recent global food crisis, animal diseases outbreaks, higher price volatility and mounting consumers' concerns about food safety issues as well as increased international integration and inefficiencies of agricultural markets.

Climate Risks in Agricultural Production: Climate risk in agriculture represents the probability of a defined hydro-meteorological hazard affecting the livelihood of farmers, livestock herders, fishers and forest dwellers. This refers to weather-related and natural disasters risks such as drought, floods, windstorms, heavy snowfall, hailstones and fires. Production, yield, water quality, fodder availability and animal health are significantly affected by climatic variations as weather influences each phase of agricultural production processes. Agriculture is deeply interconnected with weather and climate, the main drivers of agricultural production, but also the dominant factors in the overall variability of food production (Selvaraju, *et al.*, 2011) and a continuing source of disruption to ecosystem services (Howden *et al.*, 2007). Extreme climate events during the cropping season are posing a major threat to the agriculture sector. Future changes associated with climate change will present additional challenges (Karl *et al.*, 2008). FAO's global information and early warning system on food and agriculture indicates that sudden-onset disasters – especially floods – have increased from 14 percent of all natural disasters in the 1980s to 20 percent in the 1990s and 27 percent since 2000 (FAO, 2008). The intensity of tropical cyclones (Knutson *et al.*, 2010) and frequency of heavy precipitation events are very likely to increase over many areas during the twenty-first century. According to IPCC (2012), it is likely that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the twenty-first century over many areas of the globe; and there is medium confidence that droughts will intensify in the twenty-first century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration. Rainfall quantity and its distribution are key factors determining the rainy season characteristics, farming systems, field crop production and livestock rearing. Both inter-annual and intra-seasonal rainfall variability constrain crop production in the tropics and subtropics. Intra-seasonal variability leads to extreme climate events that have direct impact on crop production and livelihood opportunities in the agriculture sector.

In semi-arid area of Nigeria, particularly northern guinea savanna and the Sahel, unreliable rainfall combined with high evaporative rates and soils with low water-holding capacity and high run-off potential result in a high risk of water deficit at any stage of crop growth (Muchow and Bellamy, 1991). Frequent soil water deficit during early plant development, resulting in seedling mortality, retarded development and reduced yield, are very common.

There are many instances where water deficit during the later stages of crop development is apparent. The wet spells and excessive rainfall events during the rainy season create water logging in the root zone, reduce plant growth and hinder field operations. The rainy season duration is one of the primary factors affecting crop production prospects. Within a specific location, rainy season onset and final rain date are varying greatly from one cropping season to another. The variation of onset explains the significant variation in season duration since the onset date is more variable than the end date of the rains. Early onset of rains, relative to the mean date of onset for a given location, results in a longer growing season (Sivakumar, 1988). However, the relationship between onset date and seasonal rainfall duration is not always linear as rainy season characteristics are uncertain.

In addition to seasonal rainfall variability, higher growing season temperatures can have dramatic impacts on agricultural productivity, farm incomes and food security (Battisti and Naylor, 2009). Temperature during the cropping season often exceeds the optimum for physiological processes such as phenology, leaf area development, assimilate accumulation and grain filling. High air temperature around flowering can reduce pollen viability and grain set in major cereals of the tropics (rice, maize, sorghum, etc.). The incidence of high soil temperature during crop establishment is also a threat in semi-arid and arid environments. Soil surface temperature greater than 60 °C is common in Africa, India and Australian semi-arid tropics, and seedling mortality or thermal injuries are frequent. Multiple climate-related risks cause far-reaching consequences for the livestock sector (AIACC, 2006). Risk of climate variability affects dairy, meat and wool production, mainly arising from its impact on grassland and rangeland productivity. Heat distress suffered by animals reduces the rate of animal feed intake and results in poor growth performance (Rowlinson, 2008).

