Federal Ministry of Agriculture and Rural Development

NATIONAL AGRICULTURAL RESILIENCE FRAMEWORK

GROWING AGRICULTURE, CREATING WEALTH

A Report by the Advisory Committee on Agricultural Resilience in Nigeria

EDITED BY JIMMY ADEGOKE, CHIDI IBE AND ADEBISI ARABA

Cover Picture: *Norman Borlaug* heat- and drought-tolerant tropical wheat variety, developed by the Lake Chad Research Institute, Maiduguri. Photo by Adebisi Araba
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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 business rather than a development programme. Our goal is to add 20 million metric tonnes 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 ongoing 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, agricultural productivity and food production rose by 21 million metric tonnes in 2014.

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 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 metric tonnes of grains to support Niger Republic to address food shortages.

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 the 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 Chair and Co-Chair, respectively.

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.

Akinwumi Ayodeji Adesina (PhD.) CON

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Acknowledgements

This report was prepared by the Advisory Committee on Agricultural Resilience in Nigeria (ACARN), a group constituted by the Honourable Minister, Federal Ministry of Agriculture and Rural Development (FMARD), Dr Akinwumi Adesina and inaugurated on 17 September 2013. Membership of the Committee was drawn from distinguished experts on the subject matter from Nigeria, Africa and beyond including senior functionaries from the World Bank, the African Development Bank and the Consultative Group on International Agricultural Research (CGIAR) with Professor Jimmy Adegoke as Chair and Professor Chidi Ibe as Co-Chair. High-level functionaries from the FMARD and relevant governmental organizations were admitted as ex-officio members.

The study went through an iterative consultation process, the first of which took place during a series of Town Hall type meetings in the six geopolitical zones of the country. The Committee benefited from the frank and lively discussions and insightful comments and suggestions received during these workshops from representatives of government ministries, departments and agencies; academic institutions; national and international research institutes; non-governmental organizations and farmers' groups. The administrative and technical support of the ACARN Secretariat under the direction of Mr Damilola Eniaiyeju, Director of Extension Services at the FMARD, and incorporating Messrs Abel Adebayo, Okunlaya Adekunle, Abayomi Aina, Daniel Odogbo, Abayomi Aina, Wale Fasade, Okunlaya Adekunle, Gani Garuba, Daniel Odogbo and Haruna Yusuf, provided invaluable assistance in the course of these meetings. Mr Yarama Ndirpaya of the Agricultural Research Council of Nigeria (ARCN) provided excellent service as Hausa language translator at several of the Town Hall meetings.

The various chapters of the report benefited immensely from the research, writing and editorial contributions of various persons as follows:

- The overall supervision and detailed editorial work was accomplished by the team of Professor Jimmy Adegoke, Professor Chidi Ibe and Dr Adebisi Araba.
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- The Honourable Minister of Agriculture kept a catalysing interest in the progress of the study and, together with the Permanent Secretary of the FMARD, provided valuable guidance and support at various stages of the study.

Executive Summary

Globally, agriculture is the mainstay of most well planned economies because it contributes significantly to the national gross domestic product (GDP), creates employment, provides food for human sustenance, raw materials for industry and earns foreign exchange. Nigeria is blessed with abundant agricultural resources spanning several agro-ecological zones. Nigeria's total land area is 92.3 million ha with a cultivable area estimated at 84 million ha, which is 91% of the total area. Forests account for 13% of the land area. Most of the country's land area is fertile and conducive for growing a wide range of crops and raising livestock. Nigeria's 853-km coastline along the Gulf of Guinea is a gateway to a vast ocean, which, together with ample fresh water resources provided by the Niger and Benue river systems, affords tremendous potential for fisheries and aquaculture. Nigeria took advantage of these resources to establish itself as an agricultural powerhouse in the 1960s. According to statistics from the United Nations Food and Agriculture Organization (FAO), by 1961 the country accounted for 42% of global trade in groundnut oil and 18% of cocoa. In addition, Nigeria hosted 27%of the world's palm oil industry. The country was also self-sufficient in food production before the discovery of oil in the 1960s.

Although the Federal Government relies on crude oil for more than two thirds of its revenue, Nigeria's biggest economic sector is agriculture, which accounts for 44% of GDP and 70% of employment. Agriculture is intricately linked with many sectors of the economy and is essential for the broad-based growth necessary for development. A major policy thrust of the Government of His Excellency, the President and Commander in Chief of the Armed Forces of Nigeria, Dr Goodluck Ebele Jonathan is the Agricultural Transformation Agenda (ATA), through which the Federal Government plans to add at least 20 million metric tonnes of food to the national supply and 3.5 million new jobs in the agriculture sector by 2015. The ATA is a deliberate, bold and carefully crafted programme of the Federal Ministry of Agriculture and Rural Development (FMARD) under the leadership of the Hon. Minister of Agriculture and Rural Development, Dr Akinwumi Adesina, to "achieve a hunger-free Nigeria through an agriculture sector that drives income growth, accelerates achievement of food and nutritional security, generates employment and transforms Nigeria into a leading player in global food markets to grow wealth for millions of farmers".

To support the national ATA programme and strengthen national capacity to respond effectively to the challenges of climate change, the FMARD launched an initiative in 2013 to develop a roadmap for implementing climate-resilient agriculture based on innovative agricultural production strategies and risk management mechanisms to promote resilience in the agriculture sector. The Minister invited leading experts on climate impacts, agricultural systems and global food security to constitute the Advisory Committee on Agricultural Resilience in Nigeria (ACARN). The Committee's duty is make recommendations, based on informed expertise and research, to inform policies 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.

The methodology adopted by the ACARN in this study was to use a mix of expert consultations and 'Town Hall' style meetings with farmers, the River Basin Organization functionaries and staff of the Nigerian Agricultural Research System to distil the priority risks to the agriculture sector posed by climate change, to enquire into the most suitable strategies and technologies for overcoming or coping with such risks, and to make recommendations as appropriate that will lead either to their resolution or containment.

The introductory chapter makes a case for the eminence accorded to agriculture and agricultural resilience. It derives from the intrinsic capacity of agriculture to catalyse other sectors of economic development, a process described by the ACARN member and Director of Agriculture for Impact, Sir Gordon Conway, as "a virtuous circle". In this context, increased agricultural productivity banishes rural poverty, stimulates the rural economy by creating small businesses and employment and results in the development of roads that link rural economies to urban areas and, ultimately, to vibrant import and export markets anchored on free trade.

Chapter 2 deals with the methodological approaches and results of the modelling of various scenarios of vulnerabilities to the impacts of climate change within the agriculture sector in Nigeria by

various researchers, both within and outside the country. It tests the validity of the assumptions that served as inputs into the modelling process and concludes that, despite the lack of refinement in some of the studies, there is every reason for the emphasis and urgency on building agricultural resilience. It submits that this should be done within the remit of a low-carbon economy.

Chapter 3 describes how a safe and flourishing natural environment is an essential base for successful and productive agriculture. Unlike other production sectors of the economy, agriculture is a renewable resource deeply anchored on the ability of ecosystems to continue to provide their known goods and services. The chapter considers the status of the natural resource base and recommends what should be done to enhance it in support of resilient agriculture in Nigeria. It insists that agricultural practice must take account of the role of the natural environment and develop solutions that are in harmony with nature.

Chapter 4 dwells on the necessity to mainstream climate change adaptation into agricultural policy and practice. It discusses the most cost-efficient and effective methods of achieving this process with a view to climate-proofing agriculture. It describes the adaptation–mitigation nexus and argues that the best approach to adaptation is via technologies and strategies that produce the maximum mitigation benefits. It ends with a discussion of viable governance models that will entrench an adaptation culture and promote a preference for climate-resilient agriculture.

Chapter 5 explains how investment in agricultural research and adoption of new technologies can provide a quantum leap in productivity and concomitant economic growth, as achieved during the Green Revolution of the 1960s that kick-started the economies of the Asian Tigers and placed them on a solid path to sustainable development. It stresses the necessity to transform the research management structure in Nigeria along the lines of Brazil's EMBRAPA model, in which research is both demand- and profit-driven. The imperative to re-engineer the Agricultural Research Council of Nigeria (ARCN) from a coordinating to a managerial Council and a corresponding overhaul of its present structures is stressed.

Successful adaptation require a dissection of climate impacts to understand the risks they pose and the degree of certainty with which predictions are made, as well as assessing the various dimensions of vulnerability and the appropriateness, including costs and benefits, of a range of potential options for action. It also requires the availability of critical agricultural inputs, including insurance and credit, to enable farmers to make and implement the right choices. These aspects fall within the responsibility of agricultural extension services, which receive considerable attention in **Chapter 6**. It is not an exaggeration to say that accelerated growth in agricultural output cannot be maintained without adequate investments in rural infrastructure and agricultural research and extension.

Chapter 7 explores and recommends the policy options that will underpin the successful implementation of the recommendations of this Report and make for the general well-being of the agriculture sector. They include important and ongoing FMARD development initiatives that need to be reinforced to reduce vulnerability to climate change, 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, insurance and, critically, mainstreaming climate change in agricultural policies and practice. This chapter describes additional development issues that are critical to agricultural production, processing, storage, marketing and trade. It stresses the value chain approach as the only viable option to increase development of the agriculture sector as well as for its sustainability.

Financing for climate-resilient agriculture is a core issue in the drive for agricultural resilience to the impacts of the changing climate. Globally, the costs of adaptation (and resilience) are colossal. Still, it is recognized that there are no alternatives to tackling the problem head on. While this may be challenging to developed countries, it is a herculean task for developing countries like Nigeria because of low adaptive capacities and a weak economic base. **Chapter 8** explores innovative financing options for building agricultural resilience to the changing climate in Nigeria, and concludes that they are "doable" given the right enabling environment and commitment.

Without effective monitoring and evaluation (M&E), there can be no systematic pathway to assessing the development and impact of social learning and behavioural change in the adoption of climate-resilient agricultural practices and methodologies. Mainstreaming this good practice within the Nigerian agricultural landscape will further entrench the gains of climate-resilient agriculture in the

agriculture value chain in the country. **Chapter 9** makes recommendations for preferred approaches to successful M&E, including participatory methods of data collection that will engender new insights into people's needs for project planning and implementation.

Many stresses and shocks are interlinked, for example, energy and input price volatility, extreme weather events and climate change, growing scarcity of natural resources and poverty, inequality and unsustainable population growth. Policies must factor these competing challenges. Also important is the necessity for clear role assignments and cohesion among the various ministries, departments and agencies of government, the private sector, development partners, non-governmental and community-based organizations and agricultural communities. In the **concluding chapter**, we stress the need for harmonization and restructuring of the architecture for planning, programme formulation and implementation support across institutions with mandates relating to the many dimensions of food security, poverty eradication, sustainable development and climate change.

Whereas the present report presents a framework for achieving agricultural resilience, the greater challenge is its implementation. Scoping an implementation plan that would encapsulate the building of competencies within the FMARD to routinely undertake the implied tasks is the next logical undertaking for the ACARN. Paramount in the scheme of competencies will be the ability within the FMARD to continuously and successfully model the vulnerabilities of the agro-ecological systems to the vagaries of climate change. This will enable a continuous refinement of the strategies and agro-technologies made available through research for management of climate risk for resilience in agriculture.

1

Introduction

1.1 Why is Agricultural Resilience Important?

It is now widely accepted that climate change poses a significant and serious global threat to sustained economic growth, agricultural development, poverty reduction, food security and political stability. These threats are compounded by repeated spikes in food prices, which have created a growing food crisis in many parts of the world, high prices for fossil fuels and fertilizers, an increase in environmental degradation, and competition for food and water (Montpellier Panel, 2012). Nowhere are these challenges more marked than in Africa, where two thirds of all available land is classified as desert or dry land.

The Intergovernmental Panel on Climate Change (IPCC) identifies Africa as the continent most vulnerable to climate change and variability. The International Food Policy Research Institute (IFPRI) estimates that by 2050, the combined effect of increasing temperatures, declining rainfall and more frequent floods and droughts could result in average rice yields falling by up to 14%, wheat by up to 22% and maize by up to 5%. Based on these estimates, food availability in sub-Saharan Africa will be cut by 500 calories per person – a 21% decline (IFPRI, 2009).

Agriculture in Africa is especially vulnerable to climate change and variability because of its high dependence on seasonal rainfall. In Nigeria – Africa's most populous country and second largest economy – agriculture accounts for nearly 40% of the country's gross domestic product (GDP). More than 70% of the economically active population and their dependents (over 100 million people) rely on agriculture for their livelihoods.

Country-specific observations from studies conducted in recent decades show that various parts of Nigeria have already experienced the impacts of climate change. These include accentuated droughts, severe floods and increased occurrence and intensity of storm surges, with concomitant flooding, coastal erosion, the salinization of fresh water aquifers, and variability in the availability of fisheries resources (Adefolalu, 1986; Adegoke et al., 2010; Ibe, 1990; Ibe and Ojo, 1994; NFNC, 2003; Oladipo, 1993). Projections of future climate trends suggest that global warming may further aggravate these problems (Abiodun et al., 2012, 2013; Cervigni et al., 2013a).

1.2 The National Climate Change Adaptation Strategy and Action Plan for Climate Change in Nigeria

Current and anticipated environmental and climate-related changes will devastate Nigeria's national economy if adequate response plans and mitigation strategies are not put into place urgently. The recently completed National Climate Change Adaptation Strategy and Action Plan for Climate Change in Nigeria (NASPA-CCN) indicates that climate change is already having significant impacts in Nigeria, and that these are expected to increase in the future (BNRCC, 2011). Recent estimates suggest that without any adaptation measures, climate change could cause losses of between 2% to 11% of Nigeria's GDP by 2020. These estimates could rise to between 6% and 30% by 2050, equivalent to between N15 and N69 trillion (US$100 to US$460 billion). These are the result of a wide range of climate change impacts that affect all economic sectors in Nigeria, with agriculture being the most vulnerable.

The NASPA-CCN proposes the key adaptation measures and action points needed to minimize these risks, improve local and national adaptive capacity and resilience, make the most of any opportunities created by climate change, and facilitate collaboration with the global community. These will all help to reduce Nigeria's vulnerability to the negative impacts of climate change. Box 1.1 highlights specific recommendations for the agriculture sector.

These recommendations are supported by other studies, including two recent country-specific studies by the World Bank – *Toward Climate Resilient Development in Nigeria and Low Carbon Development: Opportunities for Nigeria* (Cervigni et al., 2013a, 2013b). These studies identify further new and innovative adaptation measures for the agriculture sector, such as:

- changes in agricultural practices to improve soil fertility and enhance carbon sequestration
- changes in agricultural water management for more efficient water use
- improved spatial targeting of investments
- agricultural diversification toward enhanced climate resilience

Box 1.1 Recommendations in the NASPA-CCN for Building National Adaptive Capacity and Resilience in the Agriculture Sector

1. Review national agriculture and related policies and programmes

The Federal Government should review all national agriculture and related policies and programmes to determine the modifications required in view of expected climate change. This would include policies and programmes related to:

- Nigeria's agriculture policy
- agricultural research, livestock, fisheries, seeds, crops, markets and food security
- water harvesting, erosion and flood control, soil conservation, and drought and desertification.

2. Leadership role

The Federal Government should play a leadership and catalytic role by encouraging and supporting new programme initiatives in the following areas:

- *Provide agricultural extension services for resilience in agriculture:* support a state-led extension programme addressing climate change adaptation. Key areas could include programmes focused on the training of trainers in priority adaptation areas, and involving the National Youth Service.
- *Create a community-based climate change adaptation support programme:* collaborate with state governments and civil society organizations (CSOs) to establish a country-wide community-based climate change adaptation support programme.
- *Create a climate change and agriculture research programme:* working through the Agricultural Research Council of Nigeria, the Federal Government can stimulate and support a new national research initiative to address climate change impacts and adaptation in Nigeria's agriculture sector.
- *Promote micro-insurance and micro-credit:* stimulate and support CSO and private sector involvement in providing insurance and access to finance for small-scale farmers vulnerable to climate change, to enable them to adapt their farming practices.
- *Promote poverty reduction through integrating adaptation and mitigation:* provide incentives to encourage enhanced income generation through intercropping with biofuel crops, especially in the low-carbon-density tracts of the country (income can be enhanced directly and through participation in carbon markets).

3. Early warning systems

The Federal Government should review current policies and programmes for early warnings. Based on this, they should develop and roll out a programme to improve the availability of, and farmers' access to, short- and long-range weather forecasts.

4. Irrigation and water supply

In view of projected rainfall changes, particularly in Nigeria's northern ecozones, the Federal Government should increase efforts to identify environmentally sound and sustainable opportunities to improve and extend irrigation for crops, and water supply for livestock.

5. Green growth technology solutions

The Federal Government should identify productive avenues for interventions and investment that promote innovation in low carbon-based technologies for green growth, including opportunities to transfer appropriate technology from other countries.

6. Gender

Climate change risks and vulnerability are exacerbated by the gender-differentiated needs and roles of society. The Federal Ministry of Agriculture and Rural Development (FMARD) should encourage community participation and active roles for women in all livelihood development initiatives within its mandate.

7. International funding

The Federal Government should facilitate access to international funding for climate change adaptation. This will support various climate-resilient (also known as climate-smart) agricultural development initiatives at the national, state and local government levels.

- reducing greenhouse gas emissions from agriculture and increasing the value of sustainable farming practices, by valuing carbon and other agricultural ecosystem services, such as water purification and biodiversity
- agricultural science and technology development
- agricultural advisory services and information systems
- risk management and crop/livestock insurance.

1.3 Building Agricultural Resilience

The National Policy on Climate Change (FGN, 2012), which was recently adopted by the Federal Executive Council, allows for an integrated agricultural intervention plan to reduce the sector's vulnerability to climate change and strengthen resilience. This will help to achieve the dual goals of food security and poverty reduction.

Vulnerability means susceptibility to harm or damage. Resilience, on the other hand, implies the ability of a system to cope, absorb stresses or shocks, and recover or "bounce back". A stress is defined as a regular, sometimes continuous, relatively small and predictable disturbance (e.g., the effect of growing soil salinity). A shock, by contrast, is an irregular, infrequent, relatively large and unpredictable disturbance, such as a rare drought or flood, or a new pest (Conway, 2012). The distinction is important: they are different phenomena (even though they sometimes blend into one another) and have different effects on agricultural production. As such, they require different responses and adaptations.

The Montpellier Panel (2012) identified seven steps that need to be taken to build resilience. These include the **anticipation** of the likelihood and location of a stress or shock, via a **survey** (or agro-climatic monitoring in the case of extreme weather events). The next steps – **prevention** and **tolerance**, **recovery** and restoration – involve defining objectives, identifying the various options and appraising them in terms of their outcomes and the relevant costs and benefits. Situations do arise when damage is unavoidable, and the only response then is to **restore** the basis for growth. Lastly, building resilience is about **learning** from past experiences.

1.4 The Agricultural Transformation Agenda

Nigeria's agriculture sector has been undergoing phenomenal change under President Goodluck Ebele Jonathan's Agricultural Transformational Agenda (ATA). The ATA is guided by a vision to unlock the full potential of agriculture by making Nigeria an agriculturally industrialized economy, along the scale and magnitude of the market revolutions of Brazil, China and India over the past two decades. In pursuit of this vision, the FMARD, led by the Honourable Minister Dr Akinwumi Adesina, set ambitious goals in 2011. These included producing an additional 20 million metric tonnes of food and creating 3.5 million new agricultural jobs by 2015.

To support the ATA and strengthen national capacity to respond effectively to the challenges of climate change, the FMARD – under the leadership of Dr Adesina – launched an initiative to develop a National Agricultural Resilience Framework (NARF). The will include a robust implementation plan that incorporates innovative agricultural production strategies and risk management mechanisms to promote resilience in the agriculture sector. The Honourable Minister invited leading experts on climate impacts, agricultural systems and global food security from within and outside Nigeria to constitute the Advisory Committee on Agricultural Resilience in Nigeria (ACARN).

The Honourable Minister inaugurated this committee on 17 September 2013. Its mandate is to develop the NARF and advise on the policies required to successfully implement a national climate-smart agricultural programme. The goal is to strengthen the capacity of small- and large-scale agricultural producers to increase productivity, grow their wealth and thrive in the face of the growing social and environmental challenges stressors – including changing climate. This initiative is Nigeria's first attempt at developing a sector-specific climate adaptation and risk mitigation programme.

1.5 The National Agricultural Resilience Framework Report: Aims, Approach and Methods

The natural world – its biodiversity, landscapes and ecosystems – is constantly changing. However, the increasing pace of climate change will place unprecedented pressures on access to, and use of, natural resources. As we pursue the intensification

of agricultural production for economic growth and national food security, it is important that agricultural reforms include the imperative to preserve the natural world. It will be necessary to develop integrated approaches to land management (e.g., sustainable land management practices such as agroforestry and conservation agriculture) that can significantly increase yields while delivering better environmental outcomes. These approaches will also enhance farmers' resilience to climate change and variability.

The NARF has the principles of adaptive management and participatory engagement as the central tenets of its implementation strategy. Adaptive management acknowledges uncertainty as a context of decision-making and builds flexibility into policy and decision-making to manage risk; it also allows for the input of new knowledge. Box 1.2 highlights the policy options, opportunities and required interventions for achieving the strategic objectives within the NARF report.

Early on in the process of developing this report, the committee decided to focus on small-scale rural farmers and agricultural communities, because they are the largest private sector producers. The report articulates a vision that speaks to and directly supports the ATA. Its broadly stated strategic objectives are aligned to the NASPA-CCN (2011) and the National Policy on Climate Change (FGN, 2012). These goals are addressed in separate chapters that describe specific programmes and interventions, along with the strategic actions needed to implement them successfully. The strategic actions are the programmatic building blocks that are needed to achieve the goals, and are highlighted throughout the report. Many chapters include a summary that identifies the principal parties responsible for implementation and the target beneficiaries.

During the three-month planning process, the ACARN hosted several stakeholder engagement sessions (Town Hall meetings) in Nigeria's six geopolitical zones to consult with a broad spectrum of stakeholders. These stakeholders provided oral and written submissions from across the country that were instructive and helpful in forming several of the recommendations in this report, including examples of successful adaptation models or ongoing activities that promote resilience. Some of these are included as case studies in boxes in the relevant sections of this report. Additional case studies from other developing countries highlight lessons that are relevant to Nigeria and potentially transferable.

Box 1.2 The NARF's strategic objectives

- Strengthen the overall policy and institutional framework for improved resilience and adaptation to climate variability and change in the agriculture sector, including planning and implementation, systems for resource mobilization and effective project monitoring and evaluation.
- Evaluate and introduce risk transfer and risk management strategies (e.g., improved seasonal and real-time weather forecasts, insurance-based risk mitigation options) into the agriculture sector and encourage the widespread deployment of these through communication technologies, including mobile phones.
- Improve productivity through training communities and farmers on land and water management strategies (e.g., irrigation, water harvesting, soil fertility enhancement and erosion control), improved farming practices and using policy instruments such as economic incentives, regulations and communication.
- Reinforce existing social safety nets through support systems that reduce vulnerability and improve livelihood conditions for the vulnerable, especially women and children.
- Improve farming systems research capacity within the national agricultural research systems (NARS) to enable and support the implementation of climate-smart agriculture in Nigeria.
- Revamp extension services, including building capacity for evidence-based assessment and management of climate risks for resilience in the agriculture sector.

1.6 Structure of this Report

This NARF report comprises ten chapters. Following this introduction, Chapters 2 and 3 provide information about Nigeria's climate and natural resource base. Chapters 4 and 5 focus on the policy and research institutional framework that must underpin any successful agricultural resilience programme; both offer important insights and recommendations for

transforming agricultural planning and research in the country. Chapter 6 focuses on agricultural extension, identifying the major gaps in the current system and offering recommendations on new programmes and strategies that could transform agricultural extension in the country. Chapter 7 identifies the key adaptation options and policy interventions necessary for implementing a successful climate-smart agriculture programme. Chapter 8 outlines a broad-based strategy for securing the internal and external resources needed to fully implement a robust agricultural resilience programme, including opportunities to leverage current and future development aid and multilateral funding in support of climate-smart agriculture in Nigeria. Chapter 9 focuses on innovative frameworks for project monitoring and evaluation, while Chapter 10 summarizes the key recommendations and offers some thoughts that should help to guide the implementation phase of the NARF.

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2

Nigeria's Changing Climate: Risks, Impacts and Adaptation

2.1 Nigeria's Climate

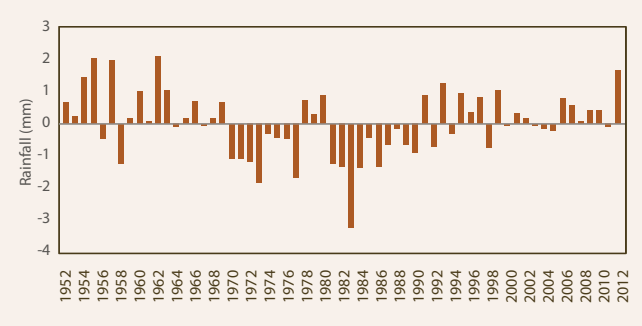
Nigeria's climate is affected by three systems: the Tropical Maritime air mass, the Tropical Continental air mass and the Equatorial Easterlies (Ojo, 1977). The Tropical Maritime and Tropical Continental air masses meet along the Inter-Tropical Discontinuity (ITD). The position and oscillation of the ITD during the year affect the spatial and temporal distribution of the key climate characteristics (Adegoke and Lamptey, 1999). Following the annual movement of the ITD across the Equator, the rainy season advances inland from March to August, and retreats from September to November, with a pronounced dry period between December and February. The Equatorial Easterlies air mass occasionally undercuts 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 south of Nigeria, giving an annual rainfall of over 2000 mm, with semi-arid conditions and annual rainfall of less than 600 mm in the north. 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) shows that Nigeria's climate has varied considerably over the last half-century (Figure 2.1). While there are significant differences between years, distinct decadal trends can be observed. For instance, there was a wet period from the early 1950s through to the late 1960s. This was followed by a very dry period during the 1970s and 1980s, and an apparent return of wetter than normal conditions in the 1990s. These swings underline Nigeria's vulnerability to extreme climate events.

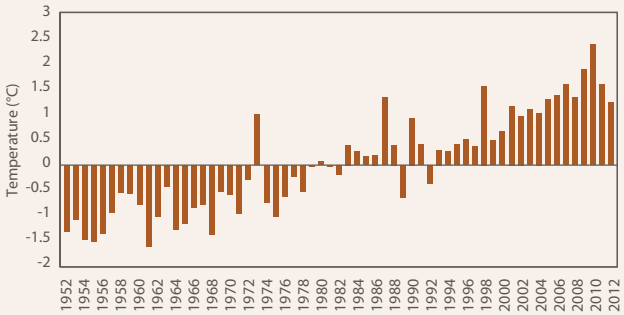
Figure 2.2 shows Nigeria's temperature variability for the period 1952–2012. This demonstrates a strong warming trend from the mid-1970s to the present;

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



Source: NIMET

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



Source: NIMET

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 recent climate projections for the country indicate a 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). It has been observed that the area experiencing a double rainfall maximum is shifting southwards, while the short dry season (August break) now occurs more frequently in July, compared to 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. The late onset of the rains, which were observed in only a few locations during the early 2000s, have become much more widespread. Similarly, early cessation of the rains, which was once 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.

2.2 Agriculture and Fisheries in Nigeria

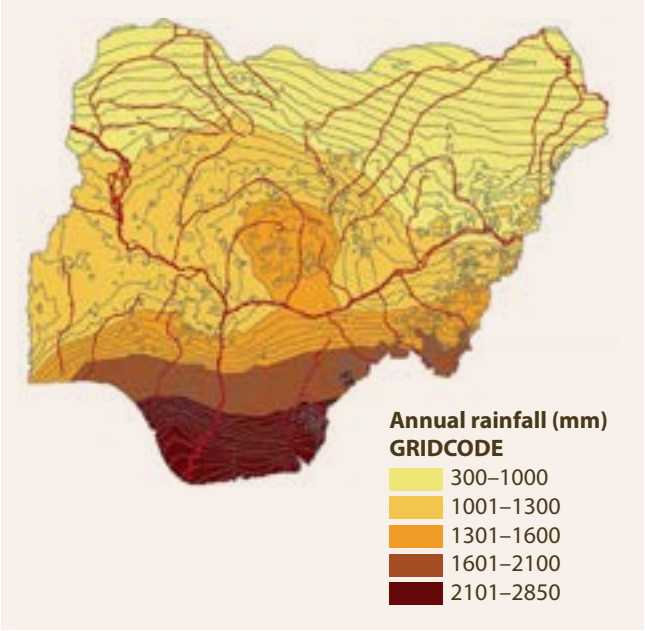
Agro-ecological zones (AEZs) are land-mapping units defined on the basis of their climate, landform and soils. In Nigeria, AEZs range from humid to dry. The variations in rainfall (described in the previous section) govern the types of indigenous plants that grow, and the exotic plants that can be successfully introduced. 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.

Nigeria is richly endowed with fisheries resources. These make an important contribution to the country's economy and food security and, if rationally exploited, these could make the country more than self-sufficient in fish production. Nigerian fisheries are found in a wide range of ecosystems, from freshwater streams, rivers, reservoirs and lakes (both natural and man-made), through brackish-water creeks, estuaries and lagoons, to the coastal inshore and offshore marine environment. There are an estimated 12.5 million hectares (ha) of inland water bodies, made up of reservoirs, lakes, ponds and perennial swamps (Ita, 1993) and some 741,500 ha of brackish water, most of which are suitable for aquaculture. The inland water surface area of 14 million ha is estimated to be capable of producing more than 2 million tonnes of fish per year, which can be augmented by expanded aquaculture.

The marine environment is characterized by a narrow shelf that breaks at depths of between 100 and 120 m. It is scoured by the Avon, Mahin and Calabar canyons and has pockets of dead Holocene coral banks. This provides rich fishery resources of both local and trans-boundary importance, with stocks supporting artisanal and industrial fisheries (Ibe, 1982). The potential production is from the nation's 200 nautical mile Exclusive Economic Zone, which stretches for 853 km along the coastline and has an area of 210,900 km2. This was estimated at 370,000 tonnes per year in 1983 (Ssentongo et al., 1986). Tobor (1990) estimated the maximum sustainable yield of Nigerian fisheries resources at 240,000 metric tonnes, but official catch figures and unofficial estimates have consistently exceeded this value.

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



Source: Abila, 2010

The unrestricted activities of global industrial fishing fleets are encroaching on the artisanal fisheries, placing food security and economic returns from Nigerian fisheries at risk. The consequences of overfishing are grave and would undoubtedly lead to a decline in catch volumes and the total disappearance of some of the most valuable fish species, including those of global significance. Additionally, the marine environment is under assault from a variety of land- and sea-based pollutants, including agro-chemicals, municipal wastes, at-sea dumping and a dominant oil industry. In addition to increasing ocean acidification, these pollutants pose a distinct threat to the health of the marine ecosystem and its rich fisheries (Ukwe et al., 2006; Ukwe and Ibe, 2008).

2.3 Risks From Future Climate Change

Climate change projections are uncertain due to the complex nature of the climate and its feedback mechanisms, which are difficult to capture in models. Uncertainties also arise from a lack of climate data, differing and uncertain scenarios for future greenhouse gas emissions, and little consideration of seasons (e.g., wet and dry seasons).

General circulation models (GCMs) are the main tools used to predict the climate of the future. They account for the effects of greenhouse gases in the atmosphere and the resulting global climate change. While they are useful at global and continental scales, they are unable to represent more local features and dynamics. The hydrologic implications of global climate change (e.g., precipitation in a region or stream flow in a river), which are of interest in climate change impact studies, are therefore usually assessed by downscaling the predictors simulated by GCMs. As a result, different GCM datasets produce varying and even contradicting results. Most studies tend to use several different models to obtain more reliable estimates of potential regional changes and to account for these uncertainties.

When assessing the likely impacts of climate change, researchers need to complement the data provided by climate models with assessments of the inherent vulnerability and resilience of particular sectors or environments. This takes the focus away from global mean surface temperature change and allows for the inclusion of other anthropogenic climate influences, such as land use change. A study by Speranza in 2010 argued 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.

The uncertainties in the amount and direction of changes in precipitation for Nigeria, as suggested by climate models, have been well documented and these pose additional challenges for developing appropriate adaptation policy responses. For example, a recent study by IFPRI on West African Climate and Climate Change (Hassan et al., 2013) showed that projected precipitation changes over Nigeria 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 most rainfall will suffer a greater loss in precipitation, while the northern part of the country will gain precipitation.

