Federal Ministry of Agriculture and Rural Development

NATIONAL AGRICULTURAL RESILIENCE FRAMEWORK

A Report by the Advisory Committee on Agricultural Resilience in Nigeria

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Ministerial Foreword

I am pleased to write the foreword to this report by the Advisory Committee on Agricultural Resilience in Nigeria (ACARN), which I had the honour of inaugurating in September 2013. It is a fulfilment of a long-held idea that could not wait any longer!

To assure food and nutritional security, eradicate rural poverty and create social stability, policies and institutions are needed to enhance the ability of individuals, households and production systems to recover from the impact of shocks and stresses on the agriculture sector induced by the changing climate. This National Agricultural Resilience Framework is written in response to that need. It offers a well-articulated national policy on short- and long-term strategies to reduce food and nutrition vulnerability, while enhancing environmental resilience.

The long-term solution to food insecurity is to raise agricultural productivity and boost food production. Nigeria embarked on a major transformation of its agriculture sector with the launch of the Agricultural Transformation Agenda in 2011 that is anchored in the philosophy of treating agriculture as a business rather than a development programme. Our goal is to add 20 million metric tonnes (MT) of food to the domestic food supply by 2015 and to create 3.5 million jobs. We are driving import substitution by accelerating the production of local food staples, to reduce dependence on food imports and turn Nigeria into a net exporter of food. To this end, we have introduced several major innovations as part of the on-going fundamental restructuring of the agricultural landscape in Nigeria.

First, to assure increased agricultural productivity, it is critical that farmers get access to affordable agricultural inputs. In Nigeria, the first ever database of farmers in the country was launched as a basis for the efficient and effective distribution of subsidized seeds and fertilizers through mobile phones in 2012 as part of the Growth Enhancement Scheme. This stimulated wider markets for agricultural inputs, and agricultural productivity and food production had increased by 17 million MT by June 2014 and is expected to reach 21 million MT by December 2014, exceeding the 20 million MT target set for 2015.

Second, the agricultural revolution is being complemented with a financial revolution. We are aggressively deploying innovative financing mechanisms, such as the Nigeria Incentive-based Risk Sharing for Agricultural Lending, which is providing credit guarantees to commercial banks for increased lending as well as the Fund for Agricultural Financing in Nigeria, a private fund, jointly set up by the Governments of Nigeria and Germany to raise private capital for funding in agriculture. These mechanisms will scale up the needed financing for the sector.

Third, to reduce some of the risks borne by farmers, the focus is currently on developing the mechanisms for establishing weather index-based insurance schemes for farmers. Current programmes to improve the density of operational weather stations in the country, thereby, improving weather forecasting models, are complementing this effort.

Fourth, social safety net policies are being used to reduce vulnerability, especially for women and children. These include conditional cash transfers, school feeding programmes and nutritional interventions. The "Saving one million lives" initiative targets the use of community management of acute malnutrition and integrated child feeding to reduce under-nutrition. Regional food reserves are also being supported. In 2012, for example, Nigeria contributed 32,000 MT of grains to support Niger Republic and address food shortages. Nigeria has also built up its silo storage capacity network to 1.3 million MT, making it the largest in West Africa.

Other policies in furtherance of agricultural resilience in Nigeria are contained in this report and will be progressively implemented. I salute the distinguished members of ACARN who produced this outstanding report. I am also pleased to acknowledge many other contributors within and outside Nigeria, including senior officials and advisors within my ministry and other government agencies. I wish to especially thank Professors Jimmy Adegoke and Chidi Ibe for their patriotism, selfless service and outstanding leadership as ACARN Co-Chairs.

I have no doubt that this report will have an enduring impact on agricultural production in Nigeria because it provides a clear road map for achieving resilience in the agriculture sector and offers pertinent policy recommendations that will strengthen the capacity of small- and large-scale agricultural producers to increase productivity, grow wealth and thrive in the face of growing challenges from multiple environmental stressors and changing climate.