Climate change threatens agriculture biodiversity; IPCC (2007) projected that approximately 20–30 percent of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5–2.5 °C over 1980– 1999 levels. The range of crop weeds, insects and diseases is projected to expand to higher latitudes (Rosenzweig *et al.,* 2001). Coastal zones and fisheries are particularly prone to risks associated with rising sea levels, changes in ocean salinity, cyclones, and a decrease in fish stocks and availability due to increasing water temperature (Hall-Spencer, *et al.,* 2008). Current scenarios show that food production needs to increase by 70 percent by 2050 to meet the demands of an increasing population, yet the agriculture, forestry and fisheries sectors are all highly vulnerable to impacts of climate change.

Risk Assessment: Although being aware of a risk is clearly important, before one can consider managing it, one must actually assess the risk being considered. Risks (and their impacts) are assessed by quantifying three main variables: hazard, vulnerability, and exposure. Hazard is the categorization of the type of risk being considered—for example, weather, price, pest, policy, or market. The quantification of the hazard is then undertaken by assessing three sub variables:

i. Frequency (How often or likely is the risk to occur?), Severity (What are the likely fiscal impacts of such a risk if it occurs?) and Spatial extent (How widespread would the impact of the risk be — one person? One village? One country?)
ii. Vulnerability is an estimation of what the impact of the realized risk would be given the assets affected by the event and taking into account the current ability to manage the impact.
iii. Exposure is the identification of the location of crops, livestock, and farm holdings that may be directly impacted by the hazard. Interdependency in the supply chain leads to indirect exposure for other parties.

The third arena of interest to economists concerns the responses that producers make to the risk exposure i.e. risk management. Climate change, extreme weather and their effects on the economy is complex. Every sector will be impacted in its own idiosyncratic way, and these points to the value of enterprise climate risk management.

Risk Management: n this paper, risk management is considered as the range of techniques and tools which can be applied in order to avoid or minimize losses and to utilize opportunities. Risk management offers the most effective approach for agricultural industry to respond and adapt to climate change and variability. Risk management is a formalized method of dealing with uncertainty or a process of implementing decisions about accepting or altering risks (Beer and Forhan, 2000; Pritchard, 2000). Risk management is a five-step process that identifies, analyses and evaluates a risk, and plans and implements a strategy to reduce the chances of the undesirable event occurring or reduce the scale of damage caused by the event (Standards Australia and Standards New Zealand, 2009). Risk management does not necessarily eliminate risk but achieves a balance between risk and return that suits the needs and desired outcomes of an individual farmer or agricultural business. All risk management options have a cost, either directly through the purchase of risk protection such as insurance or hedging, or indirectly through relinquishing some potential gains; for example, by reducing stocking rates and crop inputs. Farmers must weigh up the relative gains and losses when considering the most appropriate risk management option in any situation. Nigerian smallholders are already using a wide variety of creative practices to deal with climate risks which can be further adjusted to the challenge of climate change by planned adaptation programs.

Climate change risk management: Having first become aware of a risk and then having assessed it, the next issue is how the party (or parties) at risk can seek to manage that risk. It should first be noted that risk management should be planned on an ex-ante basis (that is, before realization of an event); this is what is considered in this paper. According to the International Research Institute for Climate and Society (IRI), climate risk management (CRM) refers to the use of climate information in a multidisciplinary scientific context to cope with climate's impacts on development and resource management problems (African Development Forum, 2010). Further, IRI's definition elaborates that climate risk management covers a broad range of potential actions, including early-response systems, strategic diversification, dynamic resource-allocation rules, financial instruments, infrastructure design and capacity building. Given the rising climate risks and disaster losses, the climate change adaptation and the disaster risk reduction constituencies should together make the case that appropriate hazard risk management, including adaptation to climate change, is not a luxury for development planning but is pure due diligence. Hence, adaptation to climate change should be addressed through a climate risk management approach—that is, an ongoing process that starts with coping strategies for current climate variability, tries to anticipate changes in climate change, and seeks to evolve new coping strategies as necessary.