Statistical downscaling of model projections by Abiodun et al. (2013) of nine GCMs show that some scenarios predict a significant increase in the temperature over all of Nigeria, with one scenario predicting the greatest warming over the Sudan savannah, of 2.2oC by mid-century (2046–2065) and 4.5oC by late–century (2081–2100). The models also predict that warming trends will lead to an increased occurrence of extreme temperatures and heat waves over the entire country, and will increase the frequency of extreme rainfall events in the south and southeast, while reducing annual rainfall in the northeast. Box 2.1 summarizes the results of a similar model-based study, published in a recent report on climate resilience in Nigeria by the World Bank (Cervigni et al., 2013a).

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 further deplete fisheries (Ajayi and Findlay, 1989; Ibe, 1990; Ibe and Ojo, 1994; Ibe, 2011). Increases in water temperature caused by climate change can affect every stage of the life cycle of fish, by affecting physiological, morphological, reproductive, migratory and behavioural responses. The displacement of brackish and fresh waters by rising sea levels in the Niger Delta and other coastal areas will also disrupt habitats and spawning grounds, cause variation in the occurrence of fish species and depress productivity, thereby adversely affecting freshwater fisheries and aquaculture.

An increase in the frequency and intensity of storms could directly endanger people and communities on Nigeria's coast, by causing damage to housing, community facilities and infrastructure used for fisheries and aquaculture. Inland, the increased variability in rainfall patterns and in air and water temperatures will affect the productivity of rivers, lakes and floodplains, which will have an impact on freshwater fisheries and aquaculture. Broader changes in Nigeria's hydrological conditions, and seasonal changes in temperature, pH, salinity and ecosystem health, will also affect productivity and increase risks. At the same time, friction with other freshwater stakeholders (e.g., agriculture, industry, energy generation and urban water supplies) are likely to arise as a result of climate change.

However, raised sea levels may create new environments and opportunities for the fisheries and aquaculture sector (e.g., coastal aquaculture and mangrove development). It is possible that the dynamic upwelling described by Ibe and Ajayi (1986) may have positive implications in the future, but more data and modelling will be required to make an accurate assessment.

2.4 Impacts on Agriculture

The likely impacts of climate change on agriculture can be assessed using crop–climate models, which integrate biophysical, agronomic and socio-economic variables and data. The development of more sophisticated crop–climate models is helping to meet the need for evidence-based decision-making and to recommend adaptation strategies, policy options and interventions across the agriculture sector. Similarly, livestock–climate models involve linking climate data to livestock production parameters such as species, land area and stocking rates. Models that combine soil–crop–weather relationships for specific countries and regions can simulate different crop-management scenarios for several years over a large area.

Box 2.1 Climate projections for Nigeria

To assess the range of future climate variability, extremes and impacts, a high-resolution regional climate model (RCM) was used to simulate and project climate change from 1971 through to 2065. This was modelled under an A1B emission scenario, which represents a median between the most extreme (optimistic and pessimistic) scenarios developed by the IPCC. The Centro Euro-Mediterraneo sui Cambiamenti Climatici - Mediterranean (CMCC-MED) global model output (see Scoccimarro et al., 2011) was used to create boundary conditions in which to run the COSMO Model in Climate Mode (COSMO-CLM) RCM (see Rockel et al., 2008).

After validating these with observed climate from 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 different 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. The results are summarized below.

Air surface temperature projections

The simulated air surface temperature, averaged across 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 (7–12°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 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 model simulations show that, around 2020, conditions in 53% of Nigeria are expected to be wetter, while 10% will be drier 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 of Nigeria 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).

There are many types of crop models, but the Decision Support System for Agro-technology Transfer (DSSAT)[1] has been tested and applied worldwide, including in 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 increases making it too hot for sorghum to grow in these areas. The expected impact of climate change on food production is not all negative, though. 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 for all cereals in

1 See: www.icasa.net/dssat

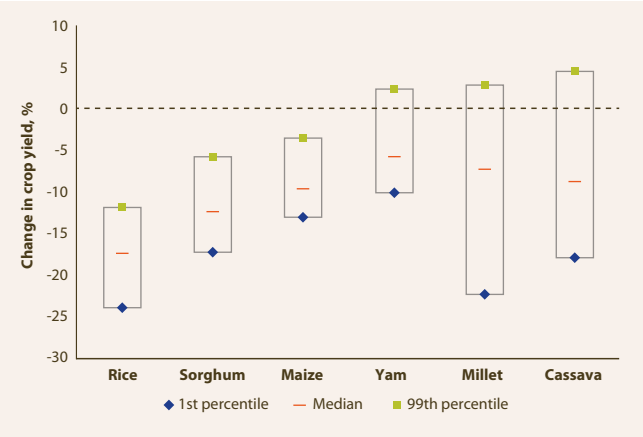
all AEZs, except for millet and maize, where projections for parts of the country are uncertain. Rice is particularly vulnerable in the northern parts of the country, where yield declines of 20–30% are predicted (see Figure 2.4). Predictions for cassava, yams and other root crops show a high variability between models, with some showing a yield decline by 2020 and 2050, and others suggesting significant increases in cassava yield for both periods (Cervigni et al., 2013a).

With appropriate land management, some aspects of climate change, such as flooding, can be turned to farmers' advantage. Although flooding can cause a temporary loss of productivity, it can allow dry-season farming to expand due to elevated soil moisture and higher groundwater levels. Similarly, while variations in the length of the growing season increase uncertainty about how much and when rain will come in any given year, the impact on agricultural production is not always negative. Furthermore, 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 and the late onset and changes in the duration of the rainy season all have significant consequences for agricultural production, because of Nigeria'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 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 importance of farm management practices and access to inputs throughout sub-Saharan Africa.

Irrigation is one solution to enhancing the climate resilience of Nigeria's agriculture. The World Bank Study (Cervigni et al., 2013a) suggested that, by 2050, a combination of 13–18 million rain-fed ha under improved management practices, and 1.5–1.7 million ha of extra irrigation, could fully offset the gap in agricultural outputs caused by climate change. If unit costs can be kept in check, the benefit–cost ratio (in terms of GDP) is favourable, ranging between 1.3:1 and 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.

Figure 2.4 Projected changes in crop yields in Nigeria by 2050



Source: Cervigni et al., 2013a; based on the authors' aggregated data per AEZ and weighted against crop yields of base year

2.5 Impacts on Fisheries

Scenario-based assessments of the possible impacts of climate change on fisheries and marine resources are now being developed for Nigeria. Most of the results that have been reported 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 ocean's mixed layer is of low salinity (<35%), warm (>24^{0}C) water and is present all year round.

Similarly, tuna reported to be of commercial significance (Wise and Ajayi, 1981; Ajayi and Talabi, 1984) may no longer migrate to Nigerian waters. The 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. Some fishing communities are already experiencing the effects of climate change, and in response they are developing secondary and tertiary livelihoods to compensate for lost income, such as mariculture, crop farming and timber logging.

Fisheries management

Fisheries management involves the processes of gathering information, analysis, planning, consultation, decision-making, allocation of resources, and formulating, implementing and enforcing (if necessary)

regulations or rules to govern fisheries activities and ensure the continued productivity of the resources and the accomplishment of other fisheries objectives (FAO, 1997). Management draws on fisheries science to find solutions that will protect fishing resources and allow their sustainable exploitation.

Managing fisheries is also about managing people and businesses, not just fish. If fisheries management is to be successful, then associated human factors, such as the practices of fishing communities, are of key importance and need to be understood.

The Federal Department of Fisheries is the main agency responsible for executing the management of Nigeria's fisheries, in collaboration with state fisheries departments and other stakeholders. The Sea Fisheries Act and the Inland Fisheries Act, both of 2004, are the principal guidelines for managing Nigerian fisheries.[2] The objectives of these Acts are to promote the optimum use and long-term sustainable development of aquatic living resources to achieve economic growth and create employment, for the benefit of present and future generations of Nigerians.

The goals of managing the fisheries resources base are to ensure an ecologically sturdy natural environment capable of sustaining its fisheries resources, and to buffer the fisheries resources management system against the impacts of climate change.

2.6 Building Resilience in Nigerian Agriculture

The uncertainty of climate change predictions means that Nigeria must focus on building the resilience of agriculture to cope with different possible scenarios. According to Ifejika Speranza (2010) this includes:

- building 'buffer' capacities that enable farmers to adapt
- improving their self-organization, and
- growing their capacity for learning.

Building the ecological buffer capacity relates to growing crops that are tolerant to the prevailing climatic conditions, adopting better agronomic practices that increase the soil's capacity to hold moisture (e.g., conservation tillage) and introducing measures to reduce soil erosion, such as terraces and bunds. Enhancing farmers' socio-economic buffer capacities entails increasing their livelihood assets to provide them with the necessary human, financial, social, physical and natural capitals, including by improving their access to markets, information and new technology.

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 is: how can farmers learn from their experiences? The Federal Government needs to understand and strengthen indigenous knowledge systems. Such a resilience approach needs to be region-specific and adapted to socio-ecological characteristics.

Four measures are crucial for successful adaptation to climate change: awareness; an enabling policy and working conditions; understanding past and future climatic trends; and integrating local knowledge. Understanding climate trends and having access to information on the likely duration and dynamics of the changes will allow researchers to suggest – and farmers to adopt – flexible adaptation options tailored to their own situations. 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 useful information.

Adaptation options must be based on information gathered from vulnerability and impact assessments. They will combine scientific research with laboratory-scale or pilot-scale projects, and will lead in to field-scale projects to demonstrate the framework and capacities needed. The target should be to mainstream climate change adaptation into all existing and new policies in the key sectors of air, biodiversity, coastal resources, energy, fishery resources, land and water. This will reduce vulnerability, build resilience and build capacity to climate change. Box 2.2 describes some effective adaptation strategies.

The preferred approach is to select adaptation measures for agriculture that are in harmony with natural ecosystems and provide key goods and services to the land and people. Adaptation to climate change must focus on maintaining and enhancing the ability of natural ecosystems to continue performing these functions. Efforts should also address the needs,

2 See: http://elri-ng.org/newsandrelease2.html

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). In cases where a community's capacity is low – as it is in most of sub-Saharan Africa – the focus should be on addressing the underlying sources of vulnerability, rather than adaptation *per se*. With higher certainty about climate change, the focus should be on addressing the impacts. Adaptation thus involves:

1. Reducing vulnerability by addressing the drivers of vulnerability to climate change. Activities generally aim to reduce poverty and other problems associated with a lack of capabilities, for example by improving livelihoods. Although these activities do not address specific climate change impacts, they help to create a buffer from climate trends and shocks, and therefore build resilience (McGray et al., 2007). This puts resilience is at the core of adaptation actions.
2. Building adaptive capacity to increase people's ability to adapt to climate change, such as communicating climate change information, building awareness of potential impacts, and investing in livelihoods.
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 others), avoiding the anticipated adverse impacts of climate change, and ensuring that the distributional impacts of adaptation are minimized (Adger et al., 2005).

Source: Ifejika Speranza (2010)

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.

2.7 Climate Resilience in a Low-Carbon Economy

Above all, climate change adaptation strategies must be sustainable. This includes adopting a low-carbon economy, or ideally a carbon-neutral economy, as a foundation for national development. Indeed, investment in low-carbon fuels and renewable energy is a pillar of the *Vision 20:2020*, which articulates Nigeria's long-term intent to launch onto a path of sustained social and economic progress. This will 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, transportation and agriculture are maintained, the World Bank estimates that achieving the Vision 20:2020 goals might emit up to 11.6 billion tons of CO_2 into the atmosphere over the period 2010–2035 — five times Nigeria's 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 benefits include a more productive and climate-resilient agriculture.

A 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, agriculture and land use options.

The World Bank suggests that the Federal Government, in partnership with the country's states as appropriate, consider a number of actions that could help to remove the barriers to low-carbon development in the agriculture sector. Actions include:

- bring up to 1 million ha of land under 'triple-win' (higher yields, better climate resilience, reduced carbon emissions), sustainable management practices by 2029
- ensure the ATA includes support for climate-resilient agriculture demonstration projects

- launch a dedicated research and extension programme on climate-resilient agriculture
- define procedures and screening tools to integrate climate considerations into project evaluations.

2.8 Conclusions

From an environmental point of view, 2012 was one of the most challenging years in Nigeria's recent history, due to unprecedented flooding that devastated 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 economic sectors was estimated at US$16.9 billion. The 2012 flood exposed Nigeria's vulnerability to extreme climate events and underscores the need for planning to enhance adaptive capacity and resilience across all sectors of the economy, including agriculture.

Despite considerable uncertainty about the future climate, we know enough to build meaningful scenarios on which to base future decision-making. 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 (Cervigni et al., 2013a) were able to build robust scenarios to 2030. This study identifies adaptation actions that can serve as good precautionary steps to prepare for a range of possible climate change outcomes. These scenarios show that the degradation of natural resources has a direct impact on agricultural productivity and livelihoods by reducing the resilience of agro-ecosystems to extreme climate events. This further undermines West Africa's future capacity to cope with climate change.

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3

Enhancing the Natural Resource Base

3.1 Nigeria's Natural Resources

Efforts to make agriculture in Nigeria more resilient to climate change must also consider the natural environment. The natural resources of biodiversity, climate, ecosystems, land, soil, vegetation, water and wildlife provide a fundamental basis for agriculture, especially in countries like Nigeria where inputs such as chemical fertilizers, energy, irrigation and pesticides are minimal. This chapter reviews the status of Nigeria's natural resource base (the key resources are described below) and recommends what should be done to enhance it and make agriculture more resilient.

Soils

In general, climate, geology, topography, vegetation and history account for the different soil types in the country, much of them iron-rich and derived from basement complex and old sedimentary rocks. Nigeria's soil resources can be classified into:

- the southeast ecological zone, where soils are dominated by low activity clays
- the southwest ecological zone, where soils are strongly influenced by geology, geomorphological processes and vegetation
- the northern savannah ecological zones, where soils are classified into: entisols, which are recently formed, well-drained sandy soils; alfisols or luvisols; ultisols or acrisols, which are more developed and less base-rich than the alfisols; vertisols, comprising heavy cracking clays of high cation content; and oxisols or nitosols, which are highly weathered and of low fertility status.

The deeply weathered soils are rich in kaolinitic clays that retain little water or nutrients; they are inherently fragile, weak in structure and readily eroded by water or wind (NLUP, 2012). Hydromorphic soils are common along major river valleys and in the Niger Delta. According to NLUP (2012), the variability in soils largely accounts for the variability of agricultural land resources within Nigeria's AEZs. These range from trees and root crops in the south to cereals and livestock in the north. Against climate change projections, the key to achieving sustainable soil management is maintaining soil health and fertility. Retention or enhancement of soil organic matter content is crucial for this purpose (FAO, 2013). Management practices that achieve this should be pursued to build resilience to climate change.

Water

Rainfall is the main source of water for agriculture in Nigeria. This is supplemented to a very negligible extent by irrigation, with only 0.3% of the total land area under irrigation (NLUP, 2012), despite the rich network of drainage systems dominated by the Niger-Benue system and the potential of groundwater sources. Managing water resources is a major challenge in achieving agricultural resilience to climate change. Crop and livestock production are adversely affected by drought and water scarcity, both of which are likely to be worsened by climate change. Conversely, extreme weather events related to climate change, including flooding, can devastate crops, livestock and fisheries (as occurred in 2012). The challenge is to devise and implement measures such as adapted crops and animal breeds, innovative water management practices, and effective early warning systems based on expanded observation networks. These will help to counter the impacts of water shortages and, at the same time, develop measures that check and manage floods.

Natural vegetation

Nigeria's natural vegetation, mainly perennial shrubs and trees, provides many benefits for agriculture and livelihoods. Some supports crops directly, enriching the soil by adding organic matter, fixing nitrogen, maintaining mycorrhizal relationships with crop roots and controlling pests. The bulk of the fodder used in livestock production is supplied by natural vegetation growing in Nigeria's vast rangelands. In addition, natural vegetation, with its wildlife and rich biodiversity, is an important source of food, fodder, medicines, cultural artefacts and raw materials, meeting various household needs.

When managing natural vegetation in farming landscapes, it is important to maintain biological corridors and safeguard biodiversity for pollination, honey-making and biological pest control, while protecting species like *Faidherbia albida* and *Dactyladenia (Acioa) barteri* that are beneficial to crop growth. Natural vegetation provides the main support or buffer mechanism for farming communities to adapt to climate change. It serves as a livelihood safety net that helps them overcome shocks from natural disasters and extreme climate events. Measures to protect natural vegetation are therefore central to discussions concerning the management of natural resources.

3.2 Ecosystem-Based Natural Resources Management

Nigeria's natural resources support many rural and urban communities. In addition to supplying ecosystem services, such as those described in the previous section, natural resources are critical to ecosystem-based adaptation to climate change. Ecological infrastructure is an emerging concept that captures nature's ability to absorb shocks and extremes. This includes the ability of mountain catchments, wetlands and coastal systems to buffer against floods, fires and sea-level rise. This ecological infrastructure can also complement engineering infrastructure in climate change mitigation.

Ecosystem services that are in good condition also buffer against alien plants invading rangelands and areas with high potential for livestock production. However, this has not always been recognized, largely because the goods and services provided by ecological infrastructure have, to date, been freely available in relative abundance. Land degradation and climate change, however, are rapidly undermining the world's ecological infrastructure and its ability to support sustainable service delivery.

Each of Nigeria's biomes (large geographical areas of distinctive plant, animal and soil groups, which are adapted to that particular environment) provides a unique suite of ecosystem services. These include producing fodder, carbon sequestration, water storage, soil conservation and replenishment, timber resources, edible fruits, traditional medicines and recreation areas. A valuation of these services is critical for appreciating the contribution they make to improved livelihoods and the national economy.

Ecosystem-based natural resources management is a holistic and robust approach that can harness these services comprehensively in building agricultural resilience. (The equivalent concept for the marine environment is the large marine ecosystem approach.) It is an adaptive management approach that seeks to ensure the co-existence of healthy, fully functioning ecosystems with the optimal use of ecosystem components by human communities. It is based on managing landscape units by deploying resource-use guidelines that are ecologically sustainable and aligned with social, cultural and economic considerations. This creates a balance between conservation and the use of natural resources for socio-economic development. Regulated resource use is the key to sustaining the productive capacities of ecosystems and achieving this balance.

The approach also strives to maintain the spatial and temporal characteristics of ecosystems, so that the component species and ecological processes can be sustained while human wellbeing is supported and improved (Living Earth, 2006). The focus on landscape units allows production systems to be integrated with the natural resource base over defined areas that are large enough to yield vital ecosystem services, and small enough to be carried out by the people using the land. It also helps to maximize gains from natural biological processes, minimizing the need for external inputs (FAO, 2013).

Integrating this approach with agriculture promotes the diversification of farming systems to include, for example by introducing agroforestry and conservation agriculture. Such activities provide long-term carbon sequestration benefits, thereby providing both mitigation and adaptation responses to climate change. Additional benefits from including agroforestry in the landscape include the contribution of nutrients when nitrogen-fixing trees are used, or increased incomes based on planting fruit trees like *Irvingia* spp. or high-value medicinal trees like *Prunus africana* or *Moringa oleifera* (Okali, 2010). Improving

Goals

The goals and strategic objectives for the management of natural ecosystems are to:

Goal 1: Secure the sustainable use of natural ecosystems for building agricultural resilience.

Objective 1: Develop a policy framework for Ecosystem-based natural resources management.

Objective 2: Design and implement pilot projects for Ecosystem-based natural resources management/agricultural production.

Objective 3: Implement these projects.

Goal 2: Develop sound biome adaptation frameworks that address the vulnerabilities of each biome to climate change and ensure sustainable natural resource management.

Objective 1: Strengthen the knowledge base for effective management of the natural environment for agricultural resilience.

incomes beyond subsistence (e.g., by developing non-timber forest products value chains as a business) expands the buffer capacity of farming communities and helps build resilience.

3.3 Sustainable Land Management

Land use changes account for about 65% of Africa's greenhouse gas emissions, and land degradation problems are intertwined with the risks and vulnerabilities associated with climate change. Changes in land use can affect the climate by altering albedo – the fraction of solar energy or shortwave radiation that is reflected from the Earth back into space. Socio-economic activity alters land cover directly, affecting food, water and energy security.

Land cover is most obviously affected by intensive human impacts, such as clearing land for crops, roads and urbanization, but there are also indirect anthropogenic impacts that are less well understood. What is critically important is to understand the drivers and implications of change, and how they interact. Building resilience in agro-ecological systems is therefore essential to planning the Nigerian agricultural revolution in a sustainable, climate-resilient way.

Sustainable land management has been defined as "the adoption of land use systems that, through appropriate management practices, enable land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources" (Bisong, 2011). Under sustainable land management, soils can be conserved and improved by increasing organic matter content, adopting low-tillage techniques, using integrated pest management, controlled use of chemical fertilizers, avoiding soil compaction, efficient use of crop residues, and introducing cover crops and crop diversification into farming systems.

But the challenges of climate change and environmental degradation have resulted in losses that threaten the productivity and sustainability of Nigeria's land resources. About 46% of Nigeria's vast cultivable land area (71.2 million ha) is currently used for agriculture (NLUP, 2012). Expanding the area cultivated with crops and grazed by livestock is not an acceptable option, since this would cause land degradation through deforestation and the over-exploitation of marginal habitats. Other drivers of land degradation include inappropriate agricultural practices, urbanization and expanding infrastructure, commercial logging, high demand for timber and fuel wood, overgrazing, population pressure on resources, weak institutions and policies, poverty and land tenure (World Bank, 2005).

Instead, to feed the growing population, productivity increases will be need to be made through sustainable land management principles, which include the following:

- Stem the degradation of existing agricultural land from desertification, erosion and pollution.
- Restore degraded land, including through the remediation of land polluted and scarred by mining operations.
- Improve the productivity of existing land by adopting appropriate upgraded technologies, including expanding the area under irrigation.
- Adopt and enforce land use policies that defend agricultural land from encroachment by unregulated uses, such as sprawling urbanization and industrialization.
- Reform and streamline access, tenure and ownership rights to enable equitable, gender-balanced access and guarantee the security of tenure that encourages investments in land improvement.

Goals

The goals and strategic objectives for the management of land and soils are to:

Goal 1: Upscale and mainstream sustainable land management in the nation's development process as a contribution to building agricultural resilience.

Objective 1: Support on-the-ground activities in all AEZs to halt land degradation.

Objective 2: Strengthen the policy and institutional environment for sustainable land management.

Objective 3: Strengthen commercial and advisory services for sustainable land management and alternative livelihood options.

Goal 2: Sustain soil productivity through maintaining a high level of soil quality.

Objective 1: Enhance and sustain the health and fertility of soils.

Sustainable land management is seen as an imperative national investment that must be aligned to achieving long-term economic growth, guaranteeing food security, sustaining the ATA and conserving natural resources. It is also imperative for building agricultural resilience. Sources from the FMARD indicate that, between 2005 and 2009, the share of public expenditure for sustainable land management in national budgets was about 1.71% (Bisong, 2009), and remains very low even now. There is a need to upscale and mainstream sustainable land management in the nation's budgetary and development processes.

3.4 Water Resources Management

The drought of 1973 that affected Africa's Sahel region forced Nigeria to adapt its agriculture to cope with water scarcity. This prompted the creation of River Basin Development Authorities (RBDAs) within the Federal Ministry of Water Resources (FMWR). The initial approach to guard against future droughts was to create large water bodies by building dams. This strategy essentially remains the same today, but with expanding horizons and tailor-made solutions. Nigeria is now divided into eight watersheds (Figure 3.1). The RBDAs each cover a watershed, with overlaps in some cases. Watershed management by the FMWR is spearheaded by the RBDAs.

Irrigation and other water needs will assume greater importance when climate change trends become the norm. There are three types of drought to consider:

- **Meteorological** drought, defined usually on the basis of the degree of dryness (in comparison to the norm or average amount) and the duration of the dry period.

Figure 3.1 Watersheds in Nigeria

Source: FMWR

- **Hydrological** drought, where there is enough water for agricultural purposes but the reduction in precipitation causes shortfalls in surface or subsurface water supply (i.e., stream flow, reservoir and lake levels, groundwater).
- **Agricultural** drought, which combines elements of both meteorological and hydrological droughts so that there is insufficient water to meet agricultural needs.

In the short term, good water resources management – providing the right amount of water at the right time and ensuring that existing water resources are not depleted faster than they are recharged – will raise agricultural production, upgrade economic benefits and help Nigeria progress into the next phase of economic development.

It is necessary to determine agricultural water needs under different climate scenarios. To meet these needs, water could be sourced from above or below ground. Surface and subsurface water sources should be monitored, measured and strategically managed to meet the nation's agricultural needs. This should be done in collaboration with the FMWR. Farmers are key to the solution, with the support and guidance of relevant ministries, departments and agencies and international organizations.

At the peak of the rainy season, it is important to eliminate or limit the damage caused by floodwaters. Excessive water energy can be managed through reducing water velocity, for example by delaying flows. In preparation for the flood season, reducing riverbed slope and increasing the capacity of conveyance channels helps to attenuate flooding. All these flood control activities affect agriculture in a changing climate. The Flood Control Department of the Federal Ministry of Environment (FME) and the Department of Dams and Reservoir Operations of the FMWR are key players in this regard. In areas prone to seasonal flooding, flood recession agriculture and dry-season farming should be encouraged to maximize the benefits of the nutrient-rich alluvial deposits that come with floods. The timing of planting and type of crop are key considerations in in combating climate change.

To determine the likely water resource management challenges for agriculture under changing climatic conditions, it is necessary to catalogue the entire water budget and compile a range of potential solutions, including small-scale water harvesting and storage. The FMWR and FME are the key ministries here. Similarly, there is a need to tackle irrigation in a holistic manner. Decisions such as how and when to collect

Goals

The goal and strategic objectives for water management are to:

Goal 1: Manage water resources effectively to enhance agricultural growth and development towards maximum yield and production, and provide adequate water for domestic use.

Objective 1: Collate and coordinate the various policies and information among different ministries, departments and agencies.

Objective 2: Build the capacity of water resources management personnel and end-users to build agricultural resilience.

Objective 3: Define and measure water resources for water banking, budgeting and disbursement

Objective 4: Plan for water needs and drainage accurately, with a lead time of at least one year.

water for irrigation, where and how to store it, and whether the release should be total or partial, require ongoing coordination and collaboration between multiple stakeholders. In addition, irrigation scheduling and water sharing must be properly put in place to minimize social conflict.

Moreover, there is a need to operate and work with the FME in getting the National Strategic Action Plan implemented, especially the National Drought Preparedness Action Plan and corresponding Flood Control Plans. There is also a need to intensify campaigns and practices to conserve water resources, and to reach out to farming communities through the Extension Department of the FMARD with strong support from the FMWR.

3.5 Conserving Biodiversity

Biodiversity conservation is an important component of ecosystem-based natural resources management (see Section 3.2) but deserves special mention due to its value in building and maintaining agricultural resilience to climate change. Harnessing the genetic variability of different species can help to improve the productivity and nutritional value of crops, as well as guarding against outbreaks of new pests and diseases in crops, livestock and fisheries. Action may include the strategic expansion and distribution of protected areas, mainly to strengthen *in situ* conservation of biodiversity in the wild. Conservation of agro-biodiversity can be enhanced by identifying and supporting farming landscapes or fisheries that contain species with desirable traits, paying due regard to indigenous knowledge and practices.

Actions are also needed to strengthen the many approaches to *ex situ* conservation in Nigeria. These range from the concentration of germplasm in plantations, arboreta and gardens, to the creation of gene banks in specialized laboratories and institutions like the International Institute of Tropical Agriculture (IITA). Additionally, there will be a need to review and strengthen the policy, legislative, institutional, administrative and law enforcement frameworks and arrangements that are in place to safeguard biodiversity and share the benefits of genetic resources equitably. In this regard, international agreements, including those dealing with biosafety and the control of genetically modified organisms, will need to be adapted to accommodate local realities. Actions to conserve biodiversity should be supported by efforts to increase understanding of the characteristics and status of Nigeria's biodiversity. This can be done through monitoring and conducting inventories, complemented by developing viable biotechnology expertise using tissue culture and genetic engineering, among other techniques.

The conservation of biodiversity should be complemented by 'bio-prospecting' Nigerian biodiversity to explore the potential for contributing to agricultural resilience. This biodiversity includes more than 5000 species of vascular plants, 3000 fungi, 800 algae, 240 mammals, 900 birds, 600 fish, 130 reptiles and 100 amphibians, as well as the more than 22,000 invertebrate species and over 500 viruses and bacteria that have been documented (NBSAP, 2006; NTWG, 2009).

The technical report on Environment and Sustainable Development for Vision 20:2020 (NTWG, 2009) draws attention to the threats to, and rapid depletion of, Nigeria's biodiversity. Natural and human-made threats, the latter most likely related to over-exploitation and unsustainable land use practices, are cited as the main contributors to biodiversity depletion. With 12.59% of the country's area designated as terrestrial and marine protected areas, Nigeria ranks 68th out of 190 countries considered in the classification of protected areas. Terrestrial protected areas are defined

Goals

The goal and strategic objectives of proposed interventions for biodiversity conservation are to:

Goal 1: Maximize the sustainable use of Nigeria's rich biodiversity in building agricultural resilience.

Objective 1: Halt the further depletion of Nigeria's biodiversity.

Objective 2: Restore degraded biodiversity hotspots of relevance to agriculture and rebuild eroded agro-biodiversity forms.

Objective 3: Review and strengthen the institutional frameworks for sustainable use of biodiversity in building agricultural resilience.

as "totally or partially protected areas at least 1000 ha in size that are designated by national authorities as scientific reserves with limited public access, national parks, natural monuments, nature reserves or wildlife sanctuaries, protected landscapes and areas managed mainly for sustainable use". Marine protected areas are "areas of intertidal or sub-tidal terrain – and overlying water and associated flora and fauna with historical and cultural features – that have been reserved by law" (Index Mundi, 2010a).

As the marine component is only 0.16% (Index Mundi, 2010b), the bulk of the protected area is terrestrial. This comprises one biosphere reserve, over 400 forest reserves of various sizes, eight national parks, 12 Strict Nature Reserves and 28 game reserves (Emma-Okafor et al., 2010). NTWG (2009) indicates that the protected area system in Nigeria covers only 5.7% of the landmass. This is far less than the 12.59% quoted above, or the 11% suggested by Aminu-Kano and Marguba (2002). The discrepancy may reflect the difference between the nominal size of protected areas, as documented by national authorities, and the actual situation on the ground. Adeyoju (2001) used a similar discrepancy between the frequently cited nominal figure (10%) and the figure of less than 6% determined from actual survey, for the size of the Nigerian forest estate, to draw attention to the rapid rate of forest loss. If this analogy is valid, it points to an urgent need to act swiftly to safeguard the integrity of protected areas in Nigeria for biodiversity conservation.

3.6 Monitoring and Early Warning Systems

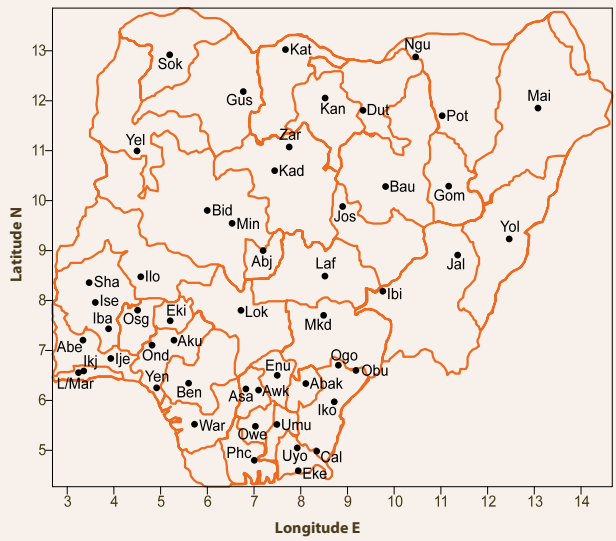
If farmers are to be prepared for the likely effects of climate change, they will need access to early warning systems for various climate-related hazards such as droughts and floods. Early warning systems are, in turn, largely dependent on having adequate weather and hydrological data.

Weather monitoring

NIMET operates 54 manual synoptic meteorological stations; an average of one per state, with a few states having more than one station. The stations are mostly located in the state capitals, or at airports, since the network was originally designed to provide aeronautical services. Figure 3.2 shows the location of the surface observing networks. A few stations are designated as marine stations because they are located on the coast and combine surface with marine observations. The stations transmit data hourly to the forecast offices for use, and monthly to the archiving unit for control and storage. In the last 10 years, a few stand-alone automatic stations have been installed within the existing network.

However, the present network of one station for every 17,100 km^2 is grossly inadequate and falls below the World Meteorological Organization (WMO) recommended standard of one station for every 50 km^2. The stations are unevenly located spatially, with large data-sparse areas in the northern and central states.

Figure 3.2 Location of Nigeria's existing meteorological observing stations



There are also about 500 rainfall stations located outside the NIMET controlled areas. These are manned by voluntary observers, who send their data to NIMET data collection centres for archiving and quality control. The number of voluntary observer stations has been increased recently by the METAGRI project, financed by the Governments of Spain and the Netherlands through the WMO.