Dr Akinwumi Ayodeji Adesina CON
Honourable Minister of Agriculture and Rural Development
September 2014

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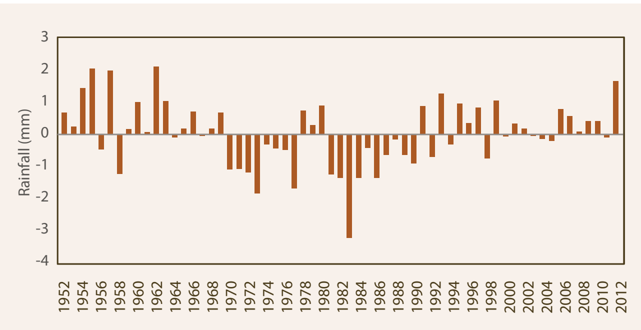
Nigeria's Changing Climate: Risks, Impacts and Adaptation in the Agriculture Sector

2.1 Overview of Current Climate and Climate Variability in Nigeria

Nigeria lies on the south coast of West Africa between latitudes 4° and 14°N and longitudes 2° and 15°E. It has a total landmass of 926,000 km^2. The climate is dominated by the influence of three main wind currents: the Tropical Maritime air mass, the Tropical Continental air mass and the Equatorial Easterlies (Ojo, 1977). The Tropical Maritime and Tropical Continental air masses meet along the Inter-Tropical Discontinuity (ITD), which is a key driver of Nigeria's climate. Its position and oscillation during the year affect the spatial and temporal distribution of key climate characteristics (Adegoke and Lamptey, 1999). Following the annual march of the ITD across the equator, the rainy season advances from the coast to the inland areas from March to August and retreats from September to November, with a pronounced dry period between December and February. The Equatorial Easterlies air mass blows over occasionally to actively undercut the Tropical Maritime or Tropical Continental air masses, giving rise to squall lines or dust devils. The interaction of these air masses and the ITD creates humid conditions in the southern parts of the country with annual rainfall over 2000 mm, and semi-arid conditions in the north with annual rainfall less than 600 mm. Three climate zones are recognized: the Sahel (11°–14°N), Savannah (8°–11°N) and Guinea (4°–8°N).

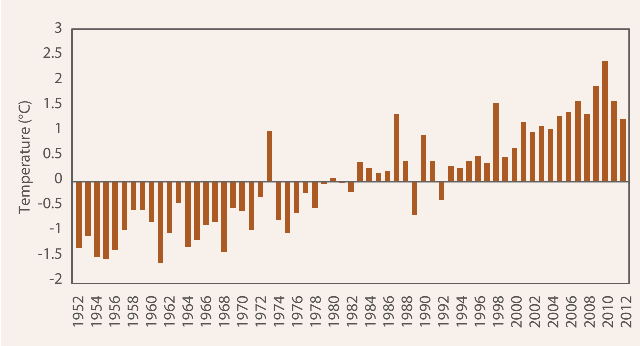
Surface climate data analysed by the Nigeria Meteorological Agency (NIMET) showed that Nigeria's climate has exhibited considerable variability over the last half-century (Figure 2.1). While there is significant inter-annual variability, distinct decadal trends are also clearly observable. For instance, there was a

Figure 2.1 Rainfall variability over Nigeria (1952–2012 national average)



Source: NIMET

Figure 2.2 Temperature variability over Nigeria (1952–2012 national average)



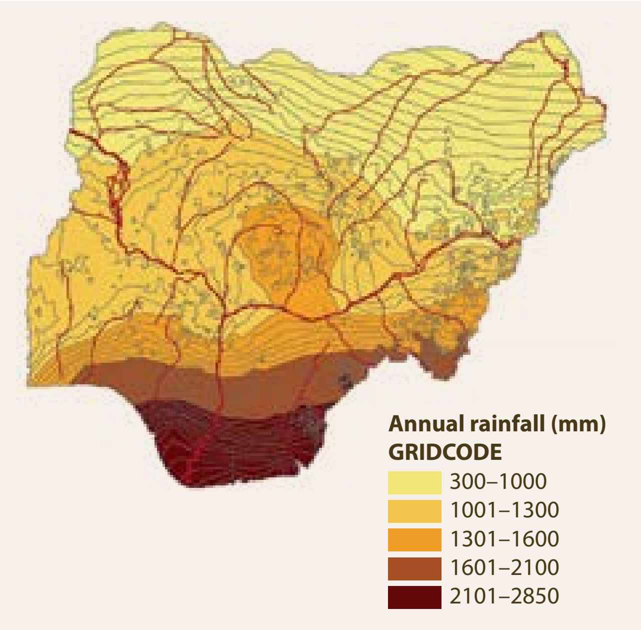
Source: NIMET

wet period from the early 1950s through to the late 1960s, followed by dry and drought-stricken decades during the 1970s and 1980s, and the apparent return of wetter than normal conditions in the 1990s. These swings in climate underline the nation's vulnerability to extreme climate events. The standardized temperature variability for the period 1952–2012 is shown in Figure 2.2. Strong warming is evident from the mid-1970s to the present. Bello et al. (2012) reported similar results using mean annual temperature data from 1901 to 2005 for 30 stations. It is very likely that this warming trend will continue, since several recently published climate projections for the country indicate temperature increase of between 1 and 4°C for all ecological zones in the coming decades (Abiodun et al., 2012; 2013; Hassan et al., 2013).