General Procedures for Managing climate Risk: The best method(s) of managing risk depends upon the nature of the risk involved. Four general procedures for managing risk are: (1) avoidance, (2) reduction, (3) assumption/retention, and (4) transfer

***Avoidance*:** Avoidance is the process of structuring the farm so that certain types of risk are nonexistent. For example in swine production, there are considerable risks associated with farrowing operations including disease, low conception rates, death loss of newborn pigs, and others. The farrow-to-finish hog producer cannot avoid these risks, although producers buying feeder pigs and finishing them out could avoid such risks. Similarly, swine finish operations producing in an integrated system can largely avoid these risks, although other sources of risk may result and returns may be altered.

***Reduction* (*Mitigation*):** Reduction is the process of lowering the risks associated with the agricultural venture. Consider the following example from the crop production side. A grain producer can hire crop scouts to spot disease, nutritional imbalances, and pest control problems. This helps reduce the risk of poor yields, but the risk is not eliminated completely. Contractors for grain and livestock production may, for example, supply experts who help the producer reduce production risks through timely advice. Again, this reduction of risk may result in implicit or explicit reductions in net returns. Other common ways for producers to reduce risk are through:

i. Diversification of farming activities, such as mixed farming, mixed cropping, crop rotation, labour reallocation; diversification of plot location and development of non-agricultural activities and sources of income outside agriculture.
ii. The use of appropriate farming practices according to valuable indigenous knowledge.
iii. Cultivating crops that are tolerant to stress and disease; using resilient livestock, as well as plant and animal disease prevention techniques.
iv. Long-term investment in infrastructure, such as in roads, warehouses, communication facilities, irrigation systems and improvement in marketing infrastructures.
v. Pest management programmes, application of sanitary and phytosanitary measures and food safety and control policies.
vi. Timely and reliable market information systems and information based on early warning systems' results and implementation of communication and learning activities for farmers such as the agricultural extensions. A critical element in reducing vulnerability is an analysis of human settlements and infrastructure in the high risk areas. Government on their part can lower the risks:
    a) *Retrofitting:* the modification of existing structures to withstand natural disasters. For example, elevating structures, and installing storm shutters or foundation strengthening.
    b) *Regulations*: by controlling the use of land and the construction of buildings, governments can significantly reduce the potential losses from disasters. Government should be strict on not allowing people to build on flood prone areas, drainages or waterways. Such acts should be,
    c) *Protective structures:* structures such as sea walls and levees can protect buildings and people and mitigate the impact of floods and storms.
    d) *Natural resource management:* better managing of natural resources controlling erosion, managing forests, and restoring wetlands preserves ecosystem services that minimize the risk of disasters.

Assumption/Retention**:** Assumption/retention is the process of retaining or accepting risks with the objective that assuming this increased risk is to maintain control and/or enhance overall profitability. Assumption may occur simply because we cannot transfer it, rather than accepting it willingly. However, by accepting/retaining it we do assess and catalogue it. Integrators in both crop and livestock production may retain ownership of products being produced under contract. Consider for example, an integrator who contracts with growers to finish hogs. The grower is often responsible for providing the grow-out facilities, for a fixed or minimum guaranteed fee, while the contractor retains ownership of the market hogs. Since the grow-out facilities are not recorded on the balance sheet of the contractor, traditional measures of financial leverage (such as the debt/asset ratio) may not reveal the risks associated with this arrangement. Because the contractor retains ownership of the animals and has a signed contract with the grower, one can think of this arrangement as a pseudo guarantee by the contractor for the loan taken out by the grower. The integrator is retaining more risk with the expectation of enhanced profits.