To provide effective weather and climate monitoring, as well as predicting and issuing early warnings regarding high-impact weather events, there is an urgent need to increase the density of the network. Improved meteorological services would greatly benefit agriculture, water resources, health, natural disaster mitigation and other environmental challenges. NIMET proposes to increase the density of its network from 54 to 1000 stations by establishing a network of Global System for Mobile Communications-enabled automatic weather stations. This will provide data for every 1000 km^2 and the expanded network will reduce forecasting errors due to shortcomings in observations. These stations are expected to collect and transmit data at least every 10 minutes to a central location. The existing conventional synoptic stations will still operate to provide backup data. There will be one new station for each of the 774 local government areas, with the remaining 226 stations placed strategically in rural areas.

Hydrological monitoring

The available information on the state of water resources and its management in Nigeria is fragmented, scarce, often out-dated and, in most cases, of doubtful quality. Stakeholders' access to data is far from satisfactory, with no common water information database. The lack of well-defined jurisdictional boundaries and the absence of a coordinated approach is also partly responsible for the poor availability and quality of hydrological data.

Responsibility for collecting and disseminating hydrological data is shared by several organisations: the RBDAs, the National Inland Waterways Authority, the Power Holding Company of Nigeria and the State Water Boards. The NIHSA, under the FMWR, is charged with supervising activities relating to the collection and processing of hydrological data.

Although it is estimated that Nigeria has a surface-water monitoring network of over 700 stations, there is no comprehensive inventory or any other form of metadata about these. Apart from the 18 automatic monitoring stations with satellite telemetry maintained under the Niger Basin Authority (an international river basin organization), the standard gauging stations are equipped only with staff gauges. Most of the RBDAs and agencies do not carry out regular discharge measurements. The lack of these measurements and consequent inability to update ratings has brought the processing of hydrological data to a halt in most agencies. Data processing in many agencies has to be done manually because the RBDAs lack dedicated computers and have limited access to computers for data processing and storage.

Goals

The goal and strategic objectives for improving climate, weather, hydrological and oceanographic observational networks are to:

Goal 1: Ensure the availability of data, as required for decision-support activities to promote resilient agriculture.

Objective 1: Assess present weather, river and ocean observing station networks

Objective 2: Identify gaps and required interventions

Objective 3: Prioritize needs with special attention to the food basket regions.

Efforts to improve Nigeria's hydrological services should include:

- a mapping exercise for all hydrologic activities in all the agencies involved
- an evaluation of the institutional coordination mechanism and the establishment of a legal framework to provide a basis for the operation of the various agencies providing hydrological services
- rationalizing and strengthening of the existing network, with a view to generating quality data and information to address the needs of the water sector and sectors related to water
- a capacity-building mechanism to train those with the responsibility of operating the hydrological network (e.g., National Water Resources Institute in collaboration with universities)
- a quality management framework to ensure that all data collection activities are performed within given standard practices
- a national water information system being set up.

3.7 Conclusions

Enhancing the natural resource base to improve the resilience of agriculture to climate change will require action across all sectors, and involve a wide range of stakeholders. Government policy should address the following areas:

- By empowering the agriculture sector economically, technologically and through knowledge, the Federal Government aims to reduce the trend of young people leaving agriculture by creating greater opportunities for wealth creation in the sector.
- Government policy in terms of transparency and efficiency will be maintained, including accountability at all levels of activities and at all levels of government. This is the same for civil society and international organizations.
- The Federal Government will promote the adoption of appropriate land use planning and practices. Rehabilitation and restoration of degraded lands and upgrading marginal agricultural land through appropriate soil conservation practices will be the main approaches for this.
- All environments, flora and fauna that are under threat should be protected. Preventing species extinctions is vital for maintaining the resilience of agriculture.
- The Federal Government should ensure water capture, conservation and efficient irrigation, using all necessary and provable methods of water collection and use. To this end, total cooperation and collaboration between the ministries, departments and agencies that promote agriculture become imperative. These institutions should adopt the principles of integrated water resources management to ensure sustainable water use for all stakeholders, including the natural environment.
- Policymakers should strongly support and encourage research institutes and universities to develop, acquire and adapt their research to the challenge of climate change. Disseminating appropriate technology is essential and there should be a focus on proven, workable science and well-tested technologies.
- The use of agricultural engineering should be increased and sustained, especially in the areas of farm power, farm machinery, soil conservation, agricultural dams and irrigation practices, farm structures and sustainable land development.
- The Federal Government has created a new advocacy and policy instrument in the Department of Extension Services, which cuts across all departments and disciplines connected to increasing agricultural productivity in the face of climate change. This includes agricultural engineering, water resources management, irrigation and soil conservation. The need for continuous support to this developing department from all others cannot be overemphasized.
- The mainstreaming of gender issues into all agricultural activities, including advocacy, programme formulation and project management, is a vital for their success.
- Harmonization among all stakeholders on the objectives of agricultural resilience is needed. There should be a clear, overarching policy framework that defines the roles and responsibilities of all actors.
- Farmers and farmers' associations and groups must have a well-defined platform for cooperation and the exchange of ideas, information and practices.

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4

Climate Change Adaptation in Agricultural Planning

4.1 Introduction

The process of mainstreaming climate change into agricultural planning and development involves assessing the risks posed by climate change, then adjusting development activities to take these into account. This process can be called 'climate-proofing' and will enhance the sustainability and impact of adaptation programmes. The clear objectives are to reduce vulnerability and build resilience among stakeholders.

It is important to integrate climate change into research and development in a coordinated manner, through the research–operations–applications chain. For example, the development of flood- or drought-tolerant crops can be linked to climate research regarding the areas where adverse conditions are most likely to occur, and to on-farm trials and sensitization activities with farmers. This chapter examines efforts in Nigeria being undertaken by the public and private sectors, non-governmental organizations (NGOs), community-based organizations (CBOs), and regional and international organizations towards achieving this goal. It also offers strategies that could be scaled up and used more widely in the future.

4.2 Application of Climate Data

Climate information services from the NIMET provide a vital input to national development planning. For example, the Seasonal Rainfall Prediction provides comprehensive rainfall data, including onset and cessation dates and total rainfall amounts for every part of Nigeria. This is particularly useful for planning in agriculture, water resources, transportation, construction and hydroelectric power generation. The NIMET issues this at the beginning of every year. The prediction includes an assessment of how the changes in rainfall patterns will affect communities and livelihoods and is accompanied by community-based awareness programmes, conducted in conjunction with the WMO. The aim is to show rural farmers the usefulness of weather and climate data in agriculture, and how they can best plan their activities to avoid weather-related losses. The NIMET also works with the Federal Ministry of Environment (FME) to provide a Flood Early Warning Service, while the FMARD has a Drought Contingency Plan that involves several other government agencies, including the NIMET.

The Inter-Ministerial Committee, recently constituted by the President to draft the National Framework on Application of Climate Services (NFACS), is expected to provide the backing from the Federal Government needed to integrate climate information in a multi-disciplinary approach and enhance socio-economic development in a sustainable manner. The NFACS should enable Nigeria to better manage climate-related risks and harness the associated opportunities in the context of achieving sustainable development. The specific objectives of the NFACS are to:

- create partnerships among various climate services producers, policymakers, planners and users
- enable the producers and users of climate information to join forces to improve the quality and quantity of climate services nationwide, particularly in vulnerable communities
- reduce the vulnerability of communities to climate-related hazards through better availability and provision of climate services
- mainstream the use of climate information in national development policies and strategies, such as the Vision 20:2020 Transformation Agenda.

4.3 Climate Change Adaptation in Nigerian Agriculture

As the climate becomes more unpredictable, agricultural practices will need to adapt in an anticipatory (proactive), reactive, or planned manner (IPCC, 2001). Of these, planned adaptation as a result of deliberate policy decisions is considered to be the most cost-effective and offers the most long-term benefits for resource use and the environment. Examples relevant to the Nigerian agriculture sector include:

- supplying and adopting drought- or disease-resistant, salt-tolerant and early-maturing crop varieties
- providing timely weather forecasts and early warnings to guide planting activities
- enhancing agricultural extension services to improve farm productivity
- entrenching a credit and insurance culture in agricultural communities
- expanding and optimizing existing irrigation infrastructure to reduce crop failures due to delays in rainfall

- diversifying livelihood portfolios to improve household incomes
- increasing crop storage facilities and promoting agro-processing to reduce post-harvest losses
- developing markets for existing and new crops
- introducing a range of livestock management activities to reduce climate stress while maintaining high productivity, including investments in pastoralism and grazing reserves, as well as a move to more sedentary livestock management systems
- developing aquaculture value chains, including promoting mariculture (cultivating organisms in the open ocean)
- managing flood-prone areas and stabilizing gullies and erosion sites
- encouraging the sustainable management of forest, fishing and water resources.

As stated in Chapter 1, adaptation options will combine scientific research with laboratory- or pilot-scale projects. These will lead to field-scale projects that demonstrate the framework and capacity to mitigate the impacts of climate change. The processes involved are highlighted in Chapter 5. Many technologies and practices can deliver both resilience to climate change and lower greenhouse gas emissions per unit production. The target should be to mainstream climate change adaptation into all existing and new policies in the key sectors, especially those of critical importance to food security.

4.4 Strategic Action Plan for Mainstreaming Climate Change Adaptation

A strategic action plan for mainstreaming climate change adaptation will address the organizational environment in which policies and programmes are developed and implemented. Such a plan for the agriculture sector could have four inter-related stages: improving the knowledge base; transfer mechanisms, capacity building; and monitoring and evaluation.

Improving the knowledge base

This stage involves strengthening the overall policy and institutional framework for planning and implementing climate change adaptation in the agriculture sector, including resource mobilization and information management. Mainstreaming climate change adaptation successfully into the FMARD's programmes requires clear policies on adaptation. These should be developed in broad consultation with staff and stakeholders, from ministry to farm level. It calls for a process to integrate climate change adaptation into all aspects of adaptation programmes, from the analysis phase through design and implementation to monitoring and evaluation. This must be accompanied by a strategy to ensure that the working environment is sensitive to climate change issues (e.g., consideration of climate-related issues in budgets) and that sufficient technical capacity, institutional arrangements and human resources are available.

Transfer mechanisms

The climate-related risks faced by agriculture businesses include flooding (direct damage to assets and indirect damage via supply chain disruption), storms, heat waves, droughts, threats to water availability, pest invasions, crop failures, harmful algal blooms and the decimation of livestock. A strategic plan would introduce risk transfer and risk management options into the agriculture sector and enable their rapid and widespread deployment through communication technologies, including mobile phones.

There are a few good examples of micro-insurance helping communities vulnerable to climate change in Africa. For example, the Horn of Africa Risk Transfer for Adaptation project in Ethiopia is helping farmers to access loans. They use the money to buy farm inputs, with the support of a national organization that provides agricultural extension services, including securing better market access. The Micro-Ensure programme in Malawi introduced one of Africa's first weather-index crop-insurance schemes during the 2005–2006 growing season.

Capacity building

The FMARD's staff and all stakeholders in the agriculture sector need to understand the importance and relevance of climate change and community-based adaptation. Capacity can be developed through briefings, training materials and short courses for staff and partners. It is also important to provide regular opportunities for knowledge and information to be shared among staff and partners working in different sectors. It is important to note that capacity building takes time. It is also essential to periodically assess the stage reached by stakeholders and to identify priority issues, setting definable, realistic and measurable goals.

Monitoring and evaluation

It is important to establish processes for measuring the FMARD's effectiveness in mainstreaming and supporting community-based adaptation. Managing the change will require continuous monitoring and dialogue within the FMARD to assess progress and approaches. This will provide opportunities to test and refine mainstreaming tools, to improve understanding of climate change adaptation issues of relevance to strategic planning and priorities, and to build the capacity of staff and partners to integrate climate change adaptation into their work. The process of mainstreaming should be viewed as open-ended: while organizations should aim to achieve the objectives and targets of a strategic plan, they should also aim to make continuous improvements to their approach. Lessons learned can be integrated into the design of new programmes and implementation strategies. The long-term outcome of mainstreaming climate change adaptation will be greater and more equitable sustainable human development, not just for stakeholders in the agriculture sector but also for all citizens.

4.5 Barriers to Integrating Climate Change Adaptation

A series of 'Town Hall' meetings arranged by the ACARN brought together farmers and other stakeholders in Nigeria's six geopolitical zones to discuss issues relating to climate change. The meetings revealed real barriers to mainstreaming adaptation into agricultural development planning. Even some measures presently contained in agriculture policy have the potential to exacerbate, rather than attenuate, the impacts of climate change. The Federal Government should review all national agriculture and related policies and programmes to determine the revisions required. Such a review should address the following challenges and barriers:

- A dearth of efficient and effective agricultural extension services.
- Poor or inadequate delivery systems preventing timely availability of agro-inputs, adulteration and high cost of inputs, poor storage, etc.
- Low levels of education in agricultural communities.
- Low levels of involvement of educated young people in the agriculture sector.
- Poor agro-meteorological, hydro-meteorological and tide-gauge coverage in the country, and consequent poor weather and river/sea-level forecasting capabilities.
- The lack of new and innovative adaptation measures to climate change in the agriculture sector.
- The lack of procedures and screening tools for integrating climate considerations into project evaluations.
- The continued prevalence of gender-differentiated needs and roles in society that put women at a disadvantage in terms of access to land, credit and farm inputs.
- Few climate-resilient agricultural development initiatives at the national, state and local government levels
- The lack of access to loans for farmers and, when loans are available, the operation of unrealistic interest rates and repayment schemes that take no account of farming cycles.
- A poor insurance culture in the agriculture sector, due in part to certain religious beliefs but also to the lack of liberalization of the agricultural insurance business.
- The continued emphasis on high-carbon policies and practices, which are locked into the country's economic fabric and which are costly and impractical to reverse.
- Poor levels of mechanization in agriculture production systems.
- Weak culture and systems for organizing farmers into effective cooperatives.
- A poor value chain culture, which has negative impacts on preserving and storing produce, including agricultural processing.
- The lack of commodity markets and price stabilization mechanisms.
- Limited investment in research, including the application of genetic modification schemes in the search for new adaptive varieties or species.
- A failure to recognize the supportive role of the natural environment as a resource of the goods and services that are critical to successful agriculture.

Attempts to overcome these barriers should use principles of adaptive management and participatory engagement as the central tenets of the overall implementation strategy.

4.6 The Role of Institutions

Several different institutions have the responsibility for implementing climate change adaptation initiatives at different scales. These include government institutions, CSOs, regional organizations, the research community, development partners and the private sector. Structured interactions and partnerships between these organizations are essential. Understanding the specific roles and responsibilities in shaping the adaptive capacity of Nigerian agriculture is central for planning responses. This section looks at these institutions and their specific roles.

Government institutions

Government institutions in Nigeria include a broad range of actors providing functions within the domain of the state entity. They include line ministries across different sectors (agriculture, water resources, environment, economic planning, etc.), parastatal agencies supporting the line ministries (e.g., National Environmental Standards and Regulations Enforcement Agency, National Emergency Management Agency), and relevant ministries or commissions at the state level, amongst others. Box 4.1 highlights some specific roles.

Private sector

The private sector, both national and international, has a dominant role to play in realizing the Federal Government policy to categorize agriculture as a business. The private sector has the required experience, skills, structures and financial resources to scale up agriculture from its present subsistence level to become an industrial, mechanized practice. It has the ability and incentive to champion innovation and to ensure marketability and profit. Specific roles for the private sector are highlighted in Box 4.2.

Box 4.1 The role of government institutions in climate change adaptation

Make policies: Developing dynamic agriculture systems that are capable of adapting to extreme climate-related events requires a conducive, stable policy environment. Unfortunately, this has been lacking in Nigeria. The central function of the FMARD is to make appropriate national policies for climate change adaptation. These provide an operational framework for governing the diverse adaptation responses and practices at national level, and for mainstreaming climate change adaptation into Nigeria's economic development plans.

Provide leadership and create an enabling environment: The Federal Government needs to provide leadership on climate change policy, either towards sensitization programmes or by creating an enabling environment in which important actors can contribute to agricultural adaptation. An example is the need for constant communication on how climate change affects the country's long-term economic growth, social goals and vision. The Federal Government should also initiate conversations on adaptation by organizing multi-stakeholder workshops and forums.

Coordinate the agriculture sector: Agriculture cuts across many ministries. As the lead institution, the FMARD is responsible for coordinating the activities and efforts of other ministries in terms of good adaptation practices. This will ensure that interventions are organized in a coherent manner to deliver national adaptation outcomes. This could harmonize efforts in sectors such as forestry, fisheries, water and environment within a set of adaptation goals, as stipulated in an overarching policy framework.

Initiate and lever investments: The Federal Government should scale up investments to develop specific adaptation measures, particularly those that concentrate on Nigeria's most urgent needs. Such investments could leverage funds from international initiatives and financing mechanisms that assist countries with climate change adaptation. These investments could also demonstrate the Federal Government's leadership to other actors involved in adaptation.

Foster cooperation and partnerships: As Nigeria's focal point at international conventions, the Federal Government has an institutional role to foster new cooperation with international and local partners. This will help to harness technical, financial, institutional and managerial resources to support local adaptation initiatives.

Box 4.2 The role of the private sector in climate change adaptation

Use the enabling environment: The private sector should be encouraged to take full advantage of the favourable enabling environment – economic, social and political – afforded by the ATA to scale up production practices.

Form equal partnerships: Public–private partnerships are likely to succeed and flourish when the private sector is a viable partner, in terms of sourcing technology and injecting additional resources into agriculture.

Involve the community: Public–private–community partnerships are even more desirable. They have the added benefit of creating catalysing relationships that will help smallholder farmers access inputs, insurance and micro-credit. But perhaps even more importantly, these partnerships can link smallholders to viable markets, which transforms the rural economy while achieving food security and sustainable development through agriculture.

Box 4.3 The role of CSOs in climate change adaptation

Policy advocacy: Advocating for policies, both design and implementation, that provide robust and coherent responses to climate change is a core function of civil society. Using their experience, CSOs bring the climate challenges confronting the population and the agriculture sector to the attention of other institutions, especially the Federal Government. Through their networks, CSOs can raise national awareness of climate change, on policy choices that address the issues, and on mobilizing the required resources to effect policy change.

Be a conduit for local voices and operations: CSOs are close to the agricultural communities who make adaptation decisions on the ground and often bring the voices and opinions of these communities to national attention. They support the development of local adaptation practices, especially those related to farming, diversifying livelihoods and using indigenous knowledge in coping mechanisms.

Local implementation: Designing a national policy on adaptation is not sufficient; it is vital to ensure local implementation of the choices and actions. For example, a policy to provide drought-tolerant seedlings must be accompanied by local adoption and practice. An increasing role for CSOs is to act as a bridge between national policy systems and local implementation systems. CSOs can also support policy implementation through capacity building, on-farm skill development and practical demonstrations for farmers.

Civil society organizations

CSOs include international, national and local actors working at different levels and in a range of areas of interest. They may include NGOs, conservation groups, media houses, religious organizations, gender-based social groups, trade unions and community institutions. In the context of climate change adaptation, CSOs provide important and diverse functions (see Box 4.3).

Regional organizations

The main role for most regional organizations is to initiate and influence international cooperation among relevant countries. They contribute to tackling issues such as poverty, hunger, disease and malnutrition – factors that further exacerbate vulnerability to climate risks. By addressing these problems, for example through trade liberalization, market development, and access to credit facilities, regional organizations are also contributing to adaptation in the agriculture sector. For example, the Lake Chad River Basin has been affected by climate change over the last few decades, with negative effects on its agricultural systems. International cooperation involving Cameroon, Chad, Niger and Nigeria is promoting a collaborative approach to combat desertification.

While there is no sector-specific regional institution focused on climate change in Nigeria, the experiences of regional institutions across other sectors can help respond to climate challenges. Adaptation strategies must become a central consideration for all these institutions, while individual organizational experience in managing economic, social and infrastructure interests can be useful in developing appropriate strategies The experiences and technologies of regional organizations can also help to manage trans-boundary issues relevant to meeting national

adaptation needs and priorities. For example, a plan to construct a road from Lagos to Dakar along the Atlantic coast could integrate measures to protect against potential sea-level rise in its design. This could mitigate future inland flooding that might affect agricultural lands and local livelihoods.

One major regional initiative is the *Framework for the Adaptation of West African Agriculture to Climate Change*. This guides agricultural policies in the Economic Community of West African States (ECOWAS) countries. The draft framework was developed for the International Workshop on Adaptation to Climate Change in West African Agriculture, held in Ouagadougou, Burkina Faso in April 2009. This was revised in 2010 in collaboration with the Permanent Interstates Committee for Drought Control in the Sahel (CILSS) and the WMO. Box 4.4 sets out the activities in the current framework.

Box 4.4 Framework for the adaptation of West African agriculture to climate change

- Assess the types of beneficial adaptation and mitigation practices and responses that could be promoted and adopted in the region, and compile a list of adaptation-related best practices.
- Conduct research on the impacts of climate change on agriculture in the various agro-ecological zones of West Africa (since previous research in this field remains largely insufficient).
- Increase engagement with policymakers to provide the evidence needed to justify investments in development programmes and policy change.
- Initiate and strengthen cooperation among the region's universities and research institutions, international organizations and NGOs to create opportunities to strengthen institutions, develop human resources and reinforce capacities to face the impacts of climate change.
- Encourage research into new crop varieties with tolerance to extreme climatic conditions.
- Integrate farming systems with agroforestry, supplemental irrigation and water and soil conservation techniques.
- Adapt meteorological and climatic information to producers' needs by improving the spatial and temporal scales of forecasts and by providing advice on tactical and strategic decisions.

Development partners

Development partners include those who provide technical, financial, institutional and managerial functions in virtually all sectors, either as representatives of another country or of the global community. Examples include bilateral partners, development banks, intergovernmental organizations and United Nations agencies. In terms of climate change support, many provide vital services to Nigeria's agriculture sector. Box 4.5 highlights the roles of these development partners.

Box 4.5 The role of development partners in climate change adaptation

Create financing opportunities: Many development partners working on climate change and related issues have invested in the agriculture sector. These include the United Nations Development Programme, United Nations Environment Programme, African Development Bank, and Food and Agriculture Organization of the United Nations. They have supported initiatives from macro policy development on climate resilience to implementing micro policies. Development partners can draw on a wide range of expertise and collaborate with multiple stakeholders to deliver adaptation services that increases incomes and improve the welfare of Nigerian producers.

Provide knowledge and programme management: Development partners are conduits for global and local knowledge on good adaptation practices in the agriculture sector. They support the design of knowledge systems that can fit into local technologies for adaptation purposes. Providing the required technical and managerial oversight for adaptation programmes is core to their work in many developing countries, including Nigeria. Moreover, as development work is at the heart of their operations and mandate, they are often able to gain the political buy-in of government institutions to highlight adaptation as a priority.

Provide policy advocacy: Many development partners have been advocating for policy change

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for economic and social development in Nigeria for years. When successful, this has supported the mainstreaming of climate change adaptation into national development planning. Additionally, in many cases, other non-state actors (particularly civil society and research institutions) have worked with development partners to secure government attention on climate change adaptation. Examples include workshops on the impacts of poor education, information and human capital as limiting smallholders' development in Nigeria. Like civil society networks, international and donor organizations in Nigeria see themselves as a stimulating force in policy advocacy, because they finance training and education programmes with a particular emphasis on adaptation. An example is the Coalitions 4 Change programme, funded by the UK Department for International Development, which supports cooperation between local NGOs and government agencies.

Research and scientific community

The research and scientific community, which includes policy think-tanks, has variety of strategic roles that include:

- generating and interpreting scientific knowledge on climate impacts, vulnerability and adaptation options at different scales.
- building the necessary skills and attitudes to allow the adoption of adaptation measures in agriculture.
- creating a 'basket' of solutions for various scenarios in climate change adaptation, and highlighting best practices and lessons learned.
- promoting active responses to climate change in the agriculture sector.

4.7 Climate Change-Related Governance

Since May 1992, Nigeria has maintained its early interest in the UNFCCC's processes because it recognized that the risks of a 'business as usual' approach to climate change, or worse still, a 'do nothing' approach, would be too grave to contemplate. Nigeria ratified the Convention in 1994 and signed up to the Kyoto Protocol in December 2004, ahead of its coming into force on 10 March 2005.

Nigeria made a further political commitment to climate change through the Special Climate Change Directorate in 2006 under the aegis of the FMARD. This Directorate is charged with implementing the actions of the UNFCCC, the Kyoto Protocol and for the Clean Development Mechanism (CDM). Its membership is drawn from the ministries of Finance, Agriculture and Water Resources; the Energy Commission; Nigeria National Petroleum Corporation; Department of Foreign Affairs; the NIMET; industry partners; NGOs and academia. The Special Climate Change Directorate is working with the private sector and has initiated credible Clean Development Mechanism projects that promise both environmental and economic benefits to the country.

Nigeria is also adopting an approach that mimics the Bali Plan of Action (2007), with the devolution of implementation of climate change actions to state and local government levels. The main pillars of this action plan are: a new financial mechanism; an adaptation framework; a technology mechanism; and a capacity building component. It calls for an effective institutional setting for the pursuit of agricultural resilience in Nigeria. Furthermore, Nigeria's Climate Change Policy was adopted by the Federal Executive Council in late 2012. A Bill for climate change legislation is inching closer to completion. Nigeria is also finalizing important procedural documents, including the National Emissions Mitigation Strategy, a National Climate Change Adaptation Plan and the Second Communication.

In 2012, the National Assembly passed a Bill to establish a National Climate Change Commission with responsibility for "strategic planning and coordination of national policies in the field of climate change and energy in all its ramifications" (Nigeria National Assembly, 2011). The Commission will be a clearing house and implementation authority for all climate change matters, which includes determining appropriate levels of funding for mitigation and adaptation projects, technology acquisition, market incentives, human resources development and investments in research and development towards sustained economic advancement. This will help Nigeria to overcome a common obstacle – the lack of integration between economic and environmental decision-making.

As of March 2015, the Bill is awaiting the President's approval. The chances that the President will

agree to the Bill seem high in the light of recent pronouncements and actions, such the establishment in early 2013 of an Inter-ministerial Committee on Climate Services. Nigeria was recently elected as a member of the United Nations Security Council –the second time that it has been elected to the Council under the current Presidency (2010/11 and 2014/15). Nigeria now has a unique opportunity to influence the global environmental agenda and address the strategic priorities and interests of Africa. Top of the list is the need for global action in combating the devastating effects of climate change on livelihoods and national economies.

Roles for the FMARD

The National Policy for Climate Change sets out specific initiatives for individual sectors. For the agriculture sector, it calls for an integrated intervention plan to reduce the sector's vulnerability to climate change and enhance its productivity. The issues of vulnerability to the impacts of climate change and the necessity to instil resilience in the sector are complex, and need specific attention from the FMARD. Considering the likelihood that the National Climate Change Commission will be established, it is imperative that the FMARD has an in-house structure to liaise effectively with this Commission and ensure agriculture gets its share of national attention.

The FMARD has already established an Environment and Climate Change Unit within the Department of Land Resources. While this is a positive development, the Unit is currently understaffed, underfunded and undervalued. This does not augur well for the future of agricultural resilience in Nigeria and must be addressed as soon as possible.

The ACARN is well placed to assist the FMARD in building the necessary capacity to undertake vulnerability assessments and implement adaptation measures. Climate resilience must become part of the core competencies of relevant staff, both within the Federal Government and in the business sector. This can be achieved through conceptual and practical training in such areas as:

- the creation and use of climate and socio-economic scenarios for agricultural planning and statistical assessments
- process-based methods and geographic information system techniques for the rapid evaluation of food production and high-impact hazard assessment at regional and national levels
- the use of crop and economic models to explore adaptation and mitigation strategies
- governance, institutions and the role of different actors (e.g., public, private and social sectors, basin residents and international organizations).

There have also been discussions on setting up an agricultural resilience fund. The Bill to set up the National Climate Change Commission provides for "a fund into which all the monies accruable to the Commission shall be paid and from which all the activities of the Commission shall be funded". This is the equivalent of a Climate Fund and would provide a pot from which the various economic sectors, including agriculture, could obtain their finances.

But there should also be a separate agricultural resilience fund to complement the National Climate Change Commission provision. Indeed, the National Policy on Climate Change explicitly recognizes the need for individual sectors to pursue additional measures against climate change. Categorizing agriculture as a business invites greater involvement by the private sector in building finances to tackle climate change and develop climate-resilient agriculture. The private sector has many comparative advantages, including organized structures, experience, money and trained personnel, and will engage constructively in efforts to mitigate the shocks and stresses imposed by the changing climate. It understands the marketability and the profitability of climate-resilient agriculture and is willing to back that appreciation with the necessary level of investment.

4.8 Conclusions

Mainstreaming climate change adaptation into agriculture planning and development in Nigeria should be approached from the standpoint that it is a necessity for sustainable development. There must be a greater emphasis on the principle that food security, poverty eradication, economic empowerment and social stability are the main priorities in a developing country like Nigeria.

While the FMARD will lead efforts to mainstream climate change in the agriculture sector, it will need to adopt an integrated approach that engages with all sectors of the economy to plan, implement and operate identified programmes and activities for adaptation to climate change.

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5

Research and Development for Climate-Resilient Agriculture

5.1 Introduction

On their own, most small-scale farmers would not be able to withstand the shocks and stresses that climate change is likely to bring. They would be caught in a downward spiral of diminishing yields, poverty, hunger and ill health, from which they would struggle to escape. To build their resilience to climate change, they need new knowledge and technologies, together with information that allows them to make the best decisions, such as what crop to plant where and when.

Nigeria currently has the largest national agricultural research system in sub-Saharan Africa but it is still too small: in 2012, the country allocated only US$150 million to agricultural research, equivalent to two weeks of its imports. Nigeria's goal is to become 'Africa's Brazil' in terms of agricultural efficiency, returns to smallholder farmers and international competitiveness. But this can only be met if it develops an African version of Brazil's Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) – a competitively funded, highly professional national agricultural research system. The climate resilience agenda must therefore include a major boost for the research agenda.

The following sections of this chapter highlight the six thematic priorities for research on climate resilience in Nigerian agriculture: vulnerability, targeting and social institutions; agricultural management systems; breeding for future climates; post-harvest management; landscapes, ecosystems and carbon; and climate data and knowledge systems.

5.2 Vulnerability, targeting and institutions

Targeting research resources to those who need them most is a key strategy to ensure they are used in a cost-effective way. The IPCC includes three components in its assessments of vulnerability to climate change: projected climate impacts; sensitivity of the system to those impacts; and the adaptive capacity of the impacted system or community. Impacts are usually estimated using climate models, while participatory methods are better suited to understanding and building on the adaptive capacities of farmers and institutions. Integrating impact-based and capacity-based approaches to increase resilience is especially important given the uncertainty of future climate change (Vermeulen et al., 2013).

It is important that socio-economic research clearly and scientifically assesses the level of impact of climate change on different actors in the agriculture value chain. Apart from the direct impacts on crops, livestock and fisheries (described in previous chapters), the indirect impacts of climate change on livelihoods include the effects of pests and diseases, the loss of stored products, and the loss of housing, schools, roads and other infrastructure due to flooding – as occurred in Nigeria in 1999, 2011 and 2012).

Social factors also affect the success of efforts to build farmers' resilience to climate change. Different groups need different types of support to address their own specific vulnerabilities, based on their livelihood strategy, location, social status or gender. For example, evidence shows that women's relatively reduced access to critical resources, entitlements and decision-making processes impedes agricultural development. Research can help by finding ways for climate-resilient technologies, practices and institutions to enable and increase (rather than further reduce) women's access to benefits and participation in agriculture resilience.

Box 5.1 Research priorities for vulnerability, targeting and institutions

- Rather than relying purely on climate models to steer climate interventions, integrate analyses of people's capacity and vulnerability. This will help develop locally appropriate research investments that are tailored to and targeted at specific places and social groups, including gender-specific research.
- Undertake regular assessments of the impact and costs of droughts, floods and soil erosion to farming and fishing communities.
- Develop and test cost-effective processes for participatory climate diagnosis and planning. A good example is the International Fund for Agricultural Development's participatory landscape planning approach for climate resilience in the northern states of Nigeria.
- Assess and improve all climate-resilient practices and technologies in terms of their access and utility for gender-specific application.

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- Engage extension services and farmers in the research process to set a research agenda that is informed by their needs. This will also help to enable field-testing of climate-resilient practices and technologies, and accelerate channels for adoption and up-scaling (see Section 5.3).
- Investigate cost-effective mechanisms for building on existing institutions at the local level and work closely with the Nigerian Agricultural Extension and Rural Liaison Services.
- Improve early warning systems and networks with up-to-date information technology, so emergency relief can rapidly reach affected communities particularly women and children.
- Increase investments in processes for regional integration and cooperation in research. Regional bodies can facilitate the transfer of technology, genetic materials and expertise.