Changes in the basic characteristics of the rainy season have also been reported (Odjugo, 2005; 2009). The author observed that the area experiencing a double rainfall maximum is shifting southward, while the short dry season (August break) now occurs more frequently in July, as against its more usual occurrence in August prior to the 1970s. Analyses of the mean onset and cessation dates of the rainy season conducted by NIMET revealed some disturbing results. Late onset of the rains, as observed in only a few locations in the country during the early 2000s, have become much more widespread. Similarly, early cessation of the rains, which was limited to small areas in the southwest, now affects a large swathe of the country extending from the northwest through most of the southern states to the northeast (NIMET, 2013, personal communication). These changes have serious consequences for agriculture, with marked effects on crop and livestock production, water resources management, agroforestry, fisheries and many other associated activities.

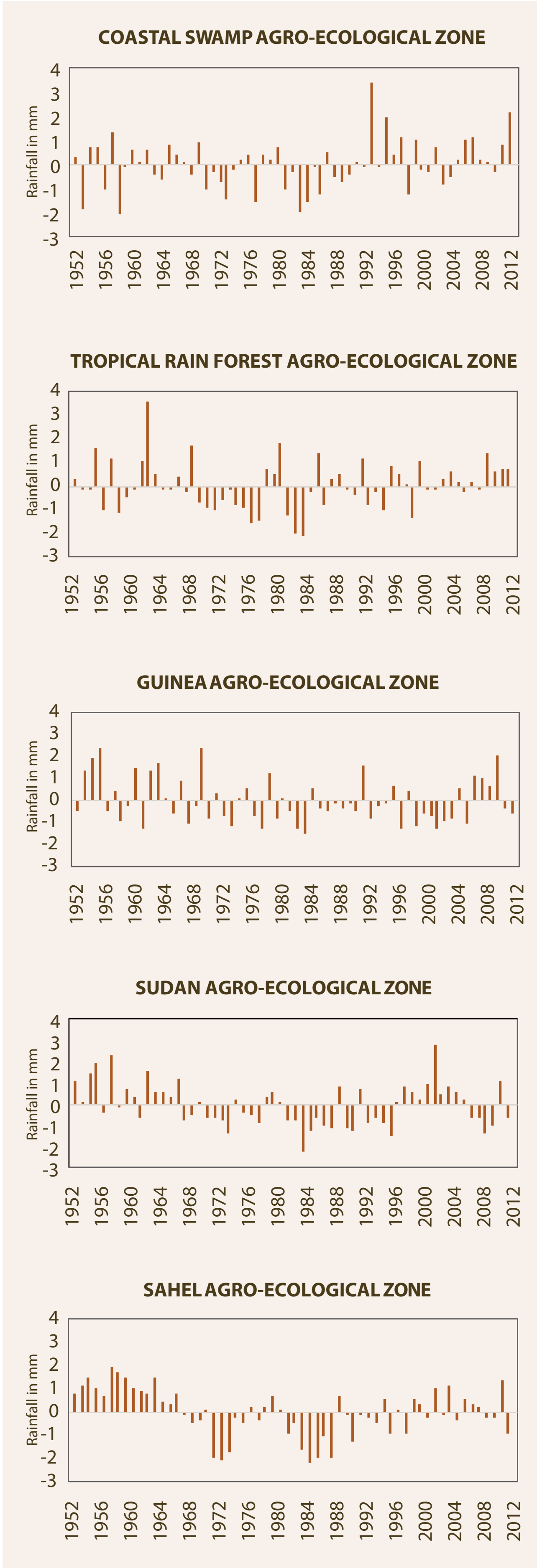
Agro-ecological zones (AEZs) are the most relevant spatial units to use when considering the impact of

Figure 2.3 Rainfall distribution across major agro-ecological zones of Nigeria



Source: Abila, 2010

Figure 2.4 Rainfall variability over Nigeria, 1952–2012



Source: NIMET

climate variability or climate change on agriculture. In Nigeria, AEZs range from humid to dry and are defined based on the combined effects of temperature, humidity and rainfall. The variations that occur in rainfall govern the types of indigenous plants that grow, and the exotic types that can be introduced successfully. For instance, in the humid tropical forest zone of the south, the longer rainy season supports plantation crops such as cocoa, oil palm, rubber and coffee, as well as staple crops like yam, cassava, cocoyam and sweet potatoes. The north, with its lower rainfall and shorter rainy season, comprises mainly Sudan and Sahel savannahs and represents almost 80% of the vegetation zones of the country (Figure 2.3). The savannah is ideal for cultivating grains such as sorghum, millet and cowpea. It is also an excellent natural habitat for grazing livestock. Because precipitation and cropping patterns differ across the AEZs, the impacts of climate variability and climate change will also vary (Figure 2.4).