Transfer**:** Transfers of risk occur when one party lowers their risk by shifting that risk to someone else, often for fee. There are numerous methods in agricultural production to shift risks in this manner. Common examples include futures and options contracts, crop insurance, and fire and hail insurance. These transfers are accomplished with a known cost, i.e. the cost of insurance, options contracts or the like. Collective groups of production and marketing of products to divide the risk between different farmers the use of share cropping arrangements to divide the risk between producers and landowners. Risk transfer can also occur in situations in which the "cost" of the transfer is more disguised or vague. For example, grain farmers can transfer price risk through forward contracts. Likewise, a contract producer of vegetables may be able to transfer price risk to the contractor. The monetary and non-monetary costs of such risk transfer are often in the form of lost opportunities (the unexpected price rise) and are less clear. Industrialized agriculture tends to alter the mechanisms for managing risk. Producers who operate under contract may have better opportunities for yield and price risk avoidance, reduction, and transfer than do traditional independent producers. However, these opportunities may be offset by increases in less traditional risks such as relationship risks and strategic risks. Integrators, on the other hand, have opportunities to assume more risk in the new industrialized forms of agriculture. Of course, higher returns are expected for accepting such risks. Insurance schemes help governments transfer the costs of a disaster brought on by extreme weather. But it is also important to take steps that actually mitigate the risks by making structures, people, and ecological systems less vulnerable to damage from a weather induced disaster.

Agricultural Insurance: Insurance is a risk-transfer mechanism that ensures full or partial financial compensation for the loss or damage caused by event(s) beyond the control of the insured party. Under an insurance contract, a party (the insurer) indemnifies the other party (the insured) against a specified amount of loss, occurring from specified eventualities within a specified period, provided a fee called premium is paid. In general insurance, compensation is normally proportionate to the loss incurred. Insurance, however, provides protection only against tangible losses. Many of the risks faced by farmers are ‘insurable’ in the sense that farm managers are typically able to neutralize the effect of a risk by taking direct action or precaution, including the purchase of formal insurance products (Topp and Shafron, 2006). However, not all risks faced by farmers are insurable. Production risk is one of the most significant risks faced by farmers. Markets for insuring agricultural production from drought and other climate risks are uncommon. Apart from insurance for fire and hail damage, there are limited options for agricultural producers to insure themselves against production risk (Productivity Commission, 2009).

The Nigerian Agricultural Insurance Corporation (NAIC) was established to protect the Nigerian farmer from the effects of natural hazards by introducing measures which shall ensure a prompt payment of appropriate indemnity (compensation) sufficient to keep the farmer in business after suffering a loss. Specifically the objectives of the Scheme are to provide financial support to farmers where loss to crops or livestock arises from natural hazards; induce the provision of credit by financial institutions to farmers; promote agricultural production; and minimize or eliminate the need for Government to provide ad hoc assistance to farmers during agricultural disasters. NAIC allows the farmer pay a premium to buy the insurance, thus acquiring a contract which, in the case of adverse events, gives him the right to an indemnity – of an amount linked to some calculation of the losses.

Strengthening risk management capacity of farmers: Although climate risk management in agriculture is ultimately the responsibility of farmers and agribusinesses, governments can assist them to manage climate risks. Governments have a key role to play in developing policies that effectively addresses inadequacies and failures in current farmers risk management strategies. The governments’ priority should be to strengthen the capacity for agro-meteorological observation; development of customized forecasting products; management of data and modeling for climate impact assessment and application of climate information at the farm level, and strengthening of decision-support systems at the institutional level (Selvaraju *et al.,* 2011). Agricultural extension services also need to be strengthened in order to address climate risks and plan for adaptation if these are to provide an efficient interface between policy-makers and the farming community.