5.3 Agricultural Management Systems

There are many agricultural management systems that require research investment and it is beyond the scope of this chapter to describe them all in detail. The focus is on conservation agriculture and agriculture in drylands as examples of where research investment is needed.

Conservation agriculture

Conservation agriculture is linked directly to climate resilience because its techniques improve soil quality, including moisture retention – a critical factor in crop growth that will be a major issue in regions of increasingly unreliable rainfall.

One conservation agriculture technique is the use of organic fertilizers. Due to the high cost of synthetic fertilizers, the Institute of Agricultural Research and Training developed an organic fertilizer for maize, cassava and melon, which was first released in 2007. This simple innovation uses local materials and can be put together by farmers. Adding organic matter improves soil fertility and structure, and yields of up to 10–12 tonnes per hectare (t/ha) for cassava, 0.3–0.65 t/ha for melon and 1.5–2 t/ha for maize have been recorded using this technology.

Resource management in the dryland areas

Nigeria's drylands are particularly vulnerable to climate change. With drought a constant threat, soils that are already poor and being further degraded by erosion. Overgrazing and deforestation have also caused desertification. Under current management practices, much of the rainfall is lost through evapotranspiration and runoff. As a result, groundwater is recharged only by seepage through the soil profile. Surface runoff events, soil moisture storage and groundwater recharge are generally more variable and less reliable than in more humid regions. Successful dryland farming therefore requires the integrated management of soil, water, crops and plant nutrients.

There are research-based interventions from other dryland areas that should be pilot-tested in Nigeria. For example, using date palms to fight desert encroachment has been successful in Israel. The Nigerian Institute for Oil Palm Research should develop improved date palm seedlings that can be an export crop and also fight desert encroachment.

Box 5.2 Research priorities for agriculture management systems

- Improve crop and grazing land management systems to increase soil carbon storage.
- Restore cultivated peaty soil and degraded lands and improve cultivation techniques, particularly for rice, to reduce nitrous oxide (NO_2) emissions.
- Promote the composting of organic waste, controlled wastewater treatment, recycling and minimization, bio-covers and bio-filters to optimize methane oxidation.
- Expand rainwater harvesting, water storage and conservation techniques, water reuse and water desalination, and improve the efficiency of water use for agriculture and irrigation to reduce water stress.
- Improve techniques for applying nitrogen fertilizers to reduce nitrous oxide emissions (these contribute to climate change).
- Develop new techniques that: control water runoff and soil erosion control (for example planting trees); improve water harvesting and

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storage for irrigation; improve soil organic matter content, structure and biodiversity.

- Assess how invasive alien species are, and the resilience of ecosystems to mitigate biodiversity threats and minimize the loss of important and useful native plant species; these will be vital in breeding new climate-resilient crops.
- Introduce techniques for reduced feed wastage and promote non-conventional animal feeds, such as new fodder crops and fish feeds (e.g., maggots); these could replace feeds that become scarce due to climate change.

5.4 Breeding for Future Climates

A significant area for research investment will be breeding new varieties to cope with the changing climate. This includes new varieties of crop, livestock and fish.

Climate-resilient crop varieties

Crop research can be used to breed for specific traits that increase climate resilience, including tolerance to heat, drought, salinity and submergence. This will be a key strategy for adapting to climate change. Examples of ongoing work in Nigerian research institutes are highlighted in Box 5.3.

Research by international research institutes is also an important contributor. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has bred millet, sorghum and groundnut varieties for higher yield and resistance to major diseases, as well as to drought. Early maturity, aflatoxin resistance, nutrient efficiency and water utilization are other important attributes being researched.

Under irrigated dry-season crop production, which could play an increasingly significant role in Nigeria's agricultural production, temperature becomes important: it can be too low (about 20°C or lower) early in the season (December–January) or too high (above 40°C) later in the season (April–May), affecting the productivity of tropical crops. ICRISAT has started breeding crop varieties that not only tolerate drought, but are adapted to high temperatures. For example, millet varieties are being bred that tolerate excessive temperatures (up to 45°C) and produce higher yields (more than 4.5 t/ha) at those temperatures.

Box 5.3 Examples of crop breeding for resilience in Nigeria

In 2004, the Cocoa Research Institute of Nigeria developed an early-maturing cocoa variety with yields of up to 1 t/ha juvenile yield, rising to about 2.5 t/ha mature yield, with reduced agricultural inputs. This is very favourable compared with other varieties that give average yields of 300 kg/ha and mature in five years. Early-maturing varieties will be useful as patterns of rainfall and dry seasons vary with climate change.

Climate-resilient technologies being developed at the National Root Crops Research Institute largely focus on breeding for drought-resistant cassava genotypes for Nigeria's Sahelian northern states, and saline water-resistant genotypes that are mainly for the southern states.

The increase in precipitation intensity observed in the southeast of Nigeria has exacerbated the problem of soil erosion. High-branching cassava varieties developed by the National Horticultural Research Institute reduce the effects of erosion and have been introduced to famers. A moisture-tolerant cassava variety was also developed for environments of high rainfall. The Institute, in collaboration with IITA, also developed a drought-tolerant cassava variety for the northern part of the country where rainfall has been declining.

Source: ACARN publications and stakeholder engagement sessions held by the ACARN

Climate-resilient livestock varieties

Livestock make up about one third of Nigeria's agricultural GDP. They provide food, income, transport, employment, farm energy, fuel and manure. They are also a major source of government revenue. Livestock, especially ruminants, are the most efficient users of uncultivated land and can contribute substantially to crop production, for example through manure and as draught animals.

The National Animal Production Research Institute (NAPRI) has the mandate for livestock research in Nigeria. While many of the methods and technologies it has researched were not developed with climate resilience in mind, they are targeted at boosting production. This makes the sector more

resilient in the event of losses resulting from climate change. For example, drought has often taken its toll on livestock in Nigeria, particularly in the north. A higher production capacity will ensure animals can be replaced more quickly after extreme climate events.

One of NAPRI's key goals is "genetic and reproductive improvements of livestock species" and one of its key achievements is the upgrading of indigenous cattle by crossbreeding them with exotic breeds to produce animals that produce 70% more milk than indigenous breeds. Researchers at NAPRI have evaluated the productivity of indigenous cattle, sheep and goat breeds. The breeds and suitable management procedures for extensive and intensive production systems in Nigeria's various ecological zones have been identified and practical guidelines for farmers documented.

Climate-resilient fisheries

For fisheries, the National Institute for Freshwater Fisheries Research (NIFFR) and the NIOMR have mandates to breed hardy strains that can withstand adverse changes in the environment. Most tropical freshwater fish species thrive well in water temperatures between 20^{0}C and 27^{0}C. Lower or higher temperatures will significantly retard metabolic activities in freshwater fish. Tilapia and catfish, for example, will not spawn when it gets too cold, while fingerlings will die if it gets too hot. There is a need to breed fish that have higher hatchability and survival rates. In this regard, some fish farmers use techniques like adding ice blocks to water to bring down the temperature and thereby reduce heat stress on fingerlings.

Box 5.4 Research priorities for crop, livestock and fisheries breeding

- Breed crops varieties that are drought-resistant, heat-resistant, insect- and pest-resistant, as well as early-maturing varieties.
- Breed varieties that grow with efficient use of resources e.g., crops that perform well under low soil fertility and low soil moisture conditions.
- Encourage the use of alternative energy sources (solar or charcoal) for fisheries breeding.

5.5 Post-harvest Management

Roughly one third of food produced globally for human consumption – about 1.3 billion tonnes each year – is lost or wasted. Not all losses are avoidable, but many are. This problem is extremely important in Africa. For example, in sub-Saharan Africa on average 13.5% of cereals by weight are lost between harvest and consumption; these have a value of about US$4 billion per year (Hodges et al., 2013). This is more than the total food aid received by the continent between 1998 and 2008, equal to total cereal imports between 2000 and 2007, and enough to meet the requirements of 48 million people (World Bank, 2011). Unpublished figures for Nigeria provided by the FMARD indicate post-harvest losses of approximately20% for all foodstuffs.

Climate change is likely to exacerbate post-harvest losses, not only in cereal value chains, but also in other plant-based foods, livestock-based foods and fisheries. Higher temperatures increase the prevalence and toxicity of spoilage; aflatoxin in maize is an important example for Nigeria as it can cause fatalities. Greater climate variability and associated climate extremes can cause hailstorms, floods and landslides that have severe acute effects on harvests and post-harvest management.

Reducing losses in food value chains represents a major opportunity to simultaneously improve food security, increase household resilience to climate change, and mitigate food-related greenhouse gas emissions. Most losses in Nigeria occur at the post-harvest stage, during on-farm storage, village-level processing and local transportation.

The Nigerian Stored Products Research Institute (NSPRI), which has the national mandate for the preservation of agricultural commodities, has developed several technologies that help make post-harvest management more climate-resilient, and many institutes that have post-harvest units have developed similar technologies. Box 5.5 highlights some successful examples.

Often the technical solutions to improved post-harvest management are fairly simple and well established, so do not need substantial further research. But where farmers do not produce surpluses and are disconnected from value chains, improving post-harvest management is an important challenge for policy and research (Hodges et al., 2013). More efficient

Box 5.5 Technologies for improved post-harvest management

Smoking kilns

Local kilns, which are used for post-harvest activities such as for smoking fish to preserve them, are often inefficient and use a lot energy, which means more wood, more CO_2 emissions and more forest being cut down. Olokor (2003) found that fish processors use 16.41 kg of fuel wood per day, or 7.5 m^3 of forest wood compared to 0.46 m^3 estimated for developing countries by earlier studies. The NSPRI, the NIOMR and the NIFFR have developed more efficient smoking kilns that reduce the amount of firewood used. Some eliminate the need for fuel wood altogether by using only sawdust, wood shavings or briquettes made from waste materials like rice husks.

Solar dryers

The Kainji solar dryer, which uses only solar radiation, has been used widely around Kainji and Jebba lakes for drying fish. It is cheap and can be easily constructed by local manufacturers, and turns out clean, quality products. It can be used to dry most agricultural products, particularly vegetables, fish and perishable items so that they keep for longer. The advantage of this technology is that it produces higher quality products compared with the local method of sun drying on the bare ground, which leads to contamination by dust, sand, stones and flies. Since open-sun drying is slower than solar dryers, some spoilage begins in the products before they get the chance to dry properly.

post-harvest management can also contribute to sustainable food provision and climate resilience by saving valuable energy, water and financial resources.

5.6 Landscapes and Ecosystems

Research into climate resilience will also need to consider innovations at the scale of landscapes and ecosystems. These include livestock systems and forests.

Box 5.6 Research priorities for post-harvest management

- Look for further innovations in efficient and locally appropriate technologies for post-harvest management, for example simple dryers that mimic sun drying.
- Research economic incentives in value chains for farmers to reduce post-harvest losses.
- Develop statistical and modelling approaches for better prediction of the epidemiology of post-harvest spoilage under near-term climate variability and long-term climate change.
- Improve and share information systems on post-harvest losses, including connections to the African Postharvest Losses Information System.

Livestock and pasture systems

Nigeria's livestock sector plays an important role in contributing to food security and economic growth (see Section 5.4). However, it is important to understand how climate change will influence livestock production in order to develop response policy and adaptive management interventions. Various climate models predict slightly different futures for Nigeria (see Chapter 2) but there is a general agreement that there will be a decrease in precipitation in the centre and the southwest of Nigeria, coupled with a predicted increase of 2–2.5°C in average daily maximum temperatures during the warmest month (Cervigni et al., 2013). This suggests drier climatic conditions will dominate in the future, perhaps enough to influence species composition, forage quality and plant community structure. If atmospheric CO_2 increases, the shift from grasses to woody plant dominance is also likely to follow. How pasture and other crop species that are important in mixed crop–livestock systems will cope with these changes remains unknown. As well as research into livestock breeding, investments must be made to build research capacity in Nigeria to provide answers to the following critical questions:

- How will climate change (especially changes in precipitation and temperature) influence the vegetation of Nigeria at biome level? Will this affect the resilience of existing and future livestock production systems?

- How will changes in the state of natural resources associated with climate change influence the availability and quality of grazing resources, fuel wood and other ecosystem services that impact rural livelihoods?
- What are the major drivers and consequences of land cover change (shifts in plant community structure and assemblages) and land use change (land transformation for agriculture or development) in Nigeria, particularly on productive ecosystems prone to rapid change?
- How sensitive is southern (wetter) and northern (drier) Nigerian land cover (vegetation structure and composition) to human drivers of change (e.g., land use change)?
- How will Nigeria's ATA influence rates of land use and land cover change, and what are the likely impacts on ecosystem processes, ecosystem services and the biodiversity that underpin livestock production?
- How will changes in Nigerian land cover and land use feed back to regional and global climate dynamics and to future climate projections?

Managing forest resources

Forests are conspicuously decreasing in Nigeria and the country has one of the highest deforestation rates in Africa (FAO, 2010). The consequence of increased biodiversity loss limits the functions of forest ecosystems and the ability of forests to provide ecosystem services. Climate change impacts (including extreme events) and increasing population pressure create a higher need for conservation and restoring tree cover in forested ecosystems (Aerts and Honnay, 2011). The loss of tree cover has biophysical effects, which include changes in land surface properties, evapotranspiration and the climate beyond the fate of CO_2 (Bala et al., 2007). Also, the loss and degradation of essential ecosystem functions (e.g., pollination) and services (e.g., flood mitigation, topsoil retention, non-timber forest products, water recycling) are threatening the majority of people living in tropical countries (Bruijnzeel, 2004; Bradshaw et al., 2009) and require urgent action.

Climate-resilient agricultural practices that raise farmers' incomes may benefit livelihoods in the short term, but could also incentivize further forest clearance to create more agricultural land, decreasing carbon storage and sequestration. Two ways to conserve trees in the landscape are land sharing (mixing trees with cropping systems) and land sparing (delineating forested lands to farming lands), or a combination of both (Parrotta et al., 2012). Success in increasing trees in farming landscapes will depend, among other political and social aspects, on levels of forest and soil degradation, residual vegetation after disturbances, desired restoration outcomes and how to combine livelihood benefits with ambitious reforestation programmes (Chazdon, 2008). This level of knowledge requires a good monitoring system of land use change and vegetation dynamics at country level.

Box 5.7 Research priorities for landscapes and ecosystems

- Develop an understanding of the incentives for deforestation and how to incentivize an increase in forests and trees within productive landscapes instead.
- Introduce innovative uses and adoption of trees in farming practices.
- Understand the socio-cultural and economic factors that foster or constrain agroforestry (e.g., mixing trees with forest systems).
- Understand the social and environmental benefits of trees outside the forest.
- Expand rural livelihood opportunities by developing non-timber forest products.

5.7 Climate Data and Knowledge Systems

Climate information and downscaled models

At present, climate research in Nigerian agricultural research institutes is not well established. They only have small units for applied climate research that oversee the collection of daily weather data. However, assessments of climate impacts on agriculture, based on top-down analysis from global climate models, have recently been undertaken for Nigeria and published by the World Bank (Cervigni et al., 2013) and by the Consultative Group on International Agricultural Research (CGIAR) (Hassan et al., 2013). There is now a need to mainstream climatic and associated environmental factors into the research across the Nigerian agricultural research system.

The thrust of research should go beyond collecting weather data to in-depth climate research, including joining global efforts to improve the downscaling of climatic models and projections of impacts on agriculture. Relevant research needs to be underpinned by a good network of modern weather stations in all the research stations (discussed in Section 3.6, Chapter 3). This should be coordinated at a central climate databank that works closely with the NIMET. The NIMET must also raise the country's capacity to manage and use weather information and climate data effectively, while ensuring free and unrestricted access to all interested stakeholders, in accordance with the WMO Resolution 40 (Cg-XII) on the exchange of meteorological and related data and products.

Climate scenarios

Nigeria would benefit from embarking on a scenario planning process for agriculture. Given the huge uncertainties about climatic futures, it is helpful to understand the range of possible futures, and to explore how climate change trends and drivers interact with other trajectories, such as population growth, economic growth and emerging markets. The interaction of socio-economic and climatic changes is particularly relevant since Nigeria is a large economy undergoing swift changes that are associated with large uncertainties, with consequences for climate resilience. At the same time, perceptions of a predominant business as usual can be strong in Nigeria. Therefore the use of scenarios by policymakers and wider stakeholder groups may be a very valuable and important way to open up new policy pathways.

One approach to scenarios is already working well in West Africa. The CGIAR programme Climate Change, Agriculture and Food Security (CCAFS) has teamed up with major stakeholders from the West Africa sub-region to develop, through participatory consultative approach, scenarios up to 2050 for the sub-region (CCAFS, 2013).

CCAFS is working with ECOWAS to use these scenarios to examine and guide ECOWAS-facilitated investments in climate-resilient agriculture. In Nigeria, these scenarios could be used to guide national agricultural adaptation and mitigation policies. They can also be used to test whether policies are able to deal with future climatic and socio-economic changes, help think about more strategic and flexible policies, and guide investments in agriculture, food security and the environment.

Scenario planning may bring up many assumptions about agriculture and its potential contribution to the economy and to livelihoods. However, these scenarios should also look critically at agriculture as a major contributor to global climate change through global emissions.

Engaging with non-scientists

Even if greenhouse gas emissions are limited in the near future, climate change will continue to develop over the next century. It is not a simple switch from one state to another, but a condition of ongoing change. Thus one-time technological fixes will be inadequate.

Investment is required in long-term, iterative research and knowledge systems that develop the adaptive capacity of the agriculture sector. The best knowledge systems will provide for learning among multiple partners, including consumers, farmers, the private sector and scientists. A modern, inclusive approach should apply the following principles.

- **Work closely with farmers and integrate local knowledge:** Hunger and climate change have global causes, but they are experienced by people in highly specific cultures and habitats. Local knowledge, values and actions are central to improved nutrition in the future. The limited coverage and capacity of extension services and other sources of knowledge in many places make local knowledge even more crucial.
- **Engage society to assess synergies and trade-offs for climate-resilient agriculture:** Near-term food security, longer-term adaptation and co-benefits to mitigation may sometimes be achieved in synergy, but there may also be conflicts and trade-offs among the three goals. Research can make an important contribution to policy decisions by providing empirical analyses of these trade-offs at different scales of time, space and governance.
- **Invest in knowledge systems and capacity at all levels:** Investing in institutions to promote the management and sharing of knowledge among diverse stakeholders can speed up learning and uptake, while cutting costs. Interventions should also ensure equitable access to knowledge and technologies, which includes education for women, who ensure household food security, and youth, who will be responsible in the future.

Box 5.8 Research priorities for climate data and knowledge systems

- Establish fully equipped and automated agro-meteorological stations at all the agricultural research institutes in Nigeria. These should be linked to a central institute for archiving, processing and dissemination.
- Liaise with the NIMET and the Federal Ministry of Aviation to explore opportunities for jointly investing in expanding the country's network of meteorological stations.
- Invest in Nigerian agro-climatic research, in terms of hardware (weather stations, data management systems, crop and agricultural impact modelling capacity, downscaling techniques, etc.) and software (skills base, access and affordability of climate data, links between stakeholders including farmers).
- Create at least four centres of excellence for agro-climatic research, focusing on the Coastal, Forest, Guinea Savanna, Sahel Savanna, and Sahel AEZs.
- Ensure the sensible use of climate information; do not base interventions to increase climate resilience on a handful of downscaled climate projections.
- Establish a Nigerian process on climate scenarios, linking the agriculture sector with other sectors, and drawing on the wider ECOWAS approach.
- Use scenarios to make important decisions on choices and trade-offs in agricultural development.

5.8 Building Institutions and Capacity

The challenges faced by Nigerian farmers today are perhaps more complex than ever before. Demand- and supply-side pressures are converging in a way that will require innovative systems that are as responsive and inclusive as possible. Confronting climate change will depend on local capacities for immediate action, but will also surpass the limits of local knowledge. Scientific tools, such as techniques for forecasting, scenarios and modelling, will be increasingly important for planning and action, working in tandem with local observations and judgements.

Hunger and climate change are highly complex problems where there is no clear agreement on the solutions, or even the causes of the problem. Trade-offs among different goals for agriculture may be very different for different stakeholders. Historically, one-way knowledge systems, in which experts develop technologies and then disseminate them to beneficiaries, have often failed. Farmer-led research to find ways to reduce exposure to climate risks often provides a better alternative.

Putting farmers at the centre of research

Nigerian farmers already respond to climate risks in various ways, but their adaptation responses are limited. For example, farmer adoption of drought-tolerant maize in the northeast Guinea and Sudan Savannah zones is limited by affordability and access to the technology, complementary inputs, extension services and climate information (Tambo and Abdoulaye, 2012). In the southeast region, factors such as poor market access, poor extension services and limited information on climate change affect the capacity of farmers to adapt to changes in agricultural production, including climate variability (see: Onyeneke and Madukwe, 2010; Ozor et al, 2010).

Understanding different farming systems and how farmers experience these conditions, their access to resources and their actions to cope with climate hazards is a necessary first step. The 'Fadama' projects,[1] under the FMARD, are addressing many of these limitations and can offer various lessons to draw from. But they do not explicitly adopt a climate-resilient approach to increase the synergies between mitigation, adaptation, improved food security and development. Also, to put farmers at the centre of research means maintaining continuous contact with them, to learn about the challenges they face and the successes and failures they encounter in their own experiments. Farmers' experimentation offers researchers the opportunity to learn and to collaborate on such ideas with farmers.

The limited mobility of public extension services means there is a need for additional ways to

1 'Fadama' is a Hausa word for irrigable land.

contact farmers. This can be through encouraging and empowering farmers' organizations to directly inform research organizations about the constraints and opportunities in production. For example, the Fadama projects use a community-driven approach in which farmers have formed 4,814 Fadama Community Associations, comprising 58,354 Fadama user/economic interest groups (World Bank, 2012) with most states federating their community associations up to the state level (World Bank, 2011).

The existing farmers' organizations (including those outside the Fadama programme) provide a basis for greater research collaboration. The FMARD can facilitate this by introducing a broad-based research programme with farmers. This should be accessible to all research organizations in Nigeria on a peer-review basis, whereby it is mandatory for farmers and researchers to jointly define the research problem. This will ensure that farmers are really at the centre of research. Already, performance-based contracts with research organizations are planned in the Fadama projects (World Bank, 2011) and experiences can feed into researcher–farmer partnerships that are supported and financed by the FMARD.

Finally, while Nigerian agriculture is predominantly small-scale, large-scale farmers also have the potential to increase agricultural production, due to the spatial scale of their enterprises and because they tend to have more financial resources to invest in research and new technologies. Thus, the FMARD needs to connect researchers with large-scale producers as well.

Agricultural research organizations

Agricultural research organizations have a crucial role to play in promoting climate-resilient agriculture in Nigeria. In the last few years the Agricultural Research Council of Nigeria (ARCN) has worked hard to meet the needs of the NARS and relevant universities in climate change research and climate-resilient technologies. It has conducted sensitization training for research scientists on the subject and carried out surveys to assess capacity and available technologies. This section features part of the survey report conducted by ARCN (2011) entitled *Available Climate Friendly Agricultural Technologies and Practices among Nigerian Farmers*.

The NARS is already well prepared to support the implementation of climate- resilient agriculture in Nigeria. There are 15 research institutes under the ARCN. They have the mandate for farming systems research and the responsibility for researching genetic improvement, production increases and product development in a wide range of agricultural commodities. They have additional mandates covering research in areas such as soil and water management and the long-term effects of human-made lakes on ecology and the environment. There are also training mandates for the Federal Colleges of Agriculture under the guidance of the ARCN.

These mandates span all the AEZs of the country and are critical for climate- resilient agriculture. For example, to be able to mitigate and adapt to the impacts of climate change, there is a need to diversify the production base and properly integrate all aspects of production. The wide scope of the mandates makes them very relevant in this regard. Research and dissemination can help farmers to introduce a wider range of commodities, farming systems and approaches to natural resources management, going beyond primary production and into processing and adding value to their produce. The existing structures within research institutes mean they are well placed to support climate-resilient agriculture in these different zones. Working on a common mandate can also build synergies among the various institutes involved in the zones as well as promoting integrated agriculture.

Particular approaches to support include crop rotation and improved farming systems, which can reduce greenhouse gas emissions from agricultural production. Furthermore, farmers should adopt systems with reduced reliance on external inputs, such as rotations that include legume crops. Sustainable practices such as organic agriculture strongly reduce reliance on external inputs, for example by recycling waste as a source of nutrients, using nitrogen-fixing plants and avoiding synthetic pesticides.

However, to effectively combat the impacts of climate change, there is need for proper funding for relevant research initiatives. Consequently, the ARCN and the NARS will have to look beyond the capital budget, which has been limited and inadequate in the past. There are several funds that could be tapped for climate change mitigation and adaptation projects. First, however, the ARCN needs to develop a comprehensive strategic plan for its climate change projects. This would provide a basis on which to engage stakeholders and funders in meaningful talks to support proposed projects (ARCN, 2011).

Box 5.9 Research priorities for institutions and to build capacity

- Improve the understanding of different farming systems in their social, agro-ecological, governance and economic contexts, including how farmers experience these conditions, their access to resources and their actions to secure their production against climatic hazards.
- Put farmers at the centre of research on climate resilience in agriculture, with farmers experimenting with climate-resilient technologies and practices.
- Use existing farmers' organizations, within and beyond the Fadama programme, as the institutional mechanism for putting farmers at the centre of research on climate resilience.
- Seek avenues to connect researchers with large-scale producers.
- Strengthen extension agents, particularly agricultural development programmes, through materials and capacity to pass climate- resilient technologies to farmers and give adequate feedback to researchers.
- Improve the funding model for research on climate resilience in Nigerian agriculture to provide a secure, competitive financial resource base for top-quality research.

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6

Improving Agricultural Extension Services

6.1 Introduction

Climate change, coupled with population growth and energy and natural resource depletion, will increasingly challenge our ability to feed ourselves. Recognizing problems, forming responses and making proactive preparations are the first steps to meeting this challenge, and these will be iterative as our knowledge expands and new interactions and effects become clear. Agricultural extension agents and advisory services will need to serve both as the critical link between farmers and sources of information and tools, and as the facilitators of widespread behavioural adaptation.

Climate change is expected to have the greatest impact on poor smallholder farmers who lack the resources and knowledge base to respond adequately or take advantage of new environmental circumstances. In a large country like Nigeria with varied agro-climatic conditions, numerous indigenous and evolving production systems and socio-cultural communities, these challenges are even greater. Meshing indigenous with modern systems capitalizes on the strength of existing farming methods.

However, as the need for knowledge transfer on how to adopt climate- resilient farming practices grows, decades of underinvestment have left government extension services throughout Africa in a sorry state. The lack of resources means that staff are often unmotivated and lack adequate knowledge. Furthermore, they tend to operate in a top-down fashion, with decision-making and prioritization coming from those in power. This is the opposite of the required objective of farmer engagement and empowerment. Ideally, extension programmes need to be more decentralized, pluralistic, highly efficient and demand-driven; in summary, more responsive to the actual needs of farmers. Extension arrangements should culminate in, or at least include, a community-based climate change adaptation support programme. There is also a need to integrate traditional knowledge gathered from farmers themselves.

6.2 Extension Services in Nigeria

Agricultural extension is considered the prime vehicle for bringing technological innovations to farmers for sustainable development and improved quality of life. But its efficiency and effectiveness are a major concern because it has not had the desired impact of making Nigeria food secure or alleviating poverty in rural areas. The focus has been on increasing crop production to the detriment of livestock, fisheries and post-harvest handling and processing, and with insufficient efforts to strengthen the capacity of small-scale farmers and other actors along the value chain to ensure sustained agricultural development (Arokoyo, 2005). Today, the majority of farmers in Nigeria are inadequately serviced: there is, at best, one extension agent for every 2000 farming families and, at worst, one to every 22,000, depending on the state (see Table 6.1).

The void created by the lack of national extension services is filled by NGOs, notably the British–American Tobacco, the Evangelical Church of West Africa Rural Development Project (in the north), the Shell and the Mobil outreach programmes (in the Niger Delta), the Leventis Foundation, the Sasakawa Global 2000 and the United States Agency for International Development (USAID) Markets programme. It is expected that, with appropriate capacity building, private agricultural extension and advisory services may be able to effectively compliment the public extension service and fill the gaps.

The Research-Extension-Farmer-Inputs Linkage System (REFILS) is a research and extension management tool, which provides a platform to bring together all the stakeholders (researchers, extension workers, farmers, private sector and government actors) in technology development, adaptation, dissemination, adoption and utilization. The development and operation of REFILS reached its peak during the World Bank-assisted National Agricultural Research Project (NARP), which supported Nigeria's NARS from 1995–2000. Similar to the experience of the agricultural development programmes, the termination of NARP support marked the downward turn of REFILS and its virtual collapse. Consequently, REFILS has remained weak, uncoordinated, poorly funded and ineffective.

The major challenges facing the national agricultural extension service in Nigeria are summarized below.

- An absence of an agricultural extension policy that clearly defines the roles and responsibilities of all stakeholders in the sector and provides for innovative and sustainable funding mechanisms to ensure stability and sustainability of the system.
- Inadequate and poor quality staff; they have limited opportunities for capacity development to enhance job performance and to effectively address current challenges.
- Poor infrastructure and inadequate working tools, including poor mobility for field extension staff

Table 6.1 Extension Staffing in Nigeria

STATE	NUMBER OF EXTENSION AGENTS (EA)	NUMBER OF FARM FAMILIES (FF)	FF TO EACH EA
Abia	78	410,670	5265
Adamawa	250	450,000	1800
Akwa-Ibom	193	685,095	3550
Anambra	35	338,721	9678
Bauchi	321	648,510	2020
Bayelsa	16	95,455	5966
Benue	98	413,159	4216
Borno	235	536,322	2282
Cross-River	124	481,506	3883
Delta	92	179,256	1948
Ebonyi	170	435,328	2561
Edo	27	200,000	7407
Ekiti	32	200,000	6250
Enugu	49	246,542	5031
FCT	70	165,000	2357
Gombe	155	309,366	1996
Imo	120	303,333	2528
Jigawa	205	467,000	2278
Kaduna	178	606,007	3405
Kano	487	1,300,000	2669
Katsina	11	242,000	22,000
Kebbi	32	525,000	16,406
Kogi	97	222,894	2298
Kwara	120	300,000	2500
Lagos	100	360,000	3600
Nasarawa	127	180,433	1421
Niger	383	550,000	1436
Ogun	93	360,000	3871
Ondo	112	180,000	1607
Osun	14	254,984	18,213
Oyo	77	415,030	5390
Plateau	74	525,082	7096
Rivers	51	479,170	9395
Sokoto	119	673,944	5663
Taraba	110	288,000	2618
Yobe	130	407,834	3137
Zamfara	180	350,000	1944

Source: Arokoyo (2007); FDAE (2013)

at the critical extension agent–farmer interface, and a lack of up-to-date, site-specific weather information and models.

- A monopolistic and dominant public extension system, characterized by top-down, supply-driven extension approaches with little use of information and communication technology.
- The weak and uncoordinated REFILS programme and activities.
- Poor targeting of women and youth, who are disproportionately affected by climate change because of cultural and socio-economic factors.

6.3 The Basis of Better Advice

Farmers in Nigeria face many economic, political and environmental uncertainties. To build their resilience in the face of climate change, they need reliable data and advice to help them make informed decisions on the most appropriate agricultural practices. This means building the capacity of national agricultural extension service staff, so they can understand the impacts of climate change on local agriculture and provide better advice to farmers. Three kinds of technical support are required:

- updated knowledge and awareness among extension staff of climate change and climate variability, and their impact on agriculture
- improved skills among extension subject specialists in promoting climate change adaptation strategies in agriculture
- wider uptake and application of the currently limited climate change adaptation training programme, through backstopping and support to extension subject specialists in training frontline staff.

It is not only extension staff who will benefit from a coordinated capacity building programme. Other beneficiaries include researchers, farmers, the private sector, farmers' associations and other CSOs and CBOs involved in technology development, adaptation, dissemination, adoption and use. Therefore, research and advisory personnel must be trained so they themselves are adaptive in their structures, governance, funding and partnerships.

As discussed in Chapter 5, placing farmers at the centre of agricultural research is the key to successfully developing climate- resilient agriculture in Nigeria. REFILS is a suitable vehicle for this as it links farmers to the NARS at multiple levels, and not just as recipients

of knowledge but also as drivers of research. Capacity building and proper funding for REFILS will enable it to implement critical activities relevant to climate change adaptation and mitigation. These include: diagnostic and thematic surveys to identify climate change challenges and design appropriate research to address them; designing researcher- and farmer-managed on-farm adaptive research; and establishing training plots to disseminate the technologies and teach farmers how to use them.