As a coastal state with 853 km of coastline dominated by the Niger Delta, Nigeria has an additional AEZ in the ocean environment, which supports a vast fishery. The coastal and offshore waters, together with their associated watersheds, represent a distinct economic and food security source. Rising ocean temperatures have led to global sea-level rise and the generation of more frequent and intense storms. These storms dump heavy rains on the land and produce storm surges that inundate large expanses of agricultural land in addition to affecting the productivity of the ocean (Ibe, 1988).

The relationship between climate variability and agricultural production in sub-Saharan Africa is complex and moderated by several factors, especially agricultural land management practices. Although such climate extremes as floods often lead to temporary loss of agricultural land in the immediate aftermath of those events, they also present opportunities to expand dry-season farming because of the elevated soil moisture and higher groundwater levels in riparian areas. While variations in the length of the growing season increase uncertainty about how much and when rain will be received in any given year, the impact on agricultural production is not always negative. Similarly, higher temperatures might result in higher yields in some areas while other parts of the country might experience lower yields due to an increased rate of evapotranspiration, water deficits or increased incidence of pests and diseases. Long dry spells, late onset and changes in the duration of the rainy season all have significant consequences for agricultural production because of the country's heavy dependence on rain-fed agriculture. On a positive note, there is clear evidence that farm-level adaptations to these environmental challenges can have significant positive impacts on productivity and rural livelihoods (Apata, 2010; Ayinde et al., 2011). In fact, yields (in t/ha) of major crops have continued to increase in several parts of West Africa since 1961, despite declining rainfall and increasing temperatures (Mohammed, 2011). This underscores the important roles of farm management practices and improved access to better quality farm inputs in food production throughout sub-Saharan Africa.

2.2 Future Change in Nigeria's Climate

In addition to changes in the occurrence of extreme weather events and patterns of wet and dry, hot and cool periods, climate change also affects the average climate. This means that systems and activities adapted to an average climate can be affected. Crops are grown in particular locations because the range of temperatures and precipitation is right for those crops, and natural vegetation exists in certain locations because the climate is favourable for particular species.

General Circulation Models (GCMs) are designed to simulate time series of climate variables globally. These tools account for the effects of greenhouse gases in the atmosphere and the resulting global climate change. GCMs demonstrate significant skills at the continental and hemispherical spatial scales, and incorporate a large proportion of a complex global system. They are, however, inherently unable to represent local sub-grid-scale features and dynamics. The spatial scale at which a GCM can operate is very coarse compared with that of a hydrologic process (e.g., precipitation in a region or stream flow in a river) of interest in climate change impact studies. The hydrologic implications of global climate change are usually assessed by downscaling appropriate predictors, as simulated by GCMs (Ghosh and Misra, 2010). As a result, different available GCM datasets produce varying and even contradicting results (Varis et al., 2004). Most studies often adopt a multi-model ensemble of GCMs to obtain more reliable estimates of the spread of possible regional changes and to account for the uncertainties accompanying the projected changes.

The uncertainties in climate change projections and their impacts on agriculture arise from the complex nature of climate (Solomon et al., 2007) and feedbacks with its drivers, which are difficult to capture in models. Uncertainties also arise from the inadequate data basis, the differing and uncertain scenarios of greenhouse gas emissions, the coarse spatial and temporal resolutions, contentious assumptions in the emission scenarios and the non-consideration of seasons as they occur in reality (e.g., wet and dry seasons). Furthermore, there are no standard model specifications for input parameters, and internal variations exist in the GCMs, resulting in differing climate projections (Müller, 2009). It is therefore necessary to complement the insights provided by climate models (top-down approach) with perspectives that focus on inherent vulnerability and resilience in particular sectors or environments (the bottom-up approach). The strength of this vulnerability paradigm is that it frees climate change policy studies from the requirement to focus on global mean surface temperature change as the metric to link to economic impact due to anthropogenic changes in atmospheric composition (IPCC, 2001). It also allows for a more rigorous assessment that extends far beyond global mean temperatures and includes other anthropogenic climate influences, such as land-use change (e.g., Adegoke et al., 2007; Adegoke, 2008; Pielke et al., 2007; 2011). Another study (Ifejika Speranza, 2010) argues that climate projections for sub-Saharan Africa do not fit the spatial and temporal scales of agricultural processes, practices or planning and cannot yet produce the details needed for impact assessments. These limitations need to be understood and accounted for in research, policy and planning.