Strengthening of community networks, local institutions and norms and relationships is critical for managing climate risks. Local networks shape the farmers’ social interactions leading to better participatory decisions (Meinke *et al.,* 2006). Farmers’ knowledge sharing mechanisms relevant to local context are the key for effective communication of value-added climate information (Selvaraju, *et al.*, 2004). Farmer participatory climate workshops, Farmer Field Schools (FFS), local climate information centers and innovative information and communication technologies (e.g. mobile networks, etc.) facilitate rapid dissemination of information products to the farmers and livestock herders. National meteorological and hydrological services need to understand the information requirement of agriculture support services and farmers and accordingly mainstream development of weather and climate information products. Agricultural support services and community-based organizations should engage themselves in development of contingency plans incorporating new technologies, improving impact data collection, monitoring and analysis (including climate change), development of impact outlooks and management alternatives considering local needs, and facilitate communication of information to farmers/herders. Governments can adopt the FAO's integrated approach for Climate Risk Management (CRM) which addresses vulnerabilities to short-term climate variability and longer-term climate change in the context of sustainable development. It promotes proactive, demand driven interventions to achieve positive outcomes for communities and societies in climate-sensitive sectors such as agriculture, forestry, fisheries, water resources, environment, and ultimately food security.

A key component of integrated Climate Risk Management in agriculture is the provision of usable weather and climate information products that help the farmers, livestock herders and fishermen to proactively manage their risks and improve opportunities at local level. The ultimate objective of CRM is to enhance the resilience of rural livelihoods against climate change, and to better inform climate sensitive planning and decision making. Information technologies and weather monitoring systems are becoming more and more reliable in many parts of the world. Often, the benefits of timely and accurate forecasts, for reducing disaster impacts or improving decision making in agriculture, can be easily measured. A number of easily accessible technologies and available upgrades to weather forecasting systems would be generally affordable, as long as governments budget, staff, and equip hydro-meteorological services are at adequate levels. Some examples:

a) *Bandwidth:* A global telecommunications system organized by the United Nations World Meteorological Organization (WMO) shares global forecasts and data. Bandwidths are needed to download large files.
b) *Satellite dishes:* Weather satellites where images of storm systems, fires, coastal zone pollution and other environmental data can be obtained.
c) *Local area modeling:* devised open source models for weather prediction that lend themselves to local weather forecasting that can be run on computers only slightly more powerful than commonly used desktops.
d) *Forecasting workstations:* In some countries, satellite and radar data from neighboring countries would be available, but weather agencies often lack the workstations and software to make use of the data for forecasting purposes.

These would not only help to warn citizens of pending weather catastrophes, but would provide valuable information to the agriculture, water management, and transport sectors. Timely and increased accuracy in forecasting would assist in the timing of fertilizer application and pest and disease control, avoiding over application that raises input costs and exacerbates environmental damage. These functions have been further enhanced with the use of the Decision Support Systems (DSS) especially in the developed countries. Agricultural DSS are computer-based tools developed by scientists to provide farmers with information and procedures to assist management decisions (McCown, 2002; Hayman, 2004; Matthews *et al.,* (2008). There are a range of climate-related DSS available, which can assist with weather and climate forecasting, crop growth and management, irrigation and fertilizer management, and livestock and pasture growth and management.

Conclusions

Climate variability is a major risk for agricultural production, and this risk is likely to increase under future climate change. Nigerian farmers should be planning for a future climate that is warmer, with increasingly variable and unreliable seasonal rainfall and more extreme climatic events. As a result, risk management will become an increasingly important process for farmers to respond and adapt to risks of climate variability and climate change. Adaptation policies should complement farmers' autonomous response to climate change through the development of new drought-resistant varieties and improved weather forecasts, the provision of financial services, improvement of rural transportation infrastructure, investments in public healthcare and public welfare programs, and policies that improve local governance and coordinate donor activities. Although climate risk management in agriculture is ultimately the responsibility of farmers and agribusinesses, government policy will continue to play a key role in increasing the preparedness, responsibility and capacity of farmers to manage climate risks. The main climate risks faced by Nigerian farmers are flood and drought and this risk is set to increase under future climate change. Policies that treat extreme climatic events such as droughts as an integral part of the agricultural environment, and promote risk management as the most appropriate means to deal with such events, will continue to be required.

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