Besides technical training, farmers should be given appropriate training to organize and manage their associations and cooperatives more effectively, using appropriate strategies such as the farmer field school (FFS) approach. All states should provide adequate funding for FFSs and scale up the strategy. To ensure quality control of the services provided to farmers/producers and their associations, all private extension providers should register and be certified by the appropriate government agency or professional body. Re-certification of agricultural extension service providers should be carried out every three years.

In addition to capacity building, farmers need access to long-term climate data and short-term weather forecasting information to help them make decisions (for example, whether or not to plant seeds or apply fertilizer on a given day). For this, they need a six- to eight-hour weather forecast. A short-range weather tool-kit has been successfully demonstrated in Nigeria's Bauchi state, described in see Box 6.2, while additional lessons on participatory weather forecasting in Ghana are presented in Box 6.3. The need for better climate data is covered in Chapter 3.

6.4 Communicating Extension Messages

Different media are needed for different stakeholders, and so a mix of both traditional (printed, word of mouth, local radio) and modern (mobile phone and internet) methods should be used to communicate extension messages. From previous pilot schemes in Nigeria, it appears that private telecom operators are willing to offer discounted tariffs to support agricultural projects. There is a need to re-examine commercial information and communication technology in Nigeria with a view to forming public–private partnerships in agricultural extension. Some ideas for new communication tools are given below.

Box 6.1 Actions for capacity building

Extension services:

- An audit of extension services, followed by a training needs analysis to determine the knowledge gaps with specific reference to climate change.
- Mainstreaming adaptation to climate into regular agricultural extension and advisory services, including farm broadcasts (radio and television programmes).
- Research and higher education institutions:
- Strengthen and properly fund REFILS.
- Organize training by commodities and better characterize agricultural technologies so their suitability and resilience can be assessed before putting a foot in the field. These initiatives will not only save Nigeria resources, they will also cut the time lag between needs assessment, technology development and its adoption by farmers.
- Reassess the curricula of universities and other higher education institutions to make climate change a compulsory subject, like English, for all students.
- Start an open electronic forum to sensitize, mobilize and discuss the best global practices in climate- resilient agriculture.
- Revive the FFS approach and integrate climate- resilient technologies into FFS activities.
- Farmers, farmers' associations and community organizations:
- Promote farmer field schools.
- Sensitize communities and mobilize community groups through media campaigns on climate- resilient agriculture.

Toll-free helpline

This service is used extensively in India and could be introduced in Nigeria. The Nigerian extension service currently operates a mobile phone-based agricultural question and answer service with nine research institutes across the country. The primary objective is to provide useful information on demand to farmers and other stakeholders. In 2010, the extension service began negotiations with Nokia to produce customized phones with agricultural extension message features

Box 6.2 Planting date and maize-management forecasting

Farmers in Bauchi, Jigawa, Kaduna, Kano, Lagos, Oyo and Sokoto states experience a high incidence of crop failure when dry spells follow the planting season. This problem led to the initiation of a pilot project on reliable forecasting for safe planting windows, which was tested with farming communities, extension services and the Department of Crop Production in state and federal universities. In Kaduna and Oyo, maize and cowpea farmers perceived that the performance of their crops was better when they planted according to the forecast than when they used traditional methods. The millet and cowpea farmers in Jigawa, Kano and Sokoto who did not realize the value of the forecast replanted millet three or four times. Cowpea farmers in Bauchi lost crops planted very early and early before the window.

In Bauchi state, a situational analysis showed that, even with favourable rainfall, farmers were not taking advantage of it when selecting the best time to plant their maize. A project by Global Climate Technology Development (GCTD), a Florida-based initiative, used seasonal and within-season rainfall prediction to help farmers increase their yields by selecting the best time to plant their maize, along with when and how much fertilizer to apply.

The project trained management and field staff from the local agricultural development programme as well as extension agents in preparing a rainfall forecast for each year and advising farmers on the best management practices for the production of maize. Once the seasonal rainfall forecast was provided (around February), farmers, extension agents and researchers participated in a joint assessment of best management practices for maize using a virtual simulation tool developed by GCTD using historical field data. The tool has been widely tested and allows stakeholders to assess the benefits and risks of a range of maize production decisions, including variety, sowing density, fertilizer amount and timing, and sowing date. Once agreed upon, extension services promote these decisions to farming communities, resulting in increases in maize yield in participating communities. Staff from the Bauchi programme regularly appeared on local radio, where they answered farmers' questions and explained the benefits of forecasting.

Source: Jagtap (2008)

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built in. The service should be upgraded into a sustainable web- and mobile phone-based farming helpline to serve as an advisory platform for value-chain partners with an automated response and real-person option. The system should be programmed in all major languages in the country, including English, Pidgin, Hausa, Igbo and Yoruba, and the service should be free of charge, with a maximum 24-hour response time.

Multipurpose community telecentres

These are shared information and communication facilities for people in rural and isolated areas. The services they offer usually cover telephone, fax, typing, photocopying and printing, as well as training in the use of computers, email and electronic networking. Telecentres are operating on a pilot basis in several East and southern African countries at present. Under the ATA, such centres should be repackaged to offer youth employment and much-needed communication support to staple crops processing zones, the NARS, colleges of agriculture, adopted or model villages and major agricultural production areas.

Climate change electronic forum

An E-forum for climate change would be useful to solicit inputs and suggestions from within the country and globally. It would bring together practitioners, extension and advisory services, academics, the media and policymakers to share information, best practices and experience on issues related to climate change. The objective of such a forum is to explore, discuss and pool information on climate change issues affecting sub-regions and various subsectors within Nigeria and to develop site- and issue-specific innovations. The design of such a forum needs to promote strategic discussion on how vulnerable populations can cope with and adapt to climate change, and the role of local institutions in enhancing

their capacity to adapt. The E-forum will also need to provide a repository of knowledge, and a platform for exchange of information on news, events, publications, workshops and conferences.

Farmer-to-farmer extension

In the absence of effective government extension services, there is a need to strengthen and empower communities to fill the gap in climate-resilient agricultural knowledge transfer, making it more relevant and demand-driven. A farmer-based programme to support the scaling up of climate- resilient agriculture would complement better government service. Giving farmers more responsibility will make agricultural extension programmes more sensitive to local conditions, as well as more accountable, effective and sustainable. The proposal calls for an approach that is based on farmer-to-farmer learning and exchange using the lead farmer approach, in which successful, innovative farmers who are trusted by other community members are given incentives to act as role models or hubs of research, exposure and learning. Lead farmers also serve as platforms for aggregation of services, technology, inputs and products, thus enabling the adoption and maintenance of climate- resilient practices on smallholder farms. The hope is that, by learning from their peers and by taking a hand in the collection and distribution of agricultural information, smallholder farmers will become the centre of climate-resilient agriculture.

Proactive agricultural extension and rural advisory services

More than 70% of Nigerians live in rural areas, and their main source of information comes from agricultural extension services. Their information requirements include technical knowledge and involve facilitation, brokering and coaching on improved market access, dealing with changing patterns of risk and protecting the environment. However, current extension systems are generally not very systematic and reflect the diverse priorities and responsibilities of the wide range of public, private and civil society organizations that currently offer advice and information. In fact, some of these providers would not even classify themselves as extension but rather as community developers, innovation brokers and natural resource planners. However, they are all linked by a primary focus on providing advice. Better links and coordination among them and with the government extension service would be of benefit.

Box 6.3 Participatory weather forecasting: Lessons from Ghana

Farmers in Ghana's Upper West Region routinely fall victim to unreliable rainfall. In response, they practice low-input conservative agriculture to deal with weather risks, but this means they miss out in favourable weather situations. Farmers traditionally use local rainfall forecast methods, but these are increasingly failing.

Convinced that seasonal rainfall forecasting for West Africa has improved to the point that forecasts may be of value to farmers, Mr Emmanuel Eledi, the Wa District Director, and his extension team embarked on a five-year project that ended in 2008. They worked with GCTD to train extension staff in the use of seasonal rainfall predictions as a basis for advising smallholder groundnut farmers on crop care.

Farmers in Nigeria's Upper West Region do not usually plant groundnut after June; however, when provided with advice and weather forecasting, they were able to plant a June crop

Using historical long-term daily weather data and *El Niño* southern oscillation predictions, the team predicted the incidence of monthly rainfall, rainy days and drought. Portable rain gauges were installed and monitored daily to check the forecast accuracy. Every village-based extension agent was provided with a hand-held daily rain forecaster and asked to use it to advise farmers on whether they should apply fertilizer, spray their crops or irrigate. Working in joint sessions with lead farmers, a crop calendar was drawn up. This was distributed to all extension agents and communities and was well received. The farmers normally never plant groundnut after June, but those who did so harvested a bumper crop.

Since extension staff were involved in the development, thinking and analysis of the cause and effects of rainfall variability, their confidence and

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skills in computer analysis and weather forecasting was enhanced. The farmers were encouraged to learn from their own activities, try new things, review available solutions and adapt them. In doing so, they gained both theoretical and practical knowledge on the development of annual crop calendars.

The experience demonstrated that weather forecasting was useful to farmers in the hunger hotspots of the Upper West Region, which has a high risk of drought and flood. The approach has now been extended to the entire northern region. This case study clearly shows that participatory approaches with farmers can make considerable gains in delivering useful climate and weather forecasts and information to benefit farming decisions, particularly in regions subject to high levels of climate variability. Similar successful farm management decision-making undertaken through appropriate targeting of forecast information is already providing substantial benefits in other countries and regions, especially in Argentina, Australia, Brazil, India, southern Africa and parts of the USA. The challenge remains in linking the science of weather and climate forecasting to the wide range of farming industries and regions not yet addressed.

Source: Jagtap (2008)

6.5 Forums for Sharing Information on Climate-Resilient Agriculture

The following are suggestions for creating platforms to share information on climate-resilient agriculture.

1. Regularly organize a national agricultural risk management event to engage producers, extension agents, researchers and policymakers in evaluating and learning how adaptation, emerging technologies and management alternatives can reduce climate-related risks and increase resource-use efficiency. Producers, each representing one of the adaptation strategies, could discuss the benefits and limitations of the featured technologies. The purpose of this event would be to share and compare experiences from different sectors and to identify the most promising agricultural management practices for adapting to climate change. Participants would also discuss barriers and opportunities that affect uptake of these risk-reduction technologies, along with implications for policy incentives.
2. Organize zonal climate extension and farmer mentor workshops that bring together extension agents and emerging young farmers in Nigeria, with the aim of facilitating knowledge transmission between generations and sharing strategies to manage agricultural risks and ensure climate resilience.
3. Establish a competitively funded climate information and technology support group to develop a weather and climate decision toolkit for farmers. Information technology groups will be responsible for conducting hands-on workshops with producers to build knowledge and develop skills to reduce climate-related risks. These groups should also develop presentations and short courses for farmers and extension agents on the use of climate information for managing various commodities and commodity-specific pests and diseases. This would provide extension professionals with tools and ideas for engaging farmers in climate-related discussions.
4. Organize roving seminars for schoolteachers to build their capacity in delivering educational programmes to increase youth literacy on weather and climate issues, including climate change impact and adaptation in the agriculture sector. The Global Learning and Observations to Benefit the Environment programme[1] is an internationals, hands-on, primary and secondary school-based science and education programme. Nigeria participates through the Federal Ministry of Education, and more than 80 schools are currently involved.
5. Organize regional workshops on the topic of coping with and adapting to climate variability in agriculture. The focus audience for this workshop would be extension agents, extension advisors, crop consultants and researchers from universities and agricultural research institutes.

Another objective is to set up a national portal for climate data, exploring capability and tools for calculating a variety of indices such as drought intensity, soil moisture availability, growing temperatures, etc. This portal could also provide forecasts for a variety of time scales. It is important to note, however, that all capacity-building activities, such as training for stakeholders and a staff audit and training needs assessment, as well as implementation of REFILS activities and FFSs, require funds to support agricultural development programmes, research institutes and the national network of agricultural weather stations.

1 See: www.globe.gov

6.6 Summary of Priorities, Recommendations and Actions

The success of climate- resilient agriculture in Nigeria will be determined by the ability of extension services to deliver site-specific climate-responsive technologies to farmers. Building their capacity to assess what farmers need and to offer timely, tailored solutions is pivotal. Problem recognition, response formulation and proactive preparation are the first steps, and will be iterative as our knowledge expands and new interactions and effects manifest themselves. Table 6.2 summarizes the priority actions.

Table 6.2 Priority recommendations

SHORT- AND MEDIUM-TERM PRIORITIES	LEAD AGENCY/AGENCIES	EXPECTED OUTCOMES
Train researchers and extension personnel on crop–climate decision tools to assess vulnerability and adaptation options for all sectors of Nigerian agriculture	The ARCN and the FMARD	Identification of priority action plans, technologies to focus on, and budget allocation
Assess whether Nigeria has on-the-shelf technologies for response formulation to reduce vulnerability and deliver on adaptation options	The ARCN and the FMARD	Allocate technology research and development tasks to institutions
Proactively develop extension messages tailored to seasonal weather forecasts	The ARCN and the FMARD, with consultants	Ability to tailor location-specific solutions to buffer risks of climate variability
Incorporate information and communications technology into the delivery of knowledge-driven solutions	The FMARD, private sector, telecom service providers, with consultants	Demand-driven solutions for stakeholders
Build capacity at all levels, including curriculum development across the NARS, farmers' organizations and policymakers	The FMARD, farmers' organizations, Nigerian extension service, the ARCN, the NARS, universities	Long-term, iterative research and extension linkages that sustain the adaptive capacity of the agriculture sector

6.7 References

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7

Policy Support for Agricultural Resilience

7.1 Introduction

This chapter proposes actions that can be taken by government, the private sector, NGOs and CBOs to expedite the shift to climate-resilient agriculture. Such actions must be underpinned by policies and backed by legislation, including the revision of existing laws and regulations, and the creation of new institutions, as needed.

The FMARD is already working to improve the resilience of agriculture against the effects of climate change by improving agro-meteorological services, diversifying agricultural practices, improving links in agricultural value chains, enhancing social protection and microfinance, and preparing for disasters. It will also be important to minimize or eliminate aspects of agricultural policies that will exacerbate the adverse impacts of climate change.

7.2 Ongoing Policies for Climate-Resilient Agriculture

Nigeria embarked on a major transformation of its agriculture sector with the launch of the ATA in 2011. The main goal is to add 20 million tonnes of food to the domestic supply and to create 3.5 million jobs by 2015. This means accelerating the production of local food staples, reducing dependence on food imports and turning Nigeria into a net exporter of food. Nigeria no longer considers agriculture as a development programme, but as a business that can generate wealth for millions of people. The first step is to enhance resilience and so ensure food security. Box 7.1 describes the ongoing policy measures for improving resilience in the agriculture sector.

7.3 Strengthening Development Initiatives

Improving agro-meteorological services

Planning for climate-change-related agro-ecological risks must be based on reliable weather information. Agro-meteorological services provide information on weather events and advisory services on adaptation and cropping systems. Weather data can be related to

Box 7.1 Policy areas for improving resilience

The Honourable Minister of Agriculture, Dr Akinwumi Adesina, has outlined six policy areas for improving the resilience of agriculture.

1. **Affordable inputs.** Nigeria now has a database of farmers, with 14.5 million registered as of December 2014. Within 120 days of the launch of the database programme, 1.2 million farmers received vouchers to purchase subsidized seeds and fertilizers through their mobile phones as part of the Growth Enhancement Scheme. In 2014, 7 million farmers participated in the scheme; this has not only successfully reached farmers, but also stimulated wider markets for agricultural inputs and agricultural productivity. At the same time, food production had risen by 21 million tonnes in December 2014.
2. **Financial services.** The Central Bank of Nigeria has established a US$350 million risk-sharing facility to reduce the risk of lending to farmers and agribusinesses. The facility will leverage US$3.5 billion of lending from banks to agriculture. It will also reduce interest rates paid by farmers from 18% to 8%. The Federal Government is also recapitalizing the Bank of Agriculture to lend at single digit interest rates to farmers. Financial services include weather index-based insurance schemes. Because many farmers will not be able to afford the cost of insurance premiums, subsidies will be provided to support them and reduce the high fixed cost of insurance products. Area-based flood insurance schemes will be established in areas prone to floods.
3. **Enhanced capacity for prediction and assessment.** The capacity to predict shocks and thereby manage risk is being built by deploying satellite imagery and remote-sensing tools to assess the effects of climatic shocks on food production. When the country experienced a major flood in September 2012 – the worst in decades – many asked for a state of emergency to be declared. The Minister knew the situation was serious, but considered it to be less devastating than the picture being painted by the public. In partnership with the International Water Management Institute, satellite imagery and remote sensing tools were deployed to

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determine the extent of flooding across the country. Estimates showed that no more than 1.4 million ha of land were inundated and only 467,000 ha of land were expected to suffer crop loss. This represented only 1.17% of the total cultivated area.

4. **Food security.** Policies have been put in place to encourage the cultivation of drought-tolerant crops (cassava and sorghum) and to develop markets for them to enhance resilience in food systems. A major effort was launched to turn Nigeria into the largest processor of cassava and sorghum in the world. Fiscal policies are being used to encourage the production of high-quality cassava flour to replace some of the wheat imported for bread and confectionary, as well as for the production of starch, dried cassava chips for export, and high-fructose cassava syrup for sweeteners, sorbitol and ethanol. Cassava bread, made from 20% cassava flour and 80% wheat flour, is on the market in Nigeria, and is cheaper than 100% wheat flour bread. This will put over US$1 billion back into the pockets of cassava farmers and processors.
5. **Water management.** With more frequent and intense floods and droughts expected, there is a need to improve water management, including water use efficiency. The amount of arable land under irrigation in Africa is low at less than 3%, compared to close to 50% in Asia. Targeted policies will be put in place for better agricultural water management, including subsidies for motorized pumps (especially for women farmers), financing the leasing of irrigation equipment, community loans for the management of watersheds, establishing youth-led irrigation service providers, and subsidies for alternative energy in rural areas to allow the powering of motorized pumps.
6. **Social safety nets.** Policies to reduce vulnerability cover conditional cash transfers, school feeding programmes and nutritional interventions. The 'Saving one million lives' initiative targets community management of acute malnutrition and integrated child feeding to reduce undernutrition. Already, 200,000 severely malnourished children are receiving care. Nigeria released three pro-vitamin A cassava varieties in partnership with the International Institute of Tropical Agriculture, the Global Alliance for Improved Nutrition and the Bill & Melinda Gates Foundation. In partnership with the International Potato Center, Nigeria is promoting orange-fleshed sweet potato (which is rich in beta carotene), with the goal of reaching 1 million households by 2015. Policies are also needed to promote improved farm-level storage systems to reduce high post-harvest loses in the food supply system. Regional food reserves should also be supported. In 2012, for example, Nigeria contributed 32,000 million tonnes of grain to support the Republic of Niger in addressing its food shortage.

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POLICY OPTIONS

Institutional policy structures should ensure:

- **participatory planning of demand-driven programmes on decentralized weather forecasting, along with information dissemination to different AEZs in Nigeria**
- **an enabling environment and infrastructures for reliable weather data management and forecasting**
- **stronger institutional links between meteorological stations and the agriculture sector, with reliable weather forecasting disseminated through suitable outreach programmes to smallholder farmers; electronic forecasts that use mobile technology could be explored as a means of reaching the more remote rural areas**
- **greater focus on research and development of crop varieties and management practices adapted to extreme weather events**
- **the creation of free and easily accessible weather banks or a national database that research staff can use in assessing and predicting climate-related impacts on agriculture.**

typical land uses in different agro-ecological zones of the country to help tactical and logistical planning for climate change adaptation. There is an urgent need to improve agro-meteorological services in developing countries, since farmers are currently not well informed and have little capacity to cope with and recover from the effects of climate variability.

Although education campaigns are currently in place to inform farming communities of the likely impacts of climate change and the need to adapt or cope

under such occurrences, preparedness remains a key area of concern. In an agrarian country like Nigeria, an ideal way to cope with climate variability is to develop strategic plans that can be implemented at multiple spatial and temporal scales. Agro-meteorological advisory services are an important part of such a strategy. For example, in India an advisory board of the Climate Change Division provides information to farmers on crop management options appropriate to the prevailing weather conditions (Govind and Stigter, 2010**;** Government of India, 2012; CAK, 2013).

A meteorological service focused on climatic variation needs to work closely with the NARS. There is a need for synchronized and automatic weather collection systems across the different agro-ecological zones of the country to guarantee high data resolution. Furthermore, reliable data processing will allow for a systematic presentation of spatial and temporal weather variability and mapping of vulnerable areas (BNRCC, 2011).

Changes in agricultural practices

Agriculture in Nigeria is mostly rain-fed and is therefore highly vulnerable to the impacts of a changing climate. Farmers will need to adapt to climate change by introducing new technologies that produce adequate yields even in the face of changing climatic and weather conditions. Given that shorter rainy seasons and increasing rainfall variability are predicted, it is prudent to consider specific adaptation strategies for different farming systems. Two fundamental approaches to effective climate change adaptation are crop diversification and selection of high-yielding crop varieties, including stress-tolerant and short-duration crop varieties. Farming practices that are consistent with the principles of sustainable land management will deliver higher yields and enhance resilience to climate variability.

Farmers manage their farms within a multi-risk context. They therefore adopt strategies that are informed by their socio-ecological context, their economic priorities and the various options available to them, with the aim of maximizing the current conditions (Wiesmann et al., 2011). However, adaptation actions cannot always be associated directly with climatic triggers; their utility depends on the extent to which farmers can incorporate them into their strategies. The context therefore needs to be considered when promoting adaptation actions and attributing impacts to climate variability and climate change. Box 7.2 highlights an example of agricultural technology that has enhanced farmers' adaptive capacity.

ACTIONS AND POLICY OPTIONS

In rain-fed agriculture, practices to adapt could include:

- **Shift the sowing or planting date (one month earlier or later than the traditional date) based on access to improved weather forecasts.**
- **Encourage conservation or organic agriculture, including management of manure and residues.**
- **Use inorganic fertilizers, with applications tied to weather forecasts.**
- **Enhance rainwater harvesting.**
- **Conserve feed in the form of hay, haylage, crop residue processing and conservation.**
- **Inform pastoralists about feed conservation.**
- **Reseed all federal documented grazing reserves; 600 ha have already been reseeded in Udubo Grazing Reserve in Bauchi State.**
- **Develop stock routes and watering points.**

Policy options:

- **Create a policy framework to support capacity building in extension services.**
- **Expand irrigated agriculture in water-deficient zones and best-practice water management for the whole country.**
- **Make policies to create an enabling environment for accessibility of funds at low interest rates.**
- **Provide economic incentives and transitional programmes for the short term.**

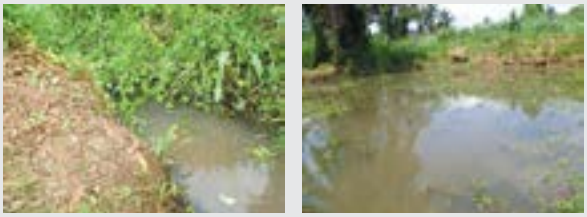
Agricultural diversification

Agricultural diversification is the reallocation of some of a farm's productive resources (land, capital, farm equipment, paid labour, etc.) into new activities. This redistributes farmers' risk in the face of climate variability and price fluctuations, as well as generating additional income. Diversification in agriculture can mean: a shift from farm to non-farm activities; a shift from a less profitable crop (or enterprise) to a more profitable crop (or enterprise); or using resources in diverse but complementary activities.

Box 7.2 Micro check dams for water harvesting on seasonal streams

In many watersheds in Nigeria, seasonal, small-capacity streams and rivers are often ignored as a source of water for agriculture. However, with adequate water harvesting systems, the yield or discharge of such streams can be harnessed as a useful water source at low cost and with minimal technological skills. To meet this need, the Institute of Agricultural Research and Training (IAR&T) developed the micro check dam for water harvesting and storage. This makes water available to farmers for supplemental irrigation or for total irrigated agriculture during the dry season. The stored water can also be used for livestock during the dry season.

A micro check dam is a small embankment structure built or placed across a stream or small river to retain and store run-off within a pond excavated for that purpose. This simple technology has been implemented at numerous sites in southwest Nigeria with the assistance of IAR&T hydrologists and engineers. The water conservation benefits are clear, and farmers testify that micro check dams assist them greatly, particularly during extended breaks in rainfall during the rainy season.



(a) (b)

A small stream (a) before and (b) after the construction of a micro check dam.

Source: IAR&T (no date)

Examples of agricultural diversification in Nigeria include:

- a shift in the cropping system, for example towards high-value commodities like vegetables or more drought-tolerant crops
- mixed farming systems such as crop–livestock and agroforestry
- on-farm food processing
- non-farming activities and rural jobs, such as retail shops
- expansion of aquaculture through cage culture fish farming, etc.
- exploitation of under-used fish resources in the Nigerian offshore waters
- production of non-traditional crops within an existing market.

Crop diversification and genetic diversity help mitigate such climate risks as unpredictable dry spells and flash floods. A mixed farming system can exploit crop/tree/livestock synergies to increase livelihood options and incomes while enriching and buffering water and nutrient supplies, protecting soils and moderating microclimates.

Diversification also includes the reclamation of degraded lands by, for example, using an adapted agroforestry system with high-value annual crops like okras and drought-tolerant trees or bushes or oil-producing crops, and techniques of water and soil conservation.

Introduction of grain legumes leads to better soil and pest management. Incorporating nitrogen-fixing legumes through rotation or intercropping with dryland cereals improves soil fertility, reduces nutrient mining, can help trap pests and could lead to a more diversified diet and better household nutrition.

Agricultural diversification must be achieved within the principle of green growth; i.e., fostering economic growth and development while ensuring that natural ecosystems continue to provide the resources and environmental services on which people depend. Box 7.3 describes an example of agricultural diversification through innovative strategies in aquaculture.

POLICY OPTIONS

- **Research is crucial for successful agricultural diversification and, as such, policy that supports research for innovative methods/technologies should be promoted.**
- **Policy that creates an enabling environment for accessibility of funds at low interest rates would promote agricultural diversification.**

Box 7.3 Agricultural diversification through innovative strategies in aquaculture

Nigeria requires about 2.66 million tonnes of fish annually to meet its needs. The domestic supply of fish from capture and aquaculture is only about 0.6 million tonnes, so there is a deficit of over 2 million tonnes annually. However, the natural lakes that contribute to fish supply in the country are drying up following a 20-year period of below-average rainfall. Nigeria imports fish to address the shortfall, at huge financial cost. Aquaculture will have to be stepped up to address food security and also provide alternative livelihood options for rural farmers. Current government policy is to gradually reduce fish imports while increasing fish production. This could easily be achieved if tested low-level technology is applied in aquaculture. The cage culture system of farming has been tested and earlier government intervention projects have been successful in Lagos and Bauchi States, where a programme encompassing the supply of equipment, capacity building, supply of seeds and feeds was fully implemented.

Cage culture could maintain climate change neutrality as its impacts are low, especially when technology is applied and managed. Earlier cage intervention used a 2 m x 3 m x 1.5 m (9 m^3) cage, which can rear three cycles of fish annually, providing up to a tonne of fish per cycle. In Lagos, four cycles are achievable, showing that the system could meet the national goal of self-sufficiency in fish. A national goal of 1 million cages over five years across the country could be set, which would give a minimum of 2 million tonnes of fish beyond what is being produced presently. The concept of agricultural fish farming estates, with large-scale earth ponds and tank production systems, should be considered for land-based aquaculture where facilities can be provided centrally or smaller-scale facilities interconnected within a location.

Source: H.A. Fashina-Bombata, Department of Fisheries College of Agriculture, Lagos State University, Lagos, Nigeria.

Water management

Better water management is a major option for improving low-yielding smallholder farming systems in sub-Saharan Africa, particularly in the face of climate change. Its importance has been highlighted in Nigeria since the severe drought of 1973. Crop and livestock productivity can be improved using rainwater, surface water and groundwater. Agricultural water management systems can be classified into several categories:

- Soil and water conservation
- Run-off harvesting and management
- On-farm storage for supplementary irrigation
- Run-off diversion and spreading
- Spate irrigation
- Wetlands farming in valley bottoms or flood recession cultivation (e.g., *fadama*, land drainage interventions)
- Stream diversion for smallholder irrigation, using either gravity or pumps
- Various irrigation technologies (low-head drip, sprinkler, furrow and basin, micro systems)
- Soil management and fertility improvement
- Conservation agriculture (conservation tillage, crop residue management, agroforestry, etc.).

Managing water for agriculture means improving water use efficiency through careful planning, monitoring, harvesting, distribution and use of water to achieve maximum yield and productivity, while providing sufficient water for domestic use and maintaining the sustainability of the water source.

There is considerable potential to increase the area under irrigation in Nigeria and thereby increase the productivity of key crops, including cereals, cowpea and high-value horticultural crops. However, efforts towards increased irrigation also need to provide for groundwater recharge and to guard against over-use of irrigation and the related threat of soil salinity.

A survey by the Japan International Cooperation Agency (JICA, 1993) suggests that 39% of the country's land mass is potentially suitable for agriculture. Out of this, between 4.0 million and 4.5 million ha (approximately 4.5–5.0% of the land) are judged suitable for irrigated agriculture, but only about 1 million ha is currently irrigated in Nigeria. By contrast, India irrigates nearly 45 times as much land.

Statistics from the FMWR indicate that, of the 323 dams in Nigeria, 106 are large dams (with walls higher than 15 m, or 10–15 m high with a crest length of over 500 m, or having a reservoir capacity of 1 million m^3); 27 are medium-sized dams (with walls 8–10 m high); and 192 are small dams (walls less than 8 m). Since big dams are expensive, take a long time to deploy, and provoke environmental problems, low-technology and low-cost small dams based on indigenous water conservation and retention strategies should be preferred. Box 7.4 describes a run-off water harvesting technology. An excellent example of the use of dams to spur and sustain agricultural development in Nigeria is the Kano River Irrigation Project. However, such projects should always be part of a whole basin development in order to take adequate care of downstream effects.

The preferred approach is to determine the water needs of agriculture under different climate scenarios and the characteristics and extent of these water requirements. The water could be sourced from above or below ground. Surface and subsurface water must be monitored, measured and managed to meet the nation's agricultural needs. This is to be done in collaboration with the FMWR.

Box 7.4 Run-off water harvesting and soil moisture retention technology

The mean annual rainfall in the country varies from 2500 mm/year in the southern parts of the country to 500 mm/year in the north. The seasonal rainfall in the far north of the country is usually of short duration but high intensity, resulting in high run-off. Since amounts of rainfall are inadequate to begin with, it is critical to ensure that run-off water is harvested, stored and used to augment rainwater for both crop and livestock farming.

This study describes a technology designed to cushion the effects of drought in the arid and semi-arid areas of Nigeria. Run-off water harvesting involves the construction of an earth pond on a permanent drainage site. The size of the pond is site-specific and determined according to the crop–water requirement. Outlet drains are constructed to link with the main drain to carry run-off water into the pond through an inlet structure. An earthen embankment, well compacted and sown with grass to prevent erosion, is built around the pond. When the pond is full, excess water is discharged through an outlet structure or spillway. The embankment is about 1.5 m high from the ground level. Water storage capacity depends on size, soil conditions and other environmental factors.

In 1992, the FMARD, through the Federal Departure of Agricultural Land Resources, designed and constructed a prototype of the run-off water harvesting structure at Damagun in Yobe State. More than 20 years later, the technology is still functioning and benefitting local farmers. In 2006, through the Millennium Development Goals, the Ministry was able to undertake the construction of 16 additional run-off water harvesting structures spread across Yobe, Jigawa and Sokoto States at a cost of 500 million Naira. The main beneficiaries of this project are farmers, pastoralists and the local communities in the vicinity of the project. Successful implementation requires collaboration and coordination between the FMARD, state governments, local agricultural development projects and local governments. The role of local governments includes providing sites, security and maintenance of the run-off structures upon completion of the project.

The run-off water harvesting technology has been shown to be a relatively inexpensive way to reduce the vulnerability of farmers to rainfall variability in the 'drought frontline' states (Adamawa, Bauchi, Borno, Gombe, Kano, Katsina, Kebbi, Jigawa, Sokoto Yobe and Zamfara). It should be an important component of the strategies for achieving agricultural resilience in the drier AEZs of the country.