Although there are no long-term data series on which to base definitive statements about climate change and the Nigerian ocean environment, preliminary studies show that rising ocean temperatures could result in further depletion of fisheries resources (Ajayi and Findlay, 1989; Ibe, 1990; Ibe and Ojo, 1994; Ibe, 2011a). It is possible that the dynamic upwelling described by Ibe and Ajayi (1985) may be accentuated by the intensification of ocean dynamic upwelling with positive implications but this can only be elucidated by collecting further observational data and developing more robust regional oceanographic and climate models (Ibe, 2011a).

The uncertainties in the amount and direction of changes in precipitation for Nigeria suggested by climate models have been well documented and these pose additional challenges for developing appropriate adaptation policy responses. For example, the recent study completed by the International Food Policy Research Institute (IFPRI) on West African Climate and Climate Change (Hassan et al., 2013) showed that projected precipitation changes over Nigeria downscaled from four GCMs vary significantly. For example, while one model predicts an increase of 50–100 mm in precipitation by 2050 throughout the country (except in the central portion), another model predicts a complete reversal of the climate pattern in all geographical areas. In the latter scenario, the southern coastal areas that currently receive more rainfall will suffer a greater loss in precipitation, while the northern part of the country will gain precipitation. Statistical downscaling model projections by Abiodun et al. (2013) of nine GCMs show that both B1 and A2 scenarios significantly increase the temperature over all ecological zones of Nigeria, with the A2 scenario producing the greatest warming over the Sudan (short grass) savannah, of 2.2°C by mid century (2046–2065) and 4.5°C by late century (2081–2100). The warming that leads to increased occurrence of extreme temperature and heat wave events over the entire country will also raise the frequency of extreme rainfall events in the south and southeast, and reduce annual rainfall over the northeast. The results of a similar model-based study were published in a recent report on climate resilience in Nigeria produced by the World Bank (Cervigni et al., 2013a) and these are summarized in Box 2.1.

2.3 Climate Change Impacts on Agriculture

Model-based integrated assessment methods are often used to assess the impact of climate change on agricultural productivity. Crop climate models

Box 2.1 Climate Projections for Nigeria

To assess the range of future climate variability, extremes and ultimate impacts, a high-resolution regional climate model (RCM) was used to simulate and project climate change from 1971 through to 2065 under an A1B emission scenario, which represents a median between the most extreme (optimistic and pessimistic) storylines developed by the Intergovernmental Panel on Climate Change (IPCC). The Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC-MED) global model output (about 80 km of horizontal resolution; Scoccimarro et al., 2011) was used to create boundary conditions in which to run a RCM COSMO Model in Climate Mode (COSMO-CLM; about 8 km of horizontal resolution; Rockel et al., 2008). After validating with observed climate over the historical period, the RCM was bias-corrected for the whole simulated time frame. To capture the range of possible climate outcomes, maintain high resolution and take into account uncertainty about future climate, multiple climate projections from GCMs were used to "perturb" bias-corrected RCM results for 2006–2065. Nine global GCM simulations, part of the well-developed Coupled Model Intercomparison Project (CMIP3) experiment, and the CMCC-MED global model were used for this purpose. The results obtained through analyses of perturbed temperature and precipitation data are presented below.

Air Surface Temperature Projections

The simulated air surface temperature averaged over Nigeria indicates a definite increasing trend. Average temperatures in Nigeria will be 1–2°C higher in 2050 than they are at present. The warming projected for 2056–2065 compared to 2001–2010 is more evident during December–February, when the central part of Nigeria (from 7 to 12°N) is affected by warming of up to 3.5°C. From June through to August of 2056–2065, warming is less pronounced; reaching 2.8°C in the northern part. Analysis of extreme events, performed exclusively at regional high resolution via RCM, suggests tendencies for both extremely low and extremely high temperature values to increase. The southern part of Nigeria (south of 7°N) is likely to be less affected.

CONTINUED

Surface Precipitation Projections

The results of the model simulations show that, around 2020, conditions in 53% of Nigeria are expected to be wetter, 10% will have less rain and 35% will be stable. Precipitation projections are highly uncertain for the remaining 2%. In 2050, 41% of the country is expected to be wetter, 14% drier and 20% stable, but the area subject to uncertainty increases from 2 to 25%. Evident clusters of drying areas in the short and medium term are concentrated in the southeast plateau and along the southwest littoral, with stable areas in the centre and along the central and eastern coastal zones. Areas projected to become wetter are in the north, and uncertainty is evident mainly in the arid and semi-arid regions in the medium term (Cervigni et al., 2013a).

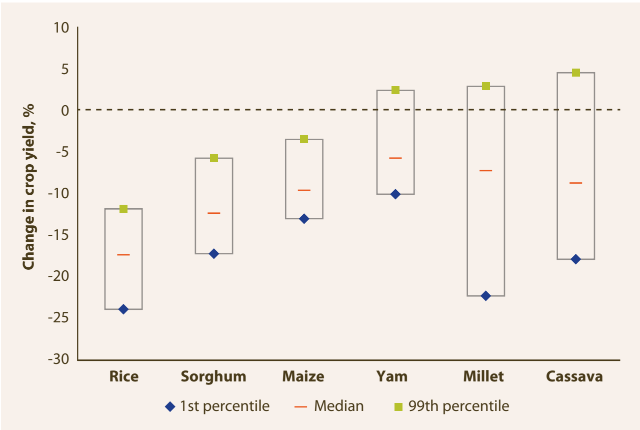
integrate biophysical, agronomic and socio-economic variables and data while livestock climate models involve linking climate data to such livestock production parameters as species, land area and stocking rates (McKeon et al., 2008). In some cases, climate variables (temperature and rainfall) have been used as the primary inputs to simulate fodder availability (Chaplin-Kramer and George, 2013). Currently, there is growing interest and investment in the development of sophisticated crop–climate models. This is driven largely by the need for evidence-based decision-making processes with climate change model outputs used increasingly to recommend adaptation strategies, policy options and interventions across the entire agriculture sector (Whitfield, 2013).

Knowledge of spatial variability due to climate and soil differences is fundamental at country and regional levels to plan crop choice and crop management and to forecast yield and crop requirements. Crop simulation models, combining soil–crop–weather relationships, can lead to simulation of crop management for several years on large areas. There are many types of crop models, but the Decision Support System for Agro-technology Transfer (DSSAT, http://www.icasa.net/dssat/) has been tested and applied worldwide, including several African countries (e.g., Ghana, Morocco, Nigeria and Tunisia), and with a broader range of applications than any other family of crop models. DSSAT integrates the effects of soil, crop, phenotype, weather and management options and allows users to ask "what if" questions and simulate results to assess possible adaptation strategies under different climate change scenarios. The user can also simulate multi-year outcomes of crop management strategies for different crops.

Results reported in the IFPRI study (Hassan et al., 2013) were based on DSSAT crop modelling projections. The study predicts a 5–25% loss of yield in areas planted with sorghum in the northern Sahelian zone, which is already prone to extreme climate variability. This is likely to be the result of expected temperature increase making it too hot for sorghum cultivation in these areas. The expected impact of climate change on food production is not all negative. For example, millet production and yield are predicted to increase in all scenarios, although the area planted with the crop will remain unchanged. Similarly, the production of cassava, sweet potatoes, yams and other root and tuber crops is projected to increase in all scenarios (Hassan et al., 2013). The results of the World Bank study (Cervigni et al., 2013a) are similar in some regards but make important distinctions. The key findings are that, by 2050, there is a very high probability of lower yields in all cereals in all AEZs, except for millet and maize, where projections for parts of the country are uncertain. Rice is particularly vulnerable in the northern parts of the country where yield declines of 20–30% are predicted (Figure 2.5). Notably, the results for cassava, yams and other root crops show high variability with some models. These results suggests yield decline in both 2020 and 2050, while other models show significant increases in cassava yield for both periods (Cervigni et al., 2013a).

DSSAT was also used in the World Bank study (Cervigni et al., 2013a) to assess crop yields in Nigeria under irrigation schemes with different climate scenarios and possible adaptation strategies. The study concludes that further expansion of irrigation

Figure 2.5 Projected changes in crop yields in Nigeria by 2050



Source: Cervigni et al. 2013a; based on authors' aggregated data per agro-ecological zone and weighted against crop yields of base year might be considered as a complementary strategy to enhance the climate resilience of agriculture. As a first approximation, it was found that, by 2050, a combination of 13–18 million rain-fed hectares under improved management practices and 1.5–1.7 million hectares of extra irrigation could fully offset the output gap. Provided that unit costs can be kept in check, the aggregate benefit–cost ratio (in terms of gross domestic product, GDP) is favourable, ranging between 1.3:1 to more than 3:1. Thus, investment decisions made on the basis of historical climate may be wrong: projects ignoring climate change could turn out to be either under- or over-designed, with losses (in terms of excess capital costs or foregone revenues) in the range of 20–40% of initial capital in the case of irrigation.