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ACTIONS AND POLICY OPTIONS

Actions to address priority risks:

- **Increase the area of cultivated land under irrigation.**
- **Promote indigenous practices for sustainable water use in agriculture.**
- **Intensify water resource conservation campaigns and practice, to reach out to the farming communities through the newly established Extension Department of the FMARD, with strong support from the FMWR.**
- **Reduce water used in irrigation by changing the cropping calendar, crop mix, irrigation method and areas cultivated.**
- **Cooperate and work with the Federal Ministry of Environment in getting the National Strategic Action Plan implemented, especially the National Drought Preparedness Action Plan and corresponding flood control plans.**

Policy options:

- **Set up an agricultural water management committee at the ministerial level between the FMARD and the FMWR to ensure effective coordination of programmes and activities designed for optimal water usage in the agriculture sector.**
- **Revisit the current statute of the river basin authorities to restore active food production roles as originally envisaged and practised.**
- **Explore options for cost sharing between government and farmers to ensure that infrastructure is maintained and ownership by farmers increased.**

Risk management and agricultural insurance

Climate-related risks faced by agricultural businesses include flooding (direct damage to assets and indirect damage via supply chain disruption), storms, heat waves, threats to water availability, pest invasion, crop failures, eutrophication, fish kills and mass livestock deaths. Governments and lending facilities in some countries have established index-based insurance programmes to create insurance or safeguarding systems against disasters. According to IFPRI (2009), "index-based insurance can serve as a buffer against climate extremes and provide the necessary support system for farmers to navigate an uncertain climatic future and avoid financial ruin".

For Nigeria, an effective insurance system should:

- be affordable and accessible to all rural people
- compensate for income losses to protect consumption and debt repayment capacity
- be practical to implement, given potential limits on data availability
- be suitable for provision by the private sector with few or no government subsidies
- avoid the problems of moral hazard and adverse selection.

A weather-based index can be successful, provided that the data forming the index are reliable, ongoing and replete with a continuous record. The challenge is to assure that the index sufficiently encompasses the actual losses for a particular farmer or farmers' cooperative. Much work remains to be done to develop the necessary techniques and practices to address the future challenges in index insurance. Nevertheless, index insurance provides a safety net for farmers and protection against climate shocks.

Because insurance prices and policies can be updated, insurance could be an important tool for adaptation. In the short term, it can allow increased accumulation of wealth that smallholder farmers can use in successful financial transitions. By representing climate change in updated insurance pricing, incentives can be made available to manage worthwhile risks while transitioning out of activities that become unfeasible as climate change unfolds.

There is a high potential for growth in risk management in this country. The Risk and Insurance Managers Society of Nigeria has advised government and corporate bodies to initiate proactive measures to deal with climate change as the world's weather is becoming more extreme. The National Agriculture Insurance Company (NAIC) is currently evaluating options for introducing weather index-based insurance in Nigeria.

During the ACARN Town Hall meeting with banking and insurance stakeholders held on 23 September 2013 in Abuja, senior officials of NAIC referred to a report by a consultant commissioned by NAIC to study the feasibility of weather index-based crop insurance. The consultant advised against such undertaking because it was primarily designed for situations of monocropping, whereas Nigerian agriculture is composed mostly of mixed cropping. Concerns about the adequacy of meteorological information available in the country were also raised in the report. The recommendations of the consultant

notwithstanding, NAIC indicated interest in going forward with a limited scope project to demonstrate the feasibility of weather index-based crop insurance in the country.

The Micro-Ensure programme, which can be a model for Nigeria, introduced one of Africa's first weather index-based crop insurance schemes during the 2005/06 growing season as a pilot in Malawi. This product provided protection against crop failure caused by drought or excess rain, and enabled farmers to access credit in order to purchase quality seeds and fertilizers to maximize output. By linking farms to local weather stations and introducing an automatic payout process, farmers were not required to file a claim or go through an expensive loss-verification process in the event of crop failure. Following the success of this pilot scheme, weather index-based crop insurance was extended to cover farmers in Rwanda and Tanzania as well as in India and the Philippines.

POLICY OPTIONS

- **Institute a policy framework is crucial for incorporating risk management and agricultural insurance for climate change adaptation. The policy would incorporate disaster-planning responses into governance. Risk transfer/financial management of natural disaster insurance and other anti-risk financing mechanisms form a critical part of a comprehensive disaster risk management strategy, and have the potential to play an important role in disaster risk reduction and climate change adaptation.**
- **Liberalize the agricultural insurance market – a policy that was unanimously endorsed during the Town Hall Meetings. Private sector involvement will introduce competition, afford choice, lower premiums, etc.**
- **Create favourable economic incentives and policies to encourage entry of non-governmental financial sectors into agricultural markets to provide long-term credit and innovative insurance products.**
- **Engage civil society groups in participatory forums to address their vulnerability and identify adaptations to climate impacts.**
- **Examine existing laws and regulations for opportunities to improve governance and resilience to climate variables.**

Secure property rights

Farmers in Nigeria tend to be landless tenants and/or to have small farms, with an average holding of less than the 1.5 ha average for smallholders in sub-Saharan Africa. In the rare cases where they own land, it is often marginal land without irrigation. They are generally unable to improve their land because of lack of income and access to credit or lack of incentive due to the precarious nature of land ownership.

During the Town Hall meetings, the ACARN found the issue of land ownership and land tenure to be quite emotional. Although land would seem to be abundant in Nigeria, given the vast tracts of uncultivated land, the customary systems of land ownership mean that farmers feel landless. A survey by JICA (1993) showed that at least 39% of Nigeria's land mass is suitable for agriculture. The fact that the farmers work the land as tenants means that they usually pay rent with part of their harvest, and this sometimes cuts deeply into their profits. Furthermore, the issue of tenancy means that there is very little incentive for farmers to make investments in improving the soil, water and other resources they recognize as essential in adapting to the challenges imposed by the changing climate. There is abundant evidence that the farmers can produce sustainable agricultural systems that will boost food security and lift themselves and their families out of poverty.

From the ensuing exchanges with the farmers, it was clear that the issue of land ownership and land rights have to be resolved equitably to increase agricultural productivity. There is no doubting the conviction of the farmers that the issue of sustainable livelihoods is hinged on the security of ownership or access to land. Discussion on the management of river basins during the Town Hall meetings described a system of land tenure in the 1980s, when the mandate of the river basin authorities included agriculture under which farmers were allocated land almost in perpetuity. Farmers agreed that the system was the next best thing to outright ownership of land and insisted that the long-term and seemingly intractable issue of inequality in land ownership be addressed.

In a submission to the ACARN, a member of the recently formed Presidential Technical Committee on Land Reform, who is also on the staff of the FMARD office that serves as secretariat to this committee, indicated that the mandate of the committee was wide ranging and transcended the question of agricultural lands. The ACARN requested that the member bring this specific issue to the attention of the committee, which he did.

ACTIONS AND POLICY OPTIONS

Actions to address priority risks:

- **The FMARD to liaise with communities and Town Unions towards guaranteeing access to land for rural farmers.**
- **The FMARD agricultural extension staff to negotiate how to offset the rents paid by farmers to landlords, which are cutting into their profits and serving as a drawback to continued engagement on the land.**

Policy options:

- **The Federal Government to reform the Land Use Act, particularly as it concerns agricultural lands.**
- **The Federal Government to enact a more egalitarian Land Rights Act.**

Sustainable land management

Sustainable land management (discussed in Chapter 3) should be regarded as a national development imperative aligned to long-term economic growth, food security and conservation of the nation's resource capital. The FMARD has developed the Nigeria Strategic Investment Framework for Sustainable Land Management (NSIF-SLM). This aims to guide investment-based development of the nation's land and renewable natural resources, with an emphasis on reducing the risk posed by climate change to the livelihoods of local farmers. NSIF-SLM can mitigate climate change through sustainable practices, and secure appropriate benefits in the process, by ensuring the productive use of the nation's natural resources and promoting forest and watershed management as well as the development of the agriculture sector's investment programmes for national food security.

The Framework is organized under five themes:

1. Supporting on-the-ground activities for scaling up sustainable land management.
2. Strengthening the enabling environment (institutional and policy) for sustainable land management.
3. Strengthening commercial services and sustainable livelihood options.
4. Supporting sustainable land management research and dissemination of best technologies.
5. Improving and strengthening knowledge management, monitoring and evaluation, and information dissemination.

The NSIF-SLM has three phases. The first phase focuses on a preliminary investment framework for sustainable land management using Cross River State as a pilot. Phase 2 will expand the process to seven or eight more states, while Phase 3 will up-scale the process to build up to the fully implemented NSIF-SLM for the entire country. The implementation plan and investment framework for the pilot in Cross River State has been completed. Outcomes of the process are highlighted in Box 7.5.

Box 7.5 A pilot strategic investment framework for sustainable land managementin Cross River State

The process and modalities for developing the pilot strategic investment framework for sustainable land management began with a series of small and large meetings with several relevant stakeholders. This fostered the emergence of a broad-based multi-stakeholder coalition for sustainable land management in Cross River State. The stakeholders' efforts were complimented by analytical studies and field data collection informed by geographic information system (GIS)-based assessment to provide the necessary background information for investment planning.

The focal area for interventions in Cross River State, as agreed among stakeholders, includes areas of:

- intensive agricultural activities
- critical watersheds
- prime ecosystems and biodiversity
- ecotourism potential.

Although priority is accorded to these areas in terms of channelling interventions, it was agreed by the stakeholders that this will be best operationalized within the framework of the agro-ecological zones of the state. Recommended interventions are reported for specific themes:

- Support on-the-ground activities.
- Strengthen the policy and Institutional environment for sustainable land management.

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- Strengthen commercial and advisory services for sustainable land management and alternative livelihood options.
- Support sustainable land management research and dissemination of best techniques.
- Improve and strengthen knowledge management, monitoring and evaluation and information dissemination for sustainable land management.

Source: Bisong (2011)

ACTIONS AND POLICY OPTIONS

Priority actions would include:

- **Support sustainable land management research and dissemination of best practices and techniques. This is to promote the creation of additional knowledge to support interventions.**
- **Improve and strengthen sustainable land management knowledge management, monitoring and evaluation and information dissemination. This is aimed at ensuring that knowledge generated is managed and communicated in a user-friendly manner to stakeholders.**
- **Provide support for the rollout and full implementation of the NSIF-SLM.**

Policy options:

- **Make sustainable land management a core agricultural policy.**
- **Adopt the NSIF-SLM as the vehicle for implementing sustainable land management in the agriculture sector.**
- **Invest in sustainable land management research and dissemination.**
- **Improve agricultural extension by providing training on sustainable land management to extension services personnel.**

Agricultural market development

Farmers attending the ACARN Town Hall meetings expressed their concern about the absence of markets and marketing services in support of the government campaign to increase production. Participants complained that, at present, they are forced to sell any surplus they produce at harvest time at low prices. Better market access and information would encourage them to produce more and help to increase their incomes, as well as encouraging more of the youth to make a career in agriculture. At present, market constraints and lack of storage facilities means farmers tend to produce only what they can sell.

In pre-independence Nigeria, markets were well developed, although targeted mostly at the key commodities of cocoa, palm oil, groundnut and rubber. Large private buyers were the dominant players in a market that operated largely on free-market principles, although there was some government involvement in ensuring an enabling environment. The post-independence era saw government take over the operations of the produce marketing boards. Of course, the usual malaise set in and it has been in a free-fall ever since. With the structural adjustment programme of the 1980s, attempts were made under the guidance of the International Monetary Fund to bring back the produce marketing boards, but these attempts were at best tentative, lacked coherence with other policies and, not surprisingly, failed to resolve the issue of market availability.

Farmers at the Town Hall meetings insisted that it was imperative to create new commodity boards operating on free-market lines as a way to guarantee markets and fair prices for their products. Besides the commodity boards for high-value produce, it is important to assure optimal trading conditions in traditional markets. These remain important outlets for both producers and consumers, particularly for rural and peri-urban areas. However, farmers complained about the operations of nefarious middlemen who insist on buying their products at a fixed price. They then re-sell them at inflated prices literally under the noses of the farmers. One sure way out of this naked exploitation is for farmers to form cooperatives or associations. As the cliché goes, there is always strength in numbers. These associations should then be empowered to gain access to formal urban markets and informal markets through deliberate government policies to support the establishment of weekly farmers markets in metropolitan areas.

A recurrent suggestion to improve fair prices in these markets is to address the high perishability of farm produce due to poor storage conditions. Such losses are estimated at 30% globally, but are much higher in developing countries. Humid and variable conditions associated with climate change (such as unseasonable rains close to harvest time) are likely to increase food

storage losses. The Federal Government has reacted positively to this by increasing the number of storage facilities. The plan is to further expand storage facilities across the country with concentrations in known areas of high agricultural production. These facilities will allow farmers to bide their time and take advantage of market dynamics to get the best prices for their produce. In the quest to improve storage, attention must be paid to the incidence of storage diseases linked to climatic conditions (such as aflatoxins on maize and groundnuts) since these can present a risk to human health.

The growth of the supermarket culture in urban and peri-urban areas offers rural farmers opportunities to get good prices for their more perishable produce. However, first, there is a need to improve rural roads to facilitate transportation of goods from the farm to the supermarket. There is a plan by the Ministry of Aviation to improve farmers' access to international markets, particularly for fresh produce like flowers and vegetables, through the establishment of fresh produce storage warehouses at all cargo airports in the country (the 'Aerotropolis' scheme). This has the technical backing of the FMARD and holds great promise for rural farmers in terms of access to international markets and the high profits this could bring. However, road infrastructure linking rural to urban areas must improve for this scheme to realize its potential. Again, attention must be paid to the barriers that prevent low-income countries from attaining their export potentials caused by unfair international trade practices and protectionist regulations.

Market access is a vital link in the value chain for agricultural products and improving market access will put more economic power in the hands of the farmers. Box 7.6 lists overall lessons learned from past efforts to improve market access for farmers.

Environmental policies in support of agricultural resilience

It is important that adaptations to climate change in the agriculture sector take into account the role of the natural environment and that the solutions developed are in harmony with nature. Such an approach will help to retain natural biodiversity, ecosystems and the goods and services that help support economic prosperity. The increasing pace of climate change will place unprecedented pressures on access to and use of natural resources. Nigeria has a range of protected

Box 7.6 Linking farmers to markets: key lessons

Several studies have been conducted over the last five years to document the experience of governments, donors, NGOs and private companies in linking smallholders to markets. While methods differ between them, the overall lessons learned from these studies are remarkably similar on many points, with six key messages.

1. Export markets, especially those for high-value and niche products, are limited, may be excessively demanding and can be high-risk.

   Smallholders face many risks, including illness, pests and diseases and drought. At present, they tend to manage them through their social networks. However, these are not adequate to deal with supplementary marketing risks (e.g., shifts in supply and demand, product perishability, long supply chains, process complexity, uncertainty in government policymaking and practice). Smallholders are therefore encouraged to look first to domestic and regional markets, since these are large, expanding, probably more stable and less demanding on the characteristics of the produce. One recent study (Vorley et al., 2012) argues that, for the vast majority of smallholders in the developing world, links to markets are informal. The authors express concern that paying too much attention to new and more sophisticated chains involving exporters and processors will cause policymakers to lose sight of the importance of informal market links and the fate of smallholders who depend on them.

2. It is important to focus on realizing a good return on investment, whether on farms or in supply chains. Successful links can be made with smallholders, but not necessarily to the very poorest.

3. Small-scale farmers need to form groups to deal with processors, traders and exporters to overcome the high transaction costs associated with dealing with individual producers. One way of making such groups more inclusive may be allowing some members to participate to a lesser degree than others, but with fewer rights. This, of course, breaks with the longstanding principle of cooperatives, in which all members are equal.

   The least successful types of organization are those that are imposed from outside and based on donor-driven criteria (e.g., size, organizational

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rules, membership rules) that do not resonate locally, have limited internal capacity and adhere to broad and ill-defined objectives. More successful results are observed from horizontal organizations that have strict entry requirements and are created by local entrepreneurs to address a specific need (Mitchell and Coles, 2011).

4. While producer organizations can reduce transactions costs and give farmers power when interacting with large firms in the supply chain, caution should be exercised in trying to replace existing private sector functions by collective action; unless, of course, it is clear that the replaced functions are ineffective, inefficient or grossly unfair.

5. Supply chains may be more effective and efficient when some agency acts as a champion, taking the initiative in brokering new arrangements, overseeing changes and resolving problems. This is often a dominant processor, wholesaler or exporter with some degree of market power, but it may be an NGO, government body or donor project.

   Champions often take risks and invest in new arrangements; private sector firms will usually only do this if there is some commensurate reward for the effort, so this will usually only occur when there is a business opportunity. Champions, of course, have some market power, so the challenge is to create conditions that will encourage such initiatives, but without allowing champions to extract undue rents.

6. The final common theme is perhaps the single strongest refrain in these studies: the importance of process in building links, rather than imposing blueprints.

   For all the cases reviewed, there is a striking absence of detailed discussion on these arrangements. Instead, the studies stress the importance of taking time to build links, to be flexible, and to build up local competences and, correspondingly, to not impose models. Whatever arrangements are being developed, those engaged have to build trust between smallholders and others in the chain and have to develop their competences as the arrangements develop. This, in turn, implies that outside agencies, especially those in the public sector, need to take care to not push for too much change too quickly, whatever the temptations of targets and the need to disburse budgets.

Source: Wiggins and Keats (2013).

ACTIONS AND POLICY OPTIONS

Actions to address priority risks:

- **The Federal Government to increase storage facilities to reduce spoilage of farm produce.**
- **Increase the number of processing facilities located close to rural areas to provide value-added schemes.**
- **Encourage rural farmers to form cooperatives or farmer associations to protect their interests and guard against undue exploitation.**

Policy options:

- **Government to improve physical and social infrastructure in rural areas, especially roads linking to urban areas.**
- **Appropriate government agencies to help in regulation of standards to improve export value of produce.**
- **Local governments to enact regulations to ban the activities of corrupt middlemen in traditional markets.**

ACTIONS AND POLICY OPTIONS

Actions to address priority risks:

- **Adopt an ecosystem approach to agricultural adaptation measures and practices.**
- **Prevent encroachment on particularly sensitive areas, both on land and in the sea.**
- **Implement integrated and sustainable approaches to land management, e.g., agroforestry and conservation agriculture that can significantly increase yields while delivering better environmental outcomes. These technologies would also enhance farmers' resilience to climate variability and change.**

Policy options:

- **Enact appropriate laws to create additional forest reserves, marine parks, wildlife refuges, Ramsar wetland sites, etc.**
- **Strengthen laws against environmental degradation, including pollution.**
- **Enact integrated coastal areas management.**

areas, including parks and reserves. These locations provide important protection for fragile environments.

Nigeria's wildlife sites and forest reserves are clearly fragmented and do not represent a coherent and resilient ecological network that is capable of responding to climate change and other pressures. The objective should be to enable these important sites to make the transition in ways that allow them to retain high biodiversity value, thereby enabling them to play a vital nature conservation role. It is important therefore, that in pursuit of intensification of agricultural production for economic growth and national food security, every effort must be made to build environmental conservation into agricultural reforms. The destruction of forests, including mangroves, and the reckless encroachment on sensitive land and marine environments must be halted (Ibe, 2013).

Social protection programmes

When climatic hazards disrupt farmers' livelihoods, access to support in the form of social protection programmes can stop farmers from falling into deep poverty. It is thus important for the Federal Government, through the FMARD, to provide social protection measures to support the functioning of agricultural production in the face of climatic and other livelihood risks, thereby maintaining development.

Several social protection programmes have been established in Nigeria and are at different stages of development and coverage. These include the conditional transfer programme Care of the Poor, launched by the National Poverty Eradication programme, which is small in scope and covers around 12,500 households, and an income transfer programme with links to Brazil for technical assistance (Nino-Zarazua et al., 2010). Hagen-Zanker and Holmes (2012) report that, although not necessarily targeting the poor, labour market programmes including federal- and state-level public works programmes, agricultural subsidies/inputs, and youth skills and employment programmes exist.

Additionally, climate-resilient social protection measures may be directly or indirectly linked to climate change. These measures include de-coupling agricultural production from climatic conditions through adaptation, supporting farmers' organizations, weather index-based crop insurance, payment for environmental services, subsidies, asset restocking and cash transfers (Davies et al., 2009; Hagen-Zanker and Holmes, 2012). Box 7.7 describes some examples of social protection measures related to climate change.

Box 7.7 Social protection measures

Institutionalization of farmers' organizations

Farmers organized in groups (as in the Fadama projects) have greater leverage with the Nigerian public and authorities. They also have reciprocal arrangements among members, such as funds the group can draw upon in times of disasters. The FMARD, together with the Nigerian insurance industry, could explore the possibilities of collective insurance for such groups.

Weather index-based crop insurance

Experience in India, Malawi and the Philippines shows that this is a viable instrument that can be used to protect farm production from climate-related impacts.

Payment for environmental services

Social protection programmes in terms of subsidies may be in conflict with international trade agreements such as those operated by the WTO. However, the FMARD can use the policy window provided by WTO to offer such subsidies. In addition, the FMARD can build on the example of Switzerland to establish an environmental protection programme in which farmers are paid for environmental services to the Nigerian people and, by extension, to the global community. This can be linked to initiatives to promote sustainable land management in Nigeria.

Asset restocking

This approach can be adopted after such extreme climatic events as severe droughts and flooding. In Nigeria this approach could be used to restock the herds of pastoralists or the fingerlings of fish farmers after severe climatic disturbances, or to promote the use of seeds adapted to local environmental conditions, with periodic adjustments to the changing climatic conditions.

Seed fairs and starter packs

Just as the FMARD works with a voucher system for farmers in the Fadama projects to help them access extension services, vouchers can be extended to local input supplies, thereby addressing the danger of undercutting local input markets.

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Cash transfers and promoting agricultural inputs to target groups

This approach can raise incomes of the poor, reduce distress sales and contribute to asset building and local employment (Davies et al., 2009; Hagen-Zanker and Holmes, 2012). However, there is a need to ensure that elite capture by better-off farmers or 'political' (non-)farmers is minimized.

Source: Chinwe Ifejika Speranza (2013)

The role of micro-finance

In 2012, to kick-start its ATA, the FMARD launched the Growth Enhancement Scheme, which provides farm inputs to small-scale farmers. During the ACARN's interaction with farmers in Town Hall meetings in the six geopolitical zones, the scheme was lauded as a revolutionary programme that has raised agricultural production levels in the last growing season. It is obvious, however, that for the concept of agriculture as a business to take hold, farmers will have to get used to paying for inputs from a dominant private sector. Their willingness to invest in inputs is anchored in their expectation that the return at harvest will more than offset the input costs.

The majority of farmers, particularly those starting out for the first time, do not have initial capital to invest, and if they do, they may fear losing their investment should the crop or livestock fail – especially as they have no insurance. This is where the role of micro-finance/credit can make a huge difference. From history, it is clear that government credit schemes made available in the early period of the Green Revolution in Asia proved highly effective in farm situations where high returns on investments could be achieved. More problematic, however, was the provision of credit to farmers where the returns were characteristically low and the risks high. Experience showed that the commercial banks were reluctant to get involved because the numbers of credit seekers were large, the amounts involved were minor and the paperwork was prohibitive. Governments, on the other hand, could not ensure functional micro-finance schemes due to bureaucracy and/or corruption.

The current situation in Nigeria mimics that of the Asian Tiger economies during the Green Revolution. Although previous governments have encouraged the establishment of micro-finance banks to assist small- and medium-scale industries with savings and loans, this initiative has failed to help agriculture, due to a reluctance to work with the rural poor, who often lacked literacy skills. Equally, government institutions like the Agricultural Bank have shown interest only in large-scale farmers and political farmers. Despite expressions of interest from commercial banks during the Town Hall Meetings and activity in the agriculture sector, they have done nothing in real terms to facilitate loans to small-scale farmers, despite favourable policy from the Central Bank of Nigeria in this regard, as inspired by the Minister of Agriculture. Farmers often complained about the exorbitant interest rates.

In the last three decades or so, there have come, mostly from Asia, numerous success stories of the effectiveness of small, locally managed credit schemes, including savings and loan operations, run by NGOs, private banks or farmers' cooperatives. There are many examples of best practices to learn from and many additional lessons in how to forge credible micro-finance facilities. The Grameen Bank founded by Muhammad Yunus in the 1970s in Bangladesh provides another useful model.

ACTIONS AND POLICY OPTIONS

Actions to address priority risks:

- **Encourage the private sector, donors, NGOs/CBOs and farmers' organizations to assist rural agricultural communities to form micro-finance and credit schemes.**
- **Encourage the rural poor to join micro-finance schemes.**

Policy options:

- **Government should privatize the Agricultural Bank and grant it initial incentives to meet its mandate.**
- **Government should revisit the statutes setting up the micro-finance banks to enable them to meet their objectives.**
- **Government should privatize the Nigerian Agricultural Insurance Commission and liberalize the operations of agricultural insurance schemes.**

Disaster preparedness

Disaster preparedness is part of climate mitigation and is linked to other disaster management activities including relief, rehabilitation, recovery and reconstruction. In practice, the level of preparedness

and the ability to reduce vulnerability to disaster largely depend on the development stage of a country or a community, and the balance between the strengths and imperfections in the functioning of its sectors, structures and institutions.

The level of disaster preparedness depends on the existing capabilities at all levels. One of the requirements for disaster preparedness is, for instance, the establishment or improvement of monitoring and early warning systems. These systems can ensure prompt and adequate preparation and response as part of a preventive development strategy. Although disaster preparedness is an important component of preventive development, its usefulness can only be determined if the people who are affected by natural hazards are aware of the potential dangers. These people have to be empowered to respond effectively and contribute to the development of their own communities on a sustained basis.

ACTIONS AND POLICY OPTIONS

Actions to address priority risks:

- **Deployment of early warning systems and effective delivery of accurate and timely weather forecasts to populations at risk.**
- **Creation of awareness among people living in hazard-prone areas of the impending danger they face and how best to respond in the event of an occurrence.**
- **Public education through a broad range of channels may include indigenous knowledge drawn from folk culture to enhance local people's awareness and confidence and to empower them to act when faced with adversity. Heightened awareness provides a basis for increased participation, particularly in promoting community-based early warning systems.**

Policy options:

- **Recognize disaster risk reduction as a key climate change adaptation strategy.**
- **Populate the country with networks of meteorological, agro-meteorological and hydrological stations.**
- **Make adequate provision for emergency response during crop failure as a result of drought or crop damage as a result of floods.**
- **Develop strategies for re-stocking and re-planting to meet food security challenges.**
- **Explore incentives to help farmers recoup losses through insurance schemes and/or federal government intervention.**

Alternative livelihoods

The shocks and stresses caused by the changing climate constitute an added pressure on farmers. From the interactions of the ACARN with smallholder farmers during the Town Hall meetings it was evident that farmers had recognized for a long while that "something had happened" and "is still happening" to the climate. Farmers reported the various measures they had taken on their own to cope with extreme events like droughts and floods as well as the vagaries of climate variability, including growing different varieties of crops and modifying planting dates and practices to cope with the shorter growing season. Those in livestock rearing recounted how climate change had altered the pastures and feed stocks on which their animals depend, and how rising temperatures have affected the vulnerability of these animals. Farmers engaged in aquaculture told of the added concerns posed by changing availability of water and how losses can occur, particularly during floods.

Even with their innovative adaptations, it was evident that not all farmers are able to respond on their own. The vast majority may need the interventions of federal, state and local governments to build suitable protective infrastructure or to develop specific policies that will serve to mitigate the impacts of shocks and stresses on their livelihoods. A tested approach is to develop resilient livelihoods through a greater diversity of incomes. In addition to diversifying their agricultural practices, they can establish a wider range of income sources, on or off the farm. Farmers interviewed listed a broad range of additional occupations that serve as an economic buffer to their incomes, particularly in disaster years. These include:

- skilled work such as tailoring, weaving, bicycle repair
- local fabrication of farm and non-farm implements
- owning small provision stores
- engaging in casual labour in nearby urban areas
- making handicrafts for sale
- collection and sale of fuel wood
- running small eateries
- trading in agricultural commodities
- trading in non-agricultural goods.

ACTIONS AND POLICY OPTIONS

Actions to address priority risks:

- **Government to provide accurate and timely meteorological forecasting services to rural farmers.**
- **Governments, private sector, NGOs/CBOs should promote skills, knowledge and access to markets.**
- **Government, aid agencies and NGOs to provide micro-finance and credit to encourage development of small businesses in farming communities.**
- **Government and private sector to promote adoption of weather index-based insurance to guarantee that farmers recover fully after disasters.**

Policy options:

- **Create specific policy for the development of rural infrastructure, especially roads, to create better rural–urban links.**
- **Invest in agricultural resilience research that generates new agro-technologies as means to cope with climate variability.**
- **Create safety nets for rural resilience.**
- **Place emphasis on schemes for women and youth.**
- **Avoid creating a dependence syndrome by adopting approaches that are in line with the philosophy of teaching people to fish, rather than providing them with the fish.**

7.4 Conclusions and Recommendations

Since enabling policy forms the foundation for achieving agricultural resilience, policymakers must consider actions to mitigate the impacts of climate change in all government policies for the foreseeable future. In addition, they should be willing to provide the initial funding necessary to galvanize actions on the part of other stakeholders. The recommendations should be understood as add-ons to the points discussed in the preceding sections. They are summarized here to guide policy coherence and coordination.

The Federal Government, state governments and the private sector should:

- increase support for reforestation and afforestation
- develop improved crop varieties
- improve agricultural extension services
- support livestock keeping
- weigh the benefits of productivity and adaptability in introducing livestock hybrids
- strengthen integrated pest management systems.

State and local governments should:

- encourage agroforestry.

The Federal Government and state governments should:

- improve rural transportation
- oversee regular vaccination of livestock and cross-border disease surveillance
- provide potable water for livestock
- promote a balanced mix of organic manure and inorganic fertilizers.

The Federal Government should:

- improve early warning systems
- provide greater support for insurance.

State governments should:

- improve agronomic practices to suit agro-ecological zones.

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8

Financing for Climate-Resilient Agriculture

8.1 Introduction

The urgent need to develop innovative financing mechanisms is underscored by the fact that the incidence of food insecurity and poverty is expected to peak in sub-Saharan African countries (including Nigeria) in the next 20 years (IFAD, 2011). At the same time, the window of opportunity to transform agricultural systems, promote growth and reduce vulnerability to climate change may close within the next 20 years (FAO, 2013).

So far, the level and composition of investment have not been adequate to stimulate the needed growth in Nigeria. While investments have increased substantially in the agriculture sector, the country still looks to the donor community for significant funding. It is unlikely that the donor community will be able to mobilize the needed funds from traditional overseas development assistance (ODA), as these resources tend to be restricted and more unpredictable in times of crisis. This, coupled with the low allocation to agriculture in the national budget (about 2% in 2013) underscores the insufficiency of public funding to finance climate-resilient agriculture in Nigeria.

Effectively implementing agricultural development requires high levels of private investment to complement public funding, as most actors in the sector are private parties. Despite recent efforts to attract private investors, the potential for private investment in the nation's ATA is far from being met. Private investors and banks show little interest in the agriculture sector because of the high risks associated with it, such as climatic risks, price risks and market failures. This is compounded by insecurity in various parts of the country. Innovative financing is urgently needed to generate long-term, adequate and predictable resources from national sources and to leverage private investment.

However, there are challenges to financing climate-resilient agriculture in Nigeria. While climate-resilient agriculture addresses the interface between climate change and agriculture, funds for agricultural development, climate mitigation and climate adaptation generally come from different sources. This separation of funding streams has contributed to inefficiencies in, and insufficient access to, financing for climate-resilient agriculture. Innovative mechanisms need to be developed to properly integrate the sources of finance for both agriculture and climate change. These challenges need to be addressed in any efforts to mobilize resources for the sector.

8.2 Investment Needs for Climate-Resilient Agriculture

While agriculture is vulnerable to the effects of climate change, it is also a leading source of greenhouse gas emissions. The necessity of adapting to, and mitigating for, climate change calls for a reconsideration of current strategies and investment priorities in the agriculture sector. Investments that support mitigation and adaptation in agriculture come with additional costs over and beyond what is needed to support conventional agricultural productivity. Climate change multiplies and alters the challenges of achieving sustainable agricultural growth.

The country lacks reliable estimates of the investment needed to achieve climate-resilient agriculture. Without including the effects of climate change, Nigeria's National Agricultural Investment Plan (2010–2014) estimates an investment need of about US$1.5 billion over the five-year period. The Comprehensive Africa Agriculture Development Program (CAADP) calls for the allocation of at least 10% of the national budget to agriculture to achieve a target of 6% annual agricultural growth. The Federal Government has set a higher growth target of 10% annual agricultural growth in the medium term. To achieve such rapid growth would require about US$5 billion per annum (Alpuerto et al., 2010). However, these estimates do not include the additional costs imposed by climate change. It has been shown that the incremental cost for adaptation of agriculture and water resources in Nigeria will exceed US$3.0 billon per year by 2020 and US$5.5 billion by 2050 (UNFCCC, 2010). Recent assessments have shown that adaptation costs per ha in Nigeria could range between US$250 and US$1,100. Large-scale irrigation investment costs could range between US$3,700/ha and US$20,000/ha for newly irrigated land, plus an annual operation and maintenance cost of about US$30/ha.