Scenario-based assessments of the possible impacts of climate change on fisheries and marine resources are now being developed for the country. Most of the results that have been reported in the literature are based on observational studies and extrapolations. For example, Ajayi and Findlay (1989) indicated that important pelagic species, such as *Sardinella aurita* and *Ethmalosa fimbriata*, may decline with global warming, since Resentlythe sardinellas are sparse in the two sectors of the West and Central African Region where the mixed layer is of low salinity, warm water (salinity <35%, temperature >24°C) and present all the year round. Similarly, the tuna previously reported to be of commercial significance (Wise and Ajayi, 1981; Ajayi and Talabi, 1984) may no longer migrate to Nigerian waters. Warming of the ocean off Nigeria's coastline may also lead to the disappearance of some demersal species (e.g., croakers, *Sciaenidae*) that are found in the littoral zone and below the thermocline where the mixed layer is either present or oscillates. There is evidence that fishing communities in Nigeria are already experiencing climate change effects. In response to such effects, the communities are developing coping strategies by having secondary and sometimes tertiary livelihoods, such as mariculture, crop farming and timber logging.

2.4 Reducing Climate Risk and Building Resilience in Nigeria's Agriculture Sector

Considering the various challenges (climatic and non-climatic), differential impacts and uncertainties in both climate projections and socioeconomic drivers, it is advisable that Nigeria should focus on increasing the resilience of agricultural production to climate change. Related measures will include building buffers and buffer capacities that enable adaptation, improve self-organization and grow capacity for learning (Ifejika Speranza, 2010). Ecological buffer capacity relates to growing crops that are tolerant to the prevailing climatic conditions, adopting better agronomic practices that increase soil moisture-holding capacity (e.g., conservation tillage) and soil erosion protection measures, such as terraces and bunds. Enhancing farmers' socio-economic buffer capacities would entail increasing their livelihood assets in ways that provide them with necessary human, financial, social, physical and natural capitals by improving their access to markets, information and new technology. Improving self-organization refers to how well farmers organize themselves to be able to address the problems they encounter with little external help. The capacity for learning refers to a farmer's management approach and openness to learning. As farmers are constantly adjusting their activities and learning from other farmers and their environment, indigenous knowledge reflects this adaptive learning. The question, then, is: how are farmers enabled to learn from their experiences? Government thus needs to understand and strengthen indigenous knowledge systems. Such a resilience approach needs to be region-specific, and adapted to socio-ecological characteristics.

The following four core measures are crucial for successful adaptation: awareness; enabling policy and working conditions; understanding past and future climatic trends; and integrating local knowledge. Understanding climate trends and enabling information on the likely duration and dynamics of such changes will allow for better tailoring of adaptation measures and for ensuring their flexibility. Farmers are continually adapting their production to variable social-ecological conditions, and they have valuable local knowledge that can provide useful insights to professionals. Considering the diversity of Nigeria's AEZs, documenting and strengthening indigenous knowledge can provide a wealth of adaptation knowledge.

A robust adaptation implementation framework must be based on information available from vulnerability and impact assessments that seek to determine the extent to which different communities, ecosystems and natural resources are likely to be affected by climate change. The adaptation options will combine scientific research with laboratory-scale or pilot-scale projects. These will lead in to field-scale projects to demonstrate the framework and capacity needed to

Box 2.2 Effective Adaptation Strategies

Two factors that shape the type of adaptation response are the existing capacity of the affected communities and the level of information about climate change impacts (McGray et al., 2007). Hence, for cases where capacity is low, as in most of sub-Saharan Africa, the major focus of adaptation would be to address the underlying sources of vulnerability, rather than addressing adaptation per se. With higher certainty about climate change, the major focus would be on addressing the impacts. Adaptation thus involves the following:

1. Reducing vulnerability by addressing the drivers of vulnerability to climate change. Such activities generally aim to reduce poverty and other problems associated with a lack of capabilities, for example through improving livelihoods. Although such activities do not address specific climate change impacts, they do help buffer actors from climate trends and shocks (McGray et al. 2007) and therefore build resilience. This means that resilience is at the core of adaptation actions.

2. Building adaptive capacity, thereby increasing the ability to adapt to change (e.g., communicating climate change information, building awareness of potential impacts, investing in livelihood capitals).

3. Implementing adaptation decisions and transforming capacity into action. This focuses on reducing the cumulative impacts of climate change, ensuring that no externalities occur from adaptation actions (i.e., adaptation by one actor does not adversely affect other actors), avoiding anticipated adverse impacts of climate change and ensuring that the distributional impacts of adaptations are minimized (Adger et al., 2005).