Therefore, achieving the CAADP targets would require a substantial increase in national budgetary allocations and improved investment efficiency in the agriculture sector. It has been shown that better investment efficiency, through improved budgetary processes, timely release of funds, greater transparency and strengthened accountability of public spending in the sector, can achieve savings of more than US$2.6 billion per year while achieving the projected 10% growth target. However, the low budgetary allocation to agriculture (2% in Nigeria's 2013 budget, less than

the 2012 allocation) indicates a greater challenge in meeting the stated targets from public sources (Alpuerto et al., 2010).

Besides adaptation, it is critically important to reduce emissions to avoid future and larger costs of climate change by incorporating low emissions considerations into agricultural investment plans. Nigeria can reduce its emissions significantly in the agriculture and forestry sectors through afforestation, agroforestry, forest protection and better agricultural and land use practices. This would require an annual investment of at least US$2 billion (UNFCCC, 2010).

However, accelerating agricultural growth also requires investments in the non-agriculture sectors. Non-agricultural investment can have a strong impact on agriculture by providing improved public goods, such as roads and other infrastructure, education and health. Such investments raise productivity for both physical and human capital in the broad economy, including the rural and agricultural economy. This calls for a more integrated approach to development in the country.

8.3 External Sources of Funding for Climate-Resilient Agriculture

There are several external funding sources for climate-resilient agriculture in Nigeria. These funds are mostly from bilateral and multilateral sources and are compartmentalized by sector: climate change adaptation, mitigation, agricultural development, reducing deforestation and forest degradation (REDD), etc. To fully take advantage of these funds, it is important to develop an integrated funding mechanism that will go beyond using climate funds to influence agricultural investments, to actually integrating some of the public sources of climate finance (for mitigation and adaptation) with those supporting agricultural development or food security that could also support climate-resilient agriculture.

Effectively supporting climate-resilient agricultural initiatives requires a strong coordination of investments across sectors, with national government actors working across ministries. In addition to investments targeting climate change and agriculture, funds targeting other natural resources like water, forestry and biodiversity conservation also need to be incorporated into planning and implementing climate-resilient agriculture. Listed below are some of the external funds specifically supporting climate change and agriculture that Nigeria could combine to support climate-resilient agriculture.

External funds to support agriculture

Official development assistance: This will continue to be a critical source of external finance. In 2011, Nigeria received about US$1.8 billion as net ODA. The proportion of this that goes to agriculture is rather small. In 2009, ODA to agriculture stood at about US$40 million, declining from an all-time high of about US$120 million. By 2012, the value has risen above US$1 billion. The dwindling financial fortunes of donor countries in the face of the current global financial and economic crises are fast rendering this an unreliable source of financing for agriculture in Nigeria.

Foreign direct investment: Inflows of foreign direct investment (FDI) into Nigeria have grown substantially in the last decade, from about US$1.14 billion in 2001 to about US$11 billion in 2009 (UNCTAD, 2011). This makes Nigeria the largest recipient of FDI in Africa and the 19th greatest recipient of FDI in the world. China is becoming one of Nigeria's most important sources of FDI as China seeks to expand its trade relations with Africa. China's direct investment in Nigeria has grown from US$3 billion in 2003 to over US$7 billion in 2012. In 2012, FDI stock in Nigeria as a percentage of GDP increased to 27.6%, while FDI flows as a percentage of gross fixed capital formation were almost 24% (Ajuwon and Ogwumike, 2013). This shows the important role played by FDI in Nigeria's development.

However, agriculture has been one of the least attractive sectors for FDI in Nigeria. From 1970 to 2001 the sector comprised only 1.7% of total FDI (Ajuwon and Ogwumike, 2013). The visible increase in FDI inflow into agriculture (about US$8 billion in the past year) is a result of the Federal Government's commitment to creating a suitable enabling environment to support investments. For instance, the Federal Government has provided investment guarantees, which has boosted the confidence of foreign investors; refocused and changed the patterns of investments in agriculture by laying greater emphasis on not only increasing volumes of agricultural produce but also extending the value chain via investment in agricultural machinery, storage and processing plants.

Private investments: Although public investment is necessary to build a favourable environment and provide the required infrastructure, a large proportion

of the required total investment should be made by private actors. Private investment is therefore central to agricultural development in Nigeria. Traditional ODA through public-driven projects has shown limited capacity to foster private investments, because implementation is often too rigid, and because projects are insufficiently market-driven and result-based. The Federal Government's new policy on agriculture recognizes this and lays emphasis on the need to create an environment favourable to private investment and to develop catalytic tools that will provide incentives while alleviating the constraints to private investments. The Federal Government has consequently attracted over US$8 billion worth of private sector investment commitments to agriculture in the past year. With proper incentives and financing mechanisms, there is huge potential for increased private sector investment in climate-resilient agriculture in Nigeria.

Development banks and financial institutions: Financial institutions are playing an important role in reviving agriculture. These institutions are providing grants and concessional loans to the Federal Government, providing micro-credit to farmers and joint ventures between banks and state governments to boost agricultural production. For instance, in the past two years, the Federal Government has secured or is in the process of securing about US$4.0 billion for the Agricultural Transformation Agenda from the World Bank, the African Development Bank, UK Department for International Development, International Finance Corporation, United States Agency for International Development, United Nations Development Programme, and the Bill & Melinda Gates Foundation. The Africa Agriculture Trade and Investment Fund administered by the German development bank KfW and Deutsche Bank provides loans, guarantees and, to a limited extent, equity to experienced private sector enterprises and farmers located in Africa. It encourages the engagement of private investors to look for more 'risky' investment opportunities. These development institutions are an important source of funding. However, it is important that the country develops a pipeline of viable and bankable projects that can be financed by these institutions through both public and private sectors.

Funds for climate change

Bilateral and multilateral funds: The bulk of climate finance comes from bilateral sources through ODA and from multilateral climate change funds and development agencies. Fifteen multilateral funds are active in sub-Saharan Africa, including Germany's International Climate Initiative (ICI), Norway's International Climate and Forest Initiative, Japan's Africa Adaptation Program and the UK's International Climate Fund. The US$96.35 million approved by the ICI for 32 projects represents the largest source of bilateral funding, but the amount disbursed is unknown. The multilateral funds are largely administered through a variety of mechanisms, which include those listed below.

Funds under the UNFCCC: There are several funds under the UNFCCC. These include funds under the Global Environment Facility (GEF), such as the GEF Trust Fund, the Least Developed Country Fund (LDCF), the Special Climate Change Fund (SCCF), and the Adaptation Fund. The GEF Trust Fund was expected to provide about US$2 billion for mitigation projects from 2010 to 2014 with agriculture and sustainable land use represented in one of the six objectives of the funding strategy. The LDCF and SCCF have thus far committed over US$350 million during 2002–2010. The Adaptation Fund has disbursed about US$400 million thus far. About 40% of the resources committed under the LDCF have been targeted at food and agriculture, and nearly all the projects funded by the Adaptation Fund have components that address the agriculture sector. Agriculture and food security are likely to continue to be a primary focus of any new climate funding streams. Of the 20 approved national projects amounting to over US$68 million, about US$8 million was allocated to an agriculture project, while another US$8 million was allocated to watershed management. Nigeria has no projects approved under the Adaptation Fund.

Green Climate Fund: In 2009, developed countries committed to jointly mobilizing up to US$100 billion a year by 2020 to support climate change actions in developing countries. The Green Climate Fund (GCF) has been established as the financial mechanism to implement this commitment. Its design is at an advanced stage and some countries have pledged resources for activities that will prepare developing countries to be able to access the GCF when it becomes operational. Some of these activities will establish national designated authorities by setting basic criteria for accreditation, appropriate safeguards and fiduciary standards. Nigeria needs to prepare itself for early participation in the activities of the GCF by setting up and empowering an appropriate designated national authority (this role is presently played by the Special Climate Change Directorate of the Federal Ministry of Environment) and preparing a pipeline of climate-resilient agricultural programmes

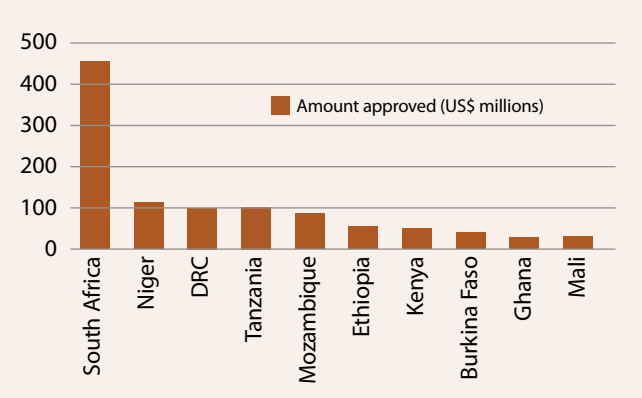
and projects for funding once the Fund becomes operational.

Climate Investment Fund: This consists of about US$6.4 billion provided by donors to address mitigation and adaptation in developing countries. It includes the Clean Technology Fund and the Strategic Climate Fund. The Clean Technology Fund has approved a total of US$401 million for five projects, 87% of which are in South Africa. Three additional programmes are funded under the Strategic Climate Fund: the Pilot Programme on Climate Resilience, the Forest Investment Partnership, and the Scaling-up Renewable Energy Programme. The Climate Investment Fund is administered by the multilateral development banks to support mitigation and adaptation in developing countries. Many of the projects submitted to the Pilot Programme for Climate Resilience (PPCR) and the Forest Investment Programme include agricultural and rural resilience components. While Nigeria is implementing a project under the Clean Technology Fund, it has no projects funded under the PPCR or Forest Investment Programme.

Nationally appropriate mitigation activities: In 2009, developing countries pledged to undertake voluntary actions to reduce their emissions, contingent on support from developed countries. Nationally appropriate mitigation activities (NAMAs) have been institutionalized in the UNFCCC process and several countries have submitted projects for funding in several sectors. Considering the potential of agriculture to reduce emissions, it is imperative that Nigeria prepares and submits NAMA programmes and projects in the agriculture sector. Nigeria has performed poorly in terms of access to these multilateral and bilateral climate funds. For instance, Nigeria has thus far received only about US$45.4 million for both mitigation and adaptation. Compare this with Morocco, which has received about US$366 million, Niger with US$115 million and Mexico with US$743 million. Figure 8.1 shows the top 10 recipient countries in sub-Saharan Africa.

Multilateral development banks: The African Development Bank and the World Bank have set aside resources to address climate change issues as part of their core business operations. The Climate Change Action Plan of the African Development Bank intends to invest about US$10 billion of its resources on activities related to mitigation and adaptation between 2011 and 2014. Nigeria could benefit from this financing opportunity. In August 2013, the African Development Bank launched its third Green Bond to raise resources to finance green investments in Africa, including those in agriculture. The World Bank has issued approximately US$4 billion in Green Bonds through 59 transactions and 17 currencies to support green initiatives in developing countries including Nigeria. Nigeria must take advantage of these resources.

Figure 8.1 Top 10 recipients of climate finance



Source: Nakhooda et al., 2011

The carbon market: Under the regulated carbon markets (part of the UNFCCC market mechanism), most investments go to mitigation in the energy sector through the offset market. The projected demand for land-based agricultural offsets is bleak. Land use sequestration projects in developing countries have been largely omitted because of the relative difficulty in meeting CDM standards and the ban by the European Union (EU) Emissions Trading Scheme. However, the voluntary carbon markets offer opportunities for land use sequestration projects. In 2010 the total voluntary carbon market was valued at US$424 million worldwide, of which "US$13 million was related to agricultural soil management, US$8.5 million for livestock projects, US$25 million for afforestation and reforestation projects, and US$123 million was attributed to REDD, which includes the use of agroforestry practices" (Peters-Stanley et al., 2011; Shames et al., 2012).

Although the global carbon market has essentially collapsed, there is every indication that, as we approach a binding global climate change agreement in 2015 to curb emissions, the market will pick up again. Virtually every permutation to mobilize long-term finance for climate action is anchored in the carbon market. Nigeria can take advantage of this source of funding by taking action to improve the overall conditions for carbon market projects in Nigeria. Such action could include accelerating negotiations with the European Union regarding a

bilateral deal on eligibility of credits from Nigerian projects for the EU Emissions Trading Scheme eligibility, and furthering discussions with Japan about its bilateral offset credit scheme, among others.

It would also be beneficial to enhance the capacity of the designated national authority in the Ministry of Environment so it can create new methodologies that allow climate-resilient agricultural practices to benefit from the compliance and voluntary carbon market. It should also calculate and publicize baselines and emission factors, host a website to inform stakeholders about relevant carbon market developments and allow project documents to be uploaded online, and develop expertise in sector credit opportunities. There are a number of external development partner initiatives that Nigeria should explore to fund these activities, including the African Carbon Support Programme of the African Development Bank and the Climate Initiative for Development of the World Bank.

Private investors and philanthropic funding: Private investments in climate change have largely been through the CDM and focused on mitigation. This is because the private sector is driven by profit. Mitigation projects have clear profits while adaptation is usually considered as a public good and is not rent-seeking. As in every other investment, the Federal Government will need to create an enabling environment to attract private investors into the climate change space. At the same time, there are untold benefits from private sector investments in adaptation. Efforts can and should be made to package adaptation projects in ways that will attract private investors. A growing cohort of private foundations and international NGOs, such as Rockefeller, Bill & Melinda Gates Foundation, CARE, Oxfam and Conservation International are joining with national NGOs and farmers' organizations to invest in climate-resilient agriculture. Nigeria can benefit from these partnerships by providing a coordination mechanism to bring coherence to these varied investments.

Opportunities and constraints associated with external resources

Climate finance for mitigation and adaptation directed towards agriculture will remain a small fraction of total investments in agriculture, and therefore the effectiveness of these climate funds will rely on their ability to strategically leverage agricultural investment in support of climate-resilient agriculture. At the national level, Nigeria could use climate finance to implement cross-sector policy integration. At the landscape scale, climate funds could be coordinated with other co-located rural development activities and to support multi-stakeholder, landscape planning exercises, extension and rural credit programmes.

Beyond using climate funds to influence agricultural investments, opportunity exists to integrate some of the public sources of climate finance (for mitigation and adaptation) with those supporting agricultural development or food security into a single mechanism that could flexibly support climate-resilient agriculture. Nigeria is developing a climate finance fund through a bill that seeks to create the National Climate Change Commission, which, as of March 2015, was inching towards renewed passage in the National Assembly. This is an opportunity to create a window in the proposed climate finance fund that could specifically finance agricultural activities.

However, the existing climate finance instruments listed in the preceding sections have inherent challenges that need to be addressed. Some of these are inherent in the funds themselves and others are particular to Nigeria's ability to access them. These challenges present major barriers to creating appropriate and efficient financing structures for climate-resilient agriculture in Nigeria. Some of these challenges (as identified by Shames et al., 2012) include:

Uncertainty in international public funding sources: Most of the external funds discussed above are generated through voluntary pledges. This creates uncertainty in the level of funding available for country-level programming. Also, there are often substantial differences between the funds pledged and the level of disbursement. Consequently it is difficult to clearly track funding levels for climate change and agricultural development by international donors. An important consequence of this uncertainty of funding levels is that countries are not able to implement long-term programmes to build the institutional capacity required across sectors to support large-scale transitions to climate-resilient agriculture.

Modest scale of climate finance relative to overall agricultural investment finance: Private investment in agricultural supply chains and land uses dwarfs the current climate finance directed towards agriculture. Agricultural climate funds have

the potential to grow and encourage low-emissions/high-resilience land use activities. The extent to which this happens will be decided through national and international policy debates, which are likely to take place over the next few years.

Fragmentation of climate finance: Climate finance streams for adaptation and mitigation have been treated separately within the UNFCCC negotiations and, consequently, it has been difficult to blend these funds strategically in a single project or programme. While such separation may make sense for many sectors, it is not the case within the land use sector – and for agriculture in particular – because the interventions that produce mitigation benefits are often identical to those required for adaptation.

Loss of synergies across landscapes: Climate-resilient agriculture necessarily includes investment across the landscape to maintain healthy watersheds and ecosystem services and to supply the full range of food, fibre, raw materials and bio-energy products. One of the key pillars of the climate-resilient framework, as introduced by the FAO is "adopting an ecosystem approach, working at landscape scale and ensuring inter-sector coordination and cooperation" (FAO, 2010). A landscape approach includes a spatial understanding of land uses and their interactions, as well as a process for coordination that reflects the institutional diversity of stakeholders. However, with individual climate or agriculture objectives supported by various funds, it is difficult to develop these landscape synergies.

National public investment remains in sector silos: National policy coherence on agriculture and climate change will be critical to the success of climate-resilient agriculture. Unfortunately, at the national level, conventional sector structures often hinder integrated projects and programmes.

Difficulties in access: Several of the international funds have access modes that have proven difficult. For instance, only five African countries have been accredited to access the Adaptation Fund. The limited access is also partly explained by the fact that many of these funds are not aligned with Africa's priorities and specificities. While the CDM plays a major role in generating resources relating to emissions, those emanating from agriculture (the largest source of Africa's emissions) are excluded. The GEF Trust Fund largely finances mitigation initiatives since these easily meet the eligibility of global benefits, while adaptation benefits are deemed to be largely local, even though it is Africa's priority.

8.4 Mobilizing National Resources to Support Climate-Resilient Agriculture

Gaining access to climate finance is essential for meeting Nigeria's goals of both adapting to and mitigating climate change through climate-resilient agriculture. In light of the limitations associated with external funds, this section proposes criteria for assessing innovation in financing climate-resilient agriculture. Due to the emphasis on innovative sources, this discussion omits any overt reference to the Ecological Fund, which is an obvious, but yet to be effectively exploited, source of funds for new initiatives in agricultural production including climate-resilient agriculture schemes. Instead, it explores the opportunities that exist for Nigeria to mobilize national resources through innovative sources and tools. These opportunities occur in the ability to attract new resources rather than traditional ODA, to catalyse private investment through innovative tools, and the ways in which these tools promote new approaches to scaling up innovative financing mechanisms.

ACTION: EXPAND THE FUND FOR AGRICULTURAL FINANCING IN NIGERIA

It is imperative to address the current inadequate and fragmented flow of investment resources for climate change and agricultural development. It is important to strengthen FAFIN and decentralize it at state and regional levels to mobilize resources from diverse public, private and donor financial resources. There should be an Agricultural Resilience Fund to complement the Fund for Agricultural Financing in Nigeria and serve as a dedicated funding vehicle to enable much greater investment in climate-resilient agriculture. The Fund should be able to engage in microfinance, carbon finance, agricultural subsidies, impact investments and foreign direct investment. The Fund should also be tasked to compile information and knowledge on sources and structures of finance, articulate problems and solutions at the regional and national levels, coordinate public–private partnerships, track trends on flows/economic valuation of production and mobilize innovative sources of finance.

Mobilizing innovative resources for the Agricultural Resilience Fund

Criteria for assessing innovative finances: Considering the inadequacy of ODA and national budgetary resources to meet the demands for climate-resilient agriculture, it is imperative to develop innovative resources that will complement these traditional sources and bridge the gap between available and required investment resources. Innovative tools for the use of public resources are also needed to catalyse private investment and alleviate constraints on its development, using delivery mechanisms that are more effective than traditional ones.

As noted by the report of the Task Force on Innovative Financing for Agriculture, Food Security and Nutrition (2012), innovative sources of finance should satisfy the following criteria: predictability, complementarity to donor funding, contributor acceptability, feasibility, anticipated amounts of resources, low cost of resource mobilization, expected impact, and effective fund management.

ACTION: EXPLORE POTENTIAL MECHANISMS TO ATTRACT NEW RESOURCES TO THE AGRICULTURAL RESILIENCE FUND

National taxes: Nigeria has options to raise resources through various innovative tax schemes, for instance a tax on financial transactions. A tax on fertilizers has been proposed by New Partnership for Africa's Development as a means to develop fertilizer consumption in Africa through smart subsidies.

Voluntary contributions: Firms and major corporations in and outside Nigeria could be encouraged to contribute to mobilizing resources for agriculture. Some of the proceeds from lotteries can also be considered (e.g., part of the lottery proceeds in Belgium is already dedicated to finance food security projects in developing countries).

Migrants' remittances: These represent considerable financial flows from developed countries into Nigeria. Remittances can be considered as both a new source of financing and existing private capital that may be channelled into agriculture. In the first case, financial instruments that mobilize this type of new resources for development include the

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securitization of remittance flows by financial institutions (i.e., mobilizing private sector financing for banks) and the mobilization of resources for development through diaspora bonds, which corresponds to mobilizing new financing for governments.

Import savings: Nigeria currently spends about US$11 billion on food imports. Shifting a fraction (say 20%) of the total spend on food imports could generate substantial resources to support climate-resilient agriculture.

Guarantee funds for bank credit: Agricultural lending in Nigeria accounts for less than 2% of formal lending. It has been on the decline since 2006 due to the perceived high risk by banks, because of a limited understanding and lack of confidence in the sector. The idea of reducing banking risk by granting a partial guarantee to banks, designed to cover a portion of the risk without relieving the banks from their credit responsibility, has been tried and launched at different occasions in the agricultural credit sector in Nigeria. First, the Federal Government's Agricultural Credit Guarantee Scheme Fund, administered by the Central Bank of Nigeria, guarantees up to 75% of all loans granted by commercial banks for agricultural production and processing. Second, the Federal Government has launched the Nigerian Incentive-based Risk Sharing for Agricultural Lending, a risk-sharing mechanism that aims to leverage US$300 million of public funds to attract US$3 billion of private financing from Nigerian commercial banks into agriculture. When fully operational, this scheme will build confidence in the credit sector.

ACTION: INNOVATIVE MECHANISMS TO CATALYSE PRIVATE SECTOR INVESTMENTS

Several tools exist to make investment in agriculture and food value chains more attractive to the private sector and to reduce the high level of risk associated with agricultural investments. Most of these tools are already being used in developed countries and have proven their efficiency for financing agriculture. They can however, be considered as innovations to be adapted and developed in Nigeria. Some of the most promising mechanisms that deserve further exploration include:

Risk management tools: Widespread availability of risk management tools makes it easier for financiers to manage the risks

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inherent in agricultural finance, and will thus catalyse private sector funding for agriculture. Agriculture financiers are exposed to several risks, including price volatility resulting in revenue that is too low to permit loan reimbursement, crop loss due to adverse weather, obstacles preventing the delivery of the crop to the buyer, etc.

Market-based weather risk management schemes: Traditional crop insurance schemes, based on individual yields and field inspections, can be very costly to administer in Nigeria. Market-based weather risk management can overcome some of the problems associated with traditional insurance schemes. These are based on weather indices, such as rainfall and temperature, rather than actual farm losses. They can be used to protect against catastrophic risks, or to protect against normal, day-to-day operational risks. The Nigerian Agricultural Bank can bundle weather risk management with its loan packages. For example, loans are forgiven if there is a drought, and the bank claims its money back from an insurance company, or they can insist that lenders take out weather insurance with the eventual claims payable to the bank, or they can insure their agricultural loan portfolio against weather-related default risk.

Weather index-based insurance: This compensates the subscriber for production loss when a reference index, for instance rainfall level, is not reached. This mechanism is being piloted in a number of countries (Ethiopia, Kenya, Malawi and Tanzania) to reduce agricultural risk, where such risk is a severe constraint to intensification and food security. Implementing this in Nigeria would require a considerable improvement in the data collection and analysis capability of the Nigeria Meteorological Agency and other related agencies.

Agricultural reinsurance schemes: This involves the creation of an agricultural reinsurance scheme to cover natural risks and enhance the operating capacity of the insurance companies. The reinsured risks could prioritize those that affect the productive capacity of the farmers. Reinsurance funds can be public or private. The risk coverage could be at the level of individual subscribers or at the national level. The EU has established its Global Index Insurance Facility to create an index insurance system for African, Caribbean and Pacific countries. Nigeria can request to be a part of this scheme.

Public–private partnerships: There are several innovative ways to stimulate private sector investment in rural infrastructure. One is entirely private, although government policies have to permit the mechanism. For instance, an entrepreneur can use off-take contracts with foreign buyers (e.g., for fruits and vegetables with a supermarket chain) to obtain long-term investment finance from local pension funds that permit the construction of the infrastructure needed to produce, process and transport the fruits and vegetables (this has been done, for example, in Zambia). Others require a more active role from the Federal Government in the form of public–private partnerships.

Through public–private partnerships governments can leverage funds from the private sector to invest in agricultural infrastructure or services benefitting small-scale farmers. The private investor, usually an agribusiness, is compensated either by subsidy or a public financial participation in the investment or by a long-term lease agreement or a build–operate–transfer scheme for agricultural infrastructure, such as irrigation schemes or storage facilities.

ACTION: ENHANCING DOMESTIC ABSORPTIVE CAPACITY

Generating new and innovative resources is one thing; creating the capacity to absorb the finances is another. Due to the long history of neglect of the agriculture sector, there is a capacity deficit in the country to readily absorb resources at a large scale. There are a number of actions that the Federal Government can take to improve the country's capacity to absorb additional resources, which will need to be taken forward concurrently with the establishment of the Agricultural Resilience Fund to maximize its effectiveness.

Creating effective national enabling environments involves the development of comprehensive, coherent policies, as well as a stable policy environment and well-functioning institutions (IIGCC, 2011); and the availability of bankable, climate-resilient investment opportunities in the agriculture sector. It also entails removing the barriers to effective scaling-up of private investment in climate-resilient agriculture.

In order to address the absorptive capacity challenges, the Federal Government needs to mainstream climate finance and planning into national plans and strategies. This primarily involves, among other actions:

- **Establishment of a participatory planning process that produces concrete and clear**

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action plans on climate-related investments (as through the development of this document).

- **Identification of appropriate institutional arrangements to manage and coordinate financial vehicles and avoid inefficiency and overlaps. This might include reinforcement of the existing inter-ministerial mechanism on climate change, whose members are drawn from all relevant line ministries, businesses and academia. Little is known or understood about the flow of climate financing into and within Nigeria, especially flows from private sources. More research is required to map, quantify and track the flows of climate financing and enable policymakers to develop appropriate mechanisms to scale up interventions where necessary and to address gaps where they exist.**
- **The Federal Government could take this opportunity to prioritize climate change by creating line items in the budget. In the context of national expenditure frameworks, the Federal Government could create a specific code within the integrated financial management system to allow climate change budgets to be tracked and reported. At present, the absence of such codes inhibits monitoring of climate change-related expenditures, which is important both for effective internal government processes as well as for reporting to the UNFCCC.**
- **Working with development partners to harmonize funding with priority interventions is another action area for the Federal Government. This could include standardizing the financial requirements and fiscal calendars of the Federal Government and development partners according to the principles of Nigeria's Joint Assistance Strategy. In developing the modalities for providing resources to the Agricultural Resilience Fund, it will be necessary to establish the processes by which development agency and government resources (as appropriate) are provided to the Fund through a joint financing agreement.**
- **Furthermore, measures could be taken by the Federal Government to enhance ongoing efforts to improve the operational and absorptive capacity of trust funds with a focus on the Agricultural Resilience Fund. With the support of the Federal Ministry of Finance, creating strong financial management capabilities within the Fund could improve disbursement and project implementation. It would also be desirable for the Fund to provide assistance to project implementing agents in areas of proposal preparation, implementation, and compliance with accounting and reporting requirements.**

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8.5 Conclusions

Transforming Nigeria's agriculture to be climate-resilient is a huge task and will require a large investment over at least the next 20 years. The main issue at present is that funding streams are mostly divided by sector, with funds for adaptation, mitigation, agricultural development and food security generally coming from different sources. This leads to inefficiencies and makes it more difficult to access sufficient funds.

At the moment, a large proportion of the available finance comes from public sources, but this is not a sustainable solution and private finance must be increased. This will require clear regulatory frameworks and it will be necessary to de-risk the climate finance sector to increase investor confidence. The best solution is to use public funding as a catalyst to attract the required private sources.

The large scale of resources required calls for innovation in identifying sources of funds as well as new mechanisms to catalyse private sector investments. At the same time, funds will need to be used as efficiently and synergistically as possible. Considering the overlapping and interrelated investments required to meet the multiple objectives of climate-resilient agriculture, the financing systems that support these objectives should also be linked closely.

Some success has been achieved in Nigeria in using domestic policy mechanisms to leverage public funds. This gives cause for optimism that similar systems may be evolved to lower the risks – either real or perceived – and thereby attract private sources into agricultural resilience financing.

Table 8.1 reviews existing international financing mechanisms in support of climate-resilient agriculture in Nigeria. The total amount approved for adaptation to climate change projects is US$934.22 million in Africa, whereas the amount disbursed to date is US$217 million.[1]

1 See: www.climatefundsupdate.org/data

Table 8.1 Existing international financing mechanisms in support of climate-resilient agriculture in Nigeria

FINANCIAL INSTRUMENTS	OPERATED BY	SCOPE	ELIGIBILITY CRITERIA	AMOUNT APPROVED FOR ADAPTATION PROJECTS IN AFRICA (US$ MILLION)	AMOUNT DISBURSED (US$ MILLION)
LDCF	The GEF and World Bank as Trustee	The Fund supports and finances National Adaptation Programmes of Actions in LDCs	All LDCs	333.69	87.02
GEF Trust Fund (GEF 4)[2]	The GEF and World Bank as Trustee	The fund aims to support developing countries to be resilient by promoting the mainstreaming of adaptation measures in national development programmes and strategies.	Countries than meet eligibility criteria established by COP are eligible for United Nations Development Programme (UNDP) technical assistance and to borrow from the World Bank	10.63	10.63
SCCF	The GEF and World Bank as Trustee	Support adaptation to climate change and technology transfer projects. It covers all the vulnerable sectors of a country: water, agriculture, forest, infrastructure, etc.	All non-Annex 1 countries	58.01	39.68
Millennium Development Goals (MDG) achievement goals	UNDP and the Spanish Government	Financial support for projects or programmes with impact on MDG 7 (Ensure Environmental Sustainability). Special focus on natural resources and ecosystems.	In Africa: Angola, Cape Verde, Democratic Republic of Congo, Equatorial Guinea, Ethiopia, Guinea Bissau, Mauritania, Mozambique, Namibia, São Tomé & Principe, Senegal and South Africa	11	11

FINANCIAL INSTRUMENTS	OPERATED BY	SCOPE	ELIGIBILITY CRITERIA	AMOUNT APPROVED FOR ADAPTATION PROJECTS IN AFRICA (US$ MILLION)	AMOUNT DISBURSED (US$ MILLION)
Adaptation Fund	The World Bank as Trustee	Projects and programmes to improve climate resilience to most vulnerable countries: (i) improving water management, agriculture, infrastructure (ii) capacity building for preventive measures planning (iii) establishment of regional and national centres for quick response to extreme events.	Part of the Kyoto Protocol and highly vulnerable to climate change (coastal countries, small island countries, etc.)	53.73	17.33
Germany's International Climate Initiative	The German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety	Working for the most vulnerable countries to increase their capacity to adapt to climate change and develop their climate change adaptation strategies.	Any project that meet priority areas	18.48	0
Global Climate Change Alliance (GCCA)	The European Commission EuropeAid	Priority on adaptation programmes and projects especially on agriculture, food safety, forests and natural resources, water and waste. The GCCA also finances the elaboration of adaptation plans in vulnerable countries other than LDCs and integrates them into poverty reduction strategies.	LDCs or Small Islands Development States	73.92	46.51
Japan's fast-track finance	Japanese Ministry of Finance	Japan pledged US$15 billion ($11 billion for public finance and S4 billion for private finance) to support developing countries to cope with climate change. Almost 10% of the money spent has been for adaptation to climate change.	Any developing country with bilateral relations with Japan	220.94	0

FINANCIAL INSTRUMENTS	OPERATED BY	SCOPE	ELIGIBILITY CRITERIA	AMOUNT APPROVED FOR ADAPTATION PROJECTS IN AFRICA (US$ MILLION)	AMOUNT DISBURSED (US$ MILLION)
PPCR	World Bank is the Trustee and African Development Bank, Asian Development Bank, Inter-American Development Bank and European Bank for Reconstruction and Development are implementing agencies.	Programme of the Climate Investment Fund to support countries to integrate climate resilience as part of the development strategies. PPCR builds on NAPAs and other development programmes.	Some pilot countries have been selected on basis of expression of interests. These are all LDCs (in Africa: Mozambique, Niger and Zambia).	154.6	4.48
TOTAL			**934**	**934**	**216**

2 The adaptation work of GEF 5 is financed through the LDCF and SCCF

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9

Monitoring and Evaluation

9.1 Introduction

Delivering the planned transformation to climate-resilient agriculture in Nigeria will require effective monitoring and evaluation (M&E). This chapter outlines the key parameters, which include baseline assessments, indicators for assessing the impacts of interventions, and capacity requirements. It also presents several activities, which show how different organizations use M&E frameworks to support the transition to climate-resilient agriculture.