Source: Ifejika Speranza (2010)

reduce the intensity of identified impacts. The target should be to mainstream climate change adaptation into all existing and new sectoral policies in the key sectors of land, water, air, energy, biodiversity, fishery resources and coastal resources. The broad objectives are to reduce vulnerability, build resilience and build capacity to adapt to climate change. Box 2.2 describes some effective adaptation strategies.

The preferred approach is for the selection of adaptation measures that are in harmony with natural ecosystems that provide key goods and services to the land and people. Adaptation to climate change must focus on the maintenance and enhancement of the ability of natural ecosystems to continue to perform these functions. It should also address the needs, choices and priorities of farmers. Thus, an ecosystem approach to climate adaptation can contribute to reducing climate change impacts, diminishing the vulnerability of people and infrastructure and increasing their resilience and adaptive capacity. Finally, appropriate policies and legislation must be adopted to promote the development and maintenance of healthy and diverse ecosystems as the basis for adaptation to climate change.

2.5 Climate Resilience in a Low-Carbon Economy

By impacting negatively on agricultural productivity and eroding the natural resource base that is needed for agriculture, climate change has the potential to worsen the supply side of Nigeria's food security and poverty reduction ambitions. In the face of difficulties in predicting inter- and intra-seasonal variability, it is imperative for the country to invest in building agricultural resilience to counter the vulnerabilities imposed by the changing climate. This will require improvements that take on-going development policies (such as promoting agricultural markets, minimizing or eliminating distortions in agricultural policies that will exacerbate climate change impacts, enhancing social protection and microfinance, preparing for disasters, etc.) above and beyond their current capacity. One such policy is the adoption of a low-carbon to carbon-neutral economy as a mantra for national development (Ibe, 2011b; Cervigni et al., 2013b).

Indeed, investments in low-carbon fuels and renewable energy are the pillars of the Vision 20:2020, which articulates the long-term intent to launch Nigeria onto a path of sustained social and economic progress, improve the living standards of all Nigerians and place the country among the top 20 economies in the world by 2020. Assuming conventional approaches to oil and gas production, electricity generation and use, transportation and agriculture are maintained, the

World Bank estimates that achievement of the Vision 20:2020 goals might add up to 11.6 billion tons of CO_2 to the atmosphere over the period 2010–2035 – five times the estimated historical emissions between 1900 and 2005. In contrast, the World Bank predicts that a low-carbon path to achieving those development objectives for 2020 and beyond would result in 32% lower carbon emissions and net economic benefits to Nigeria estimated at about 2% of GDP. These national benefits include a more productive and climate-resilient agriculture. The World Bank Report argues that the time to make that transition is now because "once locked into the country's economic fabric, higher carbon technologies are costly and impractical to reverse" (Cervigni et al., 2013b). Nigeria can and should "leapfrog" the carbon-intensive phase of development and move directly to cleaner, more advanced transport, energy, agricultural and land-use options.

The World Bank suggests that the Federal Government of Nigeria, in partnership with the states as appropriate, might consider a number of actions that could help remove the barriers to low-carbon development in the agriculture sector. These include: bringing up to 1 million hectares under "triple-win" (higher yields, better climate resilience, reduced carbon emissions), sustainable land management practices by 2029; ensuring the Agricultural Transformation Agenda includes support for climate-smart agriculture demonstration projects; launching a dedicated research and extension programme on climate-smart agriculture; and defining procedures and screening tools to integrate climate considerations into project evaluations.

2.6 Conclusion

From an environmental point of view, 2012 was one of the most challenging years for Nigeria in recent history due to the unprecedented flood that ravaged several states. According to statistics released by the US Federal Emergency Management Authority, over 2.3 million people were displaced, 363 persons lost their lives and the total value of losses across all sectors of the national economy was estimated at US$16.9 billion. The 2012 flood exposed Nigeria's vulnerability to extreme climate events and underscores the need for deliberate planning to enhance adaptive capacity and resilience across all sectors of the Nigerian economy, including agriculture.

Despite considerable uncertainty about future climate, we know enough to build meaningful scenarios on which decision-making can be based. Uncertainty about the local impacts of global climate change trends, particularly in developing countries, has hampered adaptation action to date. But even in locations with limited existing research, the test cases developed in the World Bank study discussed in this chapter (Cervigni et al., 2013a) were able to build robust scenarios to 2030. The World Bank study identifies sets of adaptation actions that can serve as good precautionary steps to prepare for a range of possible climate change outcomes. These scenarios show that degradation of natural resources has a direct impact on agricultural productivity and livelihoods by reducing the resilience of the agro-ecosystems to extreme climate events. This further undermines the region's future capacity to cope with climate change. The following chapter explores this issue in greater detail, focusing on opportunities and strategies for enhancing the country's natural resource base for agricultural resilience.

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