9.2 M&E Purpose and Scope

A farmer and a Federal Government minister will have very different priorities for M&E and thus, the three components of climate-resilient agriculture – food security and production, adaptation, and mitigation – will need to be considered differently depending on the context. It is also important to remember the difference between M&E. While monitoring measures aspects of project implementation and aims to improve the project's design and function along the way, evaluation studies the outcomes of the project (e.g., improvements in food production, uptake of new agro-technologies, changes in farmers' income, cost-effectiveness, etc.) with the aim of informing the design of future programmes.

Performing M&E in any context is challenging and complex. It is about identifying and measuring the drivers of success just as much as understanding the causes of failure. Effective M&E incurs costs, and these need to be identified upfront, budgeted for and ring-fenced for this purpose, so that they are not lost through oversight (or over-spending) as the programme/policy is implemented. The uncertainty of the likely effects of climate change on agriculture adds a further challenge.

It is also vital that the subject of M&E has a schedule of pre-agreed deliverables and outcomes, which must be specific and measurable. In this case, these are the policies, programmes, projects and activities set out in the ACARN framework. Assessment of the outcomes within this framework will highlight economic, environmental and social impacts. The schedule for monitoring and evaluation also needs to be identified and planned right at the beginning of the project cycle, and M&E needs to be integrated into the full project cycle through regular planning processes. Failure to undertake this planning at the initial stage of the project cycle will make M&E ineffectual down the line as the project develops.

Furthermore, effective M&E needs the involvement of key stakeholders, and these need to be identified early on. A combination of a top-down analytical approach and a bottom-up approach featuring community involvement/engagement is strongly recommended by all the key international institutions advocating climate-resilient agriculture. In the Nigerian context, the complexity and diversity of the six geo-political regions would certainly mandate a strong emphasis on participatory M&E. The challenge here is how to integrate participatory and non-participatory monitoring, given the diverse range of stakeholders. An additional challenge will be to clearly define the information needs and roles of stakeholders in the M&E process at the onset.

9.3 Spatial and Temporal Scales

In designing the M&E framework for the FMARD, four key biophysical parameters have been prioritized:

- Agricultural productivity, including livestock and fisheries
- Soil fertility, including soil water holding capacity, nutrient status, soil pH status
- Preventing soil loss
- Vegetation (greenness) index.

M&E for these parameters should be undertaken at the national scale as this will supply more robust data. In the short term, the national level will be the most realistic spatial scale for the FMARD, with graduations further down the spatial scale over time. Thus, in the medium term, M&E can be undertaken at the national and state levels and, in the longer term, at the national, state and local government levels.

The recommended spatial and temporal scales for M&E are:

- Short term: 1–3 years (national level)
- Medium term: 3–5 years (national and state levels)
- Long term: 5–15 years (national, state and local government levels).

These timeframes are in line with the recommendations of the NASPA-CCN report.

9.4 Baseline Assessments

The M&E framework will encompass direct and indirect observations that will be used to establish a baseline database. This, in turn, will be used to assess the outcomes of interventions (i.e., the policies, programmes and projects) proposed by the ACARN. This will include setting targets and benchmarks for outcomes.

The baseline data and framework are detailed in Tables 9.1 and 9.2.

9.5 Indicators for Assessing Impact

There are a number of internationally recommended frameworks for the establishment of indicators for assessing the impact of interventions in delivering climate-resilient agriculture. The recommendations highlighted in Table 9.3 have been adapted from the CARE framework,[1] taking the Nigerian scenario into consideration.

Table 9.1 Biophysical parameters prioritized for the ACARN M&E

BIOPHYSICAL PARAMETERS	KEY M&E INDICATORS
1. Agricultural productivity, including livestock and fisheries	• Large-scale and smallholder productivity yield/ha • Patterns of land use and type of crops grown • Animal count/ha (livestock numbers) • Fisheries count • Post-harvest loss and waste
2. Soil fertility: soil moisture content, nutrient status, soil pH status	• Soil fertility maps • Amount of land under irrigation
3. Preventing soil loss	• Soil loss (erosion) maps
4. Vegetation (greenness) index	• Rainwater (cubic metres) • Recovery of vegetation/grazing lands • Change detection/ area coverage

9.6 Type and Frequency of M&E

The type and frequency of M&E will depend on a number of variables, such as institutional capacity, levels of funding and pressure from funders/donor agencies, etc. However, the key issue is to focus on intermediate outcomes where the links between interventions, policies and programmes and impact are clear. This is because there are often many factors influencing an outcome, and so attributing change to a particular intervention becomes impossible. Even with a relatively simple intervention such as agricultural extension (where research findings are promoted to improve production practices) or small grants to support experimentation, it is notoriously difficult to measure impact on such indicators as productivity yields and net farming incomes.

It is therefore recommended that, rather than targeting endpoints or ultimate outcomes, evaluations should focus on the changes in immediate and intermediate outcomes that are delivered by climate-resilient agriculture interventions. Such intermediate outcomes might include changes in knowledge, behaviour, enhanced social learning and organizational strength, which are most likely to be related directly to intervention activities. Based on these changes, it is possible to extrapolate the likely net effect of the intervention on the ultimate outcomes rather than attempt to measure this impact. Another suggestion is to use data from trials conducted over multiple growing seasons to extrapolate from the measured changes in the adoption of climate-resilient agriculture practices to changes in yields and income. Thus, it is crucial to interrogate the contribution of the human and social capital of farmers to the impact of climate-resilient agriculture interventions when assessing the impacts of these innovations, in order to achieve a fuller understanding of the merits of the adoption of differing approaches. This is particularly relevant in the Nigerian context, where there is currently low adaptive capacity and poor levels of knowledge and social learning.

1 See: www.careclimatechange.org

Table 9.2 Framework for Baseline Assessments for M&E

PARAMETERS	FREQUENCY OF M&E	LEAD NATIONAL AGENCY	TOOLKITS AND OTHER SUPPORT AGENCIES	CONSIDERATIONS
1. Agricultural productivity, including livestock and fisheries				
Large-scale and smallholder productivity yield/ha	Annually	Crop division-Department of Agriculture in the FMARD	Remote sensing – the National Space Research Development Agency (NASRDA)	Current remote sensing data from NASRDA is up to 5 m^2 resolution. There are plans to improve the resolution to 0.5 m^2, which will improve the quality and robustness of the data.
Patterns of land use and type of crops grown	Annually	Crop division and land resources – Federal Department of Agriculture in the FMARD	The NASRDA should also contribute to M&E in this aspect	
Animal count/ha (livestock numbers)	Annually	Livestock Department in the FMARD	Remote sensing – the NASRDA	Within the context of climate-resilient agriculture, this parameter has socio-cultural implications with regard to achieving reductions in land degradation, (pastoral vs. sedentary livestock management) to maintain the overall productive capacity of land
Fisheries count	Annually – economic data on fisheries stocks and aquaculture	Federal Department of Fisheries in the FMARD		Implications include monitoring aquatic ecosystems and their impact pathways through the fisheries, aquaculture and coastal systems
Post-harvest loss and waste	Annually	Planning, research and statistics unit in the FMARD	The FMARD agricultural extension services should also contribute to M&E in this aspect	
2. Soil fertility: soil water holding capacity, nutrient status, soil pH status				
Soil fertility	Annually	Soil fertility division in the FMARD	Nitrogen, phosphorus, and potassium standard toolkit Soil organic matter content	
Soil fertility maps	To be updated every five years	Soil fertility division in the FMARD		The current soil fertility maps are obsolete as the data are over 20 years old
Amount of irrigated land	Annually	Land resources division in the FMARD	The NASRDA should also contribute to M&E in this aspect	Indications are that this parameter is not effectively monitored currently –data are patchy and ad hoc

PARAMETERS	FREQUENCY OF M&E	LEAD NATIONAL AGENCY	TOOLKITS AND OTHER SUPPORT AGENCIES	CONSIDERATIONS
3. Preventing soil loss				
Soil loss (erosion) maps	To be updated every 10 years	Land resources division in the FMARD	The NASRDA should also contribute to M&E in this aspect	The current soil loss/erosion maps are obsolete as the data are over 20 years old
4. Vegetation (greenness) index: These parameters are key outcomes for the M&E of enhanced climate-resilient agriculture in livestock management; rainfall patterns and effective irrigation schemes				
Rainwater (m^3)	Annually	The NIMET		
Recovery of vegetation in grazing land	Annually	National Centre for Remote Sensing (NCRS)-NASRDA	GIS and Remote Sensing Unit, Land Resources in the FMARD	
Change detection/area coverage	Annually	The NCRS-NASRDA	GIS and Remote Sensing Unit, Land Resources in the FMARD	

In the Nigerian context, the role of GIS analytical and mapping capabilities and community-based adaptation technologies and approaches will be critical to developing and enhancing capacity, delivering economies of scale and empowering participatory and inclusive modes of assessment. The following sections describe some of the M&E work being undertaken currently by the NASRDA and highlight the key M&E tools. Box 9.1 describes an examples of the activities carried out by the FMARD in 2012 and 2013.

The National Space Research Development Agency

The NASRDA is a key player with regard to providing data for facilitating the M&E and assessment of desired outcomes for climate-resilient agriculture in Nigeria. Some of the work currently being undertaken by the NASRDA with the Nigeriasat-1, Nigeriasat-2 and Nigeria-sat-X satellites is outlined in Table 9.4.

The Role of Geo-Spatial Techniques in M&E

The NASRDA has the mandate to provide both the infrastructure and technical competence in the development and deployment of space-based technologies for the socio-economic development of Nigeria. In pursuit of this goal, during the last decade the NASRDA has deployed three earth observation satellites and one telecommunications satellite into space. Currently two earth observation satellites (NigeriaSat-2 and Nigeria Sat-X) are operational. These have daily revisit periods over Nigeria, thereby providing capacity to adequately monitor the rates and trends of development. In addition, the NASRDA has successfully developed the capacity to deploy remote sensing and GIS tools to use the products of these satellites to support research in agriculture, infrastructure development, environmental hazards and management, security, demography, etc.

Between July and October 2012, about 12 States in Nigeria were severely affected by flooding. A post-disaster needs assessment carried out by the National Emergency Management Agency (NEMA) in conjunction with other stakeholder institutions, estimated the impact of the flood to be 2.62 billion Naira (NEMA, 2013). The total area of agricultural land affected by the flood was estimated at 11,044 km^2, with an estimated 30% of rice crop production lost to the flood (NEMA, 2013).

Assessment of the areas affected by the flood and the post-impact analysis were aided by the deployment of space techniques. Working in collaboration with the United Nations Platform for Space-based Information for Disaster Management and Emergency Response,

Table 9.3 Recommended milestones and indicators for climate-resilient agriculture in Nigeria

ENABLING FACTORS	MILESTONES	INDICATORS	DEFINITION OF INDICATORS
Farmers are using climate information for planning and employing climate-resilient agriculture	Farmers are aware of future climate projections for their locality	% of farmers able to describe broad future climate trends	Local knowledge on climate change is important in catalysing action on adaptation Raising awareness of expected trends in future climate gives farmers a base of information upon which to plan and analyse risks
	Farmers are monitoring key climate variables Farmers have the skills, knowledge and awareness to develop their own indicators of climate inputs	Mechanisms in place to monitor key climate variables (e.g., rainfall, temperature, extreme events) Observations of climate change are recorded	Monitoring of climate variables is an essential step in managing climate variability and in preparing for longer-term climate change Local observations of climate change are important to complement scientific information that is often available only at large scales
	Farmers are using climate information in planning livelihood strategies	% of farmers including vulnerable groups using climate monitoring information to plan their livelihoods (e.g., shifting to early maturing crops)	When available, climate monitoring information and seasonal forecasts can help in planning and analysing risks to agriculture and other livelihood strategies.
	Farmers are producing crops that are resilient to climate hazards	% of farmers including vulnerable groups growing crops that are resilient to climate hazards affecting the target area (e.g., drought-resistant varieties)	Crops and varieties that are suited to the changing climate must be introduced and adopted in order to reduce risk of crop loss
	Farmers are practising conservation agriculture	% of farmers using conservation agriculture practice.	Conservation agriculture practices conserve soil moisture and increase fertility, thereby increasing resilience to erratic rainfall
	Farmers are aware of adaptation strategies	% of farmers aware of climate-resilient strategies appropriate to their context	Farmers need to know that there are alternatives in order to plan for adaptation
	Farmers have technical skills to implement adaptation strategies	% of farmers trained in technical skills % of farmers demonstrating application of skills	Some adaptation strategies may require new technical skills for implementation Application of skills demonstrates proficiency

ENABLING FACTORS	MILESTONES	INDICATORS	DEFINITION OF INDICATORS
	Mechanisms exist for sharing seasonal forecasts and climate monitoring information	% of farming communities where seasonal forecasts and climate information are shared	Farmers need information about climate in order to analyse risk and plan accordingly
		Means of sharing (e.g., radio, mobile phones, community meetings, etc.)	A variety of communication means may be needed to reach the entire farming community
	Farmers are aware of how to access this information and are able to properly interpret and communicate climate change projection	% of farmers aware of information sharing mechanisms	In order for communication to be effective, farmers must be aware of how and when information is shared
Building capacity of extension workers	Extension workers understand climate risks	Extension workers are aware of climate trends	Extension workers work directly with communities, providing technical support on farmers' livelihoods, so it is important that these agents are aware of climate trends and how these may impact farmers' livelihoods.
		Extension workers are able to link climate trends to impacts on farmers' livelihoods	
	Extension workers are promoting adaptation strategies	Extension workers are aware of appropriate adaptation strategies for the local context	Awareness of climate trends should lead to identification and promotion of adaptation strategies by extension workers
		Extension workers are integrating adaptation strategies in their work with farming communities	
National and local planning processes	National and local planning processes incorporate mechanisms for participation by civil society organizations and farmers' organizations	National/local planning processes specifically mandate participation of civil society and farmers' organizations	Participation of civil society and farmers' communities in national/local planning is essential to good governance
	Views of civil society and farmers' organizations are integrated in national and local plans	Civil society and farmers' organizations feel their views have been taken up in national/local plans	Real participation means civil society including farmers are able to influence decision-making
		National/local plans reflect civil society and farmers' priorities	
	National/local planning processes incorporate mechanisms to ensure the views of women and youth are integrated	National/local planning processes specifically mandate participation of women and youth	Participation of women and youth in national/local planning is essential to good governance
			Real participation means women and marginalized groups are able to influence decision-making

ENABLING FACTORS	MILESTONES	INDICATORS	DEFINITION OF INDICATORS
	Land tenure policies provide secure access to and control over land	Land tenure policies provide clear guidance on tenure Land tenure policies do not discriminate against women and youth	Unclear tenure policies can lead to conflict among land users and owners Farmers need to understand what their rights are in order to ensure security of tenure Discriminatory policies can exacerbate vulnerability
	Government policy and planning documents incorporate analysis of the vulnerability of women and youth	Number and type of policy and planning documents that incorporate vulnerability analysis, and incorporate actions to address specific vulnerability of women and youth Quality of actions identified	An equitable approach to adaptation requires analysis of differential vulnerabilities among genders and social groups The quality of the analysis is important to lead policymakers to appropriate actions Ideally the analysis will lead to the identification of actions that address specific vulnerability of women and youth

Box 9.1 Building Nigeria's Response to Climate Change (BRNCC)

The BNRCC project operated between 2007 and 2011 and used community-based adaptation approaches in its pilot projects. The M&E of the pilot projects assessed deliverables on such objectives as improvements in climate-resilient livelihoods, disaster risk reduction, local capacity development, reduction of the underlying causes of vulnerability and changes in policy that assist communities in adaptation. Indicators were both qualitative and quantitative. Separate assessments were made for women and men to show differences in outcomes by gender. Other indicators were the level of knowledge of climate change, vulnerability status, gender sensitivity, adaptation practices and whether the project was community-driven (bottom-up rather than top-down).

Source: NEST and Woodley (2012).

the Regional Centre for Training in Aerospace Survey and the NEMA, the NASRDA acquired, processed, analysed and mapped the areas affected by the flood disaster. The assessment monitored and evaluated the extent of damage to housing, crops and infrastructure and measured the total area of farmland affected using GIS/remote sensing change detection techniques. The evaluation and comparison of pre- and post-disaster satellite images allowed the team to produce maps, charts and tables to clearly identify areas with partial and total damage. The evaluation forms the basis for risk reduction in the event of future disaster, and remediation in the affected sectors.

9.7 Structures, Staffing and Capacity Requirements

The large range of stakeholders who need to be involved in M&E regarding the transition to climate-resilient agriculture in Nigeria presents a considerable challenge to identifying appropriate structures, staffing and capacity requirements. The scenario is complicated

Table 9.4 NASRDA projects

PROJECT TITLE AND STATUS	AIMS/OBJECTIVES	SOCIO-ECONOMIC IMPACT	COLLABORATING INSTITUTIONS
1. Development of a model for cassava yield prediction using remote sensing and GIS Project completed	To model the physical features – topography, soil type, moisture content, location etc. – for predicting cassava yield To identify agro-meteorological elements of rainfall and temperatures as constraining factors for cassava production To compare trends obtained from remote sensing/GIS technologies against the current field, sub-plot, sampling method over a two-year period To provide data on the cultivatable land suitable for cassava production	Provide data on area of land put to cassava Provide data on how to increase production Provide information on potential land area	The FMARD IITA
2. Monitoring deforestation and its implications on biodiversity using data from Nigerian satellites Project completed	To evaluate spatio-temporal changes in Nigeria's reserves and its implications on flora and fauna using a GIS system-based forests monitoring and Nigerian satellites as primary data sources	The research aims to help bring about an environmentally profitable modification of policies and decision-making processes relevant to agriculture and the forestry sector in Nigeria	Obafemi Awolowo University
3. Development of Fadama Land Information Management System Project completed	To assist in the enhancement of Fadama (wetland) based rice cultivation and to boost production in Nigeria	To boost Nigeria's potential for increased rice cultivation and rice production monitoring	
4. Land use/land cover mapping of Nigeria Project ongoing	To update the current land use/land cover map produced by the Forestry Research M&E Unit (FORMECU) in 1995	To facilitate the automation of the production of land use/land cover maps of Nigeria at a good scale of 1:100,000 every five years using Nigerian satellites	The FORMECU University of Ibadan Regional Centre for Training in Aerospace Surveys
5. Satellite mapping and monitoring of irrigation command areas in Nigeria Project ongoing	To conduct a comprehensive mapping of irrigation command area distribution, and utility status of irrigation command areas using remote sensing and GIS technologies	To update spatial and statistical information on projects and monitor the level of success of irrigation programmes (e.g., Fadama) To assess potential for the application of satellite data and GIS in the monitoring of agricultural land use change projects including irrigation, floodplain development and environmental factors affecting them	
6.Nigeriasat-1 satellite data and ICT-based farming (E-agriculture) Project ongoing	To apply space technology to improve agriculture and increase productivity	Improve production practices, access to markets and food security	The FMARD The NIMET IITA

further by the fact that some of the key agencies involved are located in ministries other than the FMARD. Thus, their line management, supervisory and reporting functions are very much outside the remit of the FMARD.

This makes it difficult for M&E data to be collated, shared and disseminated, and the current situation is chaotic, ad-hoc and creates duplication. As a result, there is poor translation of data into coherent policymaking, and the dissemination of information to the primary beneficiaries – the farming, pastoralist and fishing communities – is lacking. A further complication arises from the fact that Nigerian agriculture is dominated by small-scale farmers, who have less adaptive capacity than their large commercial counterparts.

What is clear from the ACARN meetings, stakeholder Town Hall meetings, and interactions with the different government departments, agencies, institutions, etc., is that they all admit to experiencing profound challenges in terms of delivering effective M&E for climate-resilient agriculture in Nigeria. These include reporting structures (over-bureaucratic and duplicating), staffing (quantity and quality of skilled personnel), capacity and resources in terms of operating budgets, transport vehicles, information and communication technology (ICT) equipment and infrastructure, office accommodation, etc.

The NASRDA, an agency of the Federal Ministry of Science and Technology, has outlined key challenges in recovering their costs from stakeholders with regard to the downloading, encryption and transcription costs from their satellite systems. They also have difficulty recruiting and retaining skilled staff, given their high-tech operations.

For the Department of Land Resources (under the FMARD), their challenges relate to poor quantity and quality of staff and resources, particularly transport and ICT equipment and infrastructure.

The Agricultural Extension Services Department (under the FMARD) has a key role to play, particularly with regard to participatory approaches that involve the farming, pastoralist and fishing communities. Enhanced participation will secure sustained buy-in from these key end-user communities, giving them better access to and use of the data. This in turn will support the social learning and behavioural change needed to promote the transition to climate-resilient agriculture. However, as mentioned in previous chapters, the agricultural extension services suffer from a lack of investment and, at present, struggle with limitations in human resources and transport.

The NIMET, an agency of the Federal Ministry of Aviation, identifies its challenges as poor quantity and quality of staff, and the need for resources with regard to increasing its limited number of weather stations. These are needed so that they can provide more timely and detailed weather information and forecasting through communication outlets, such as radio stations and mobile phones, at minimal cost to the farming, pastoralist and fishing communities in Nigeria.

The ARCN of the FMARD is currently planning a major re-alignment of its structures, which include multi-institutional research institutions, universities of agriculture, faculties of agriculture, etc. The intention is to streamline its programmes and activities, address the waste of resources from duplication by its various entities, and identify where the gaps are, particularly with regard to extension services and reducing the gap from the "laboratory to the farm and to the fork".

There is also a need to structure and address the shortcomings in M&E in the ARCN's institutions. A possible way forward is to create a centralized M&E unit within the ARCN to co-ordinate and focus the M&E activities of its constituent entities. This centralized M&E unit could provide a coherent framework that would deliver not only cost savings through cutting duplication, but also an enhanced service to extension staff and end-users in the farming, pastoralist and fishing communities through the REFILS project.

Other relevant Federal Government ministries are those concerned with water resources, environment, and land and urban development. Their roles in the M&E of climate-resilient agriculture and the challenges they face in this regard also need to be investigated and streamlined in order to deliver a cohesive and effective M&E framework.

The complex and multi-institutional nature of the current scenario means it will be difficult to define the appropriate structures, staffing and capacity requirements for the delivery of effective M&E for climate-resilient agriculture in Nigeria in line with the ACARN recommendations. What is required is a comprehensive review of all current stakeholders, including the various government departments and agencies, and the nature of their current roles. This will provide clarity as to who undertakes what M&E, where the overlaps and duplication occur, where there are gaps in data and provision, where cost savings can be made through identification of economies of scale and cutting duplication, and the best strategic fit for all the different agencies and organizations.

9.8 Gender Mainstreaming for M&E

For M&E to have the desired effect of enhancing the transition to climate-resilient agriculture in Nigeria, it needs to be implemented in a mainstreamed approach that ensures the buy-in of all relevant stakeholders, including the Federal Government; farming, pastoralist and fishing communities; civil society; the private sector; and agro-processers – in short, all those involved in the agriculture value chain.

It will be particularly important to strengthen the capacity of women's ministries, women's groups and gender researchers to capture and document gender perspectives of climate change. The practical implications for adaptation planning is fundamental to gender mainstreaming in the M&E of climate-resilient agriculture in Nigeria.

A framework should be developed as part of the FMARD's implementation of the ACARN Report to generate the pivotal networks of gender researchers, empowerment practitioners, women farmers (who form the majority of smallholder farmers in Nigeria), and relevant strategic Federal Government ministries such as the Ministry of Women's Affairs, to dialogue, conceptualize and design a strategic gender mainstreaming programme for climate-resilient agriculture in Nigeria. A key goal for this framework will be to deliver sustainable equitable gains for women throughout the agriculture value chain and provide them with the tools they need to participate fully in and contribute to the effective M&E of climate-resilient agriculture in Nigeria.

Box 9.2 highlights good practice recommendations with regard to the sustainability of M&E for climate-resilient agriculture and gender mainstreaming, and Box 9.3 describes a smallholder agricultural adaptation programme.

9.9 Conclusions

M&E is crucial for assessing the effectiveness of the FMARD's strategies (policies, programmes, projects, activities, etc.), to deliver its vision of innovative climate-resilient agriculture in Nigeria. There are many challenges to implementing effective M&E. The first key one relates to the dynamic nature of climate change and agriculture, and the corresponding need for rapid and continuous data gathering and analysis,

Box 9.2 Climate change, agriculture and food security

There are few climate change adaptation projects and programmes already in practice in the smallholder agriculture sector. It is therefore valuable to learn from those that do exist. The CGIAR research programme on Climate Change, Agriculture and Food Security has recently published a working paper entitled *Monitoring Adaptation to Enhance Food Security: A Survey of Approaches and Best Practice*. As the title states, the paper reviews recent approaches to M&E of climate change adaptation projects. In particular, it explores methods to monitor and evaluate outcomes for local food security.

The authors of the paper draw the following lessons for M&E of adaptation projects in smallholder agriculture:

- Agree on a common framework or outcome pathway with clear and agreed outcomes. A common framework keeps all stakeholders focused on the desired outcomes (not just indicators of process), as well as the best approach to evaluating successful adaptation.
- Use scenarios exercises to handle the necessary planning under uncertainty, combined with *ex-ante* assessments of adaptation investments and interventions to identify robust strategies.
- Be explicit about what constitutes successful adaptation for the outcome pathway. Use this logic to track progress of the selected robust strategies on the ground.
- Take a learning approach to M&E with stakeholders at multiple institutional levels. This means using incoming information from monitoring on a regular basis to evaluate progress collectively and decide on any necessary change of course.
- Enable and encourage data sharing across projects doing M&E of adaptation.
- Agree on a system for assessing and prioritizing among desired outcomes for food and nutrition security, local livelihoods, rural development, adaptation and environmental benefits.

Source: Chesterman and Ericksen (2013)

Box 9.3 IFAD's Adaptation for Smallholder Agriculture Programme

IFAD launched the Adaptation for Smallholder Agriculture Programme (ASAP) in 2012 to make climate and environmental finance work for smallholder farmers. The ASAP is driving a major scaling up of successful 'multiple-benefit' approaches to smallholder agriculture, which improve production while reducing and diversifying climate-related risks. In doing so, the ASAP is blending tried-and-tested approaches to rural development with relevant adaptation know-how and technologies.

ASAP Goal: Poor smallholder farmers are more resilient to climate change.

ASAP Purpose: Multiple benefit adaptation approaches for poor smallholder farmers are scaled up.

Source: Adapted from www.ifad.org/climate/asap

as well as information dissemination. The second key challenge is the uncoordinated and ad-hoc nature of the current multi-institutional response.

9.10 References

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10

Conclusions and Recommendations

"Agriculture – is our wisest pursuit, because it will in the end contribute most to real wealth, good morals, and happiness."

—**Thomas Jefferson** in a letter to George Washington.[1]

"In the longer term, climate change is likely to have a bigger effect on food supply than any other factor. Moreover, agriculture will probably be affected more than any other economic sector in the developing countries (this may also be true for developed countries)."

—**Sir Gordon Conway**[2]

Nigeria's ATA is based on the premise that agriculture has the power to drive the economic development of the country. History shows that this can – and has – been the case in numerous countries around the world. However, climate change has the potential to derail the promised agricultural revolution unless appropriate action is taken, and policy, regulatory and institutional frameworks are developed, to guide the implementation of the Agenda and insulate it from the shocks and stresses caused by the impacts of climate change. As climate change amplifies the environmental and socio-economic drivers of food insecurity, it is imperative to prioritize where, how and when to act. There is an urgent need to instil resilience in the Nigerian agriculture sector through a shift to climate-resilient agriculture. This requires the development and implementation of planned adaptation initiatives, the outputs and outcomes of which must be assessed and evaluated systematically.

The members of the ACARN include distinguished and experienced experts on the subject matter from around the world. They include senior functionaries from the World Bank, the African Development Bank and the CGIAR. But it was clear from the outset that as distinguished as the Committee members are, there is no substitute to hearing from the farmers themselves in terms of the impacts of climate change they have experienced, and the methods deployed by them as individuals and communities in adapting to the problems encountered. Town-Hall-style meetings in all six geo-political zones of the country were therefore scheduled as part of the ACARN work programme to gather information and promote interaction among stakeholders.

The members also exchanged information with research institutes of the ACARN and the university system, as well as River Basin Authorities. These Authorities interact with the agricultural communities on a regular basis and are well positioned to attest to the farmers' innovative practices in the face of climate change and their preparedness and capability in adapting introduced technologies.

The ACARN'S subsequent interactions in the field have shown that trying to provide definitive answers using scientific knowledge and climate models was not what farmers wanted or needed most. Rather, there is evidence that, even with limited or no formal education, farmers have demonstrated dexterity in using simple science-based rules of thumb at critical points (often narrow windows), such as for planting, harvesting, pest control, etc. They use these rules to make better-informed decisions and minimize their risk while maximizing their opportunities, given the fact that the future twists and turns of the changing climate may never be fully anticipated.

The methodology adopted in this study was to distil the priority risks to the agriculture sector posed by climate variability and climate change, to enquire into the most suitable strategies and technologies for overcoming or coping with such risks, and to make recommendations as appropriate that will lead to either their resolution or containment.

Policies for climate-resilient agriculture must simultaneously address (or balance) a variety of needs, including productivity, nutrition, farmer profitability, inclusiveness, access and environmental sustainability. Many stresses and shocks are interlinked; for example, energy and input price volatility, extreme weather events and climate change, growing scarcity of natural resources and poverty and inequality. Policies must factor these competing challenges.

1 Kaminski, J.P. 2006. The Quotable Jefferson. Princeton, NJ, USA: Princeton University Press.

2 Conway, G. 2012. One Billion Hungry: Can We Feed the World? Ithaca, USA: Comstock Publishing Associates.

To mainstream climate change adaptation and entrench agricultural resilience, the FMARD will need to undertake multifaceted risk assessments that incorporate not only climate risk, but also existing vulnerabilities, such as low levels of development, a dearth of appropriate institutions and legal frameworks, poor governance models, and projected future trends such as population growth, rural-to-urban migration, and increasing land and water scarcity.

In the longer term, climate change is likely to have a bigger effect on food supply than any other factor. Although much progress has been made in developing adaptive farming systems through agro-ecological technologies and by breeding for drought or submergence tolerance, the applications are often small in scope and should be increased.

Recommendations

Governments (Federal, state and local), in partnership with the private sector, development partners and NGOs, should:

- Put climate-resilient agricultural policies at the heart of broader government economic policy, including the further development of agricultural value chains and an environment conducive to private investment.
- Adapt meteorological, hydrologic and oceanographic data and information, including early warning systems, to the needs of agricultural communities by improving spatial-temporal scales of forecasts and models and by providing timely and accurate advice on tactical and strategic decisions.
- Support sustainable intensification of agriculture by scaling up conservation farming, integrated pest management, efficient resource management and modern plant/livestock/fish breeding technologies while conserving and managing local germplasm, *in situ* and *ex situ*, for future breeding programmes and strengthening local rights over farmland and common natural resources.
- Target funding aimed at reducing land degradation, emphasizing the design of systems for financial, insurance and other incentives, and support the development of major water-use schemes, such as irrigation, micro-catchment water harvesting and conservation, as appropriate.
- Develop innovative adaptation programmes such as agroforestry, sustainable land management, conservation agriculture, etc. in consultation with local communities, and make the necessary investments to fund major efforts to take these initiatives to a large scale.
- Develop improved range management (e.g., sown pastures) and explore collaboratively with pastoralists viable futures for the development of pastoralism in Nigeria. Options to consider include a move towards more sedentary livestock management and creation of a national network of well-defined stock routes and watering points.
- Overhaul both the agricultural extension and research services and the national agricultural research management systems for efficiency and effectiveness of actions.
- Improve funding for research on climate resilience in Nigerian agriculture to provide a secure and competitive financial resource base for top-quality research.
- Develop strategies for mechanization of agricultural production.
- Build capacity within the FMARD and the agricultural research system to routinely and successfully model the vulnerabilities of the agro-ecological systems to the vagaries of climate change to enable a continuous refinement of the strategies and agro-technologies made available through research and production for management of climate risks for resilience in agriculture.
- Institute a credible monitoring and evaluation system to help create efficiencies and track improvements in climate-resilient agriculture implementation.
- Create an Agricultural Resilience Fund to provide a steady and predictable funding stream to strengthen agricultural resilience and implement a robust climate-resilient programme in Nigeria.

While concerted actions would seem a *fait accompli*, this report insists that the Federal Government has the distinct responsibility to create the enabling environment – social, economic and political – propitious for building and entrenching the requisite resilience. The implied actions, policies and institutions go beyond the mandate of the FMARD to other complementary but equally critical sectors:

- **Water resources:** more efficient river basin management planning would provide a resilient, sustainable water environment that protects existing quality and promotes improvements in irrigation, water harvesting and soil moisture-retaining technologies.
- **Aviation:** the Nigerian Meteorological Agency would provide state-of-the-art and real-time weather forecasting services, including early warning systems to agricultural communities.

- **Energy:** this would drive the development of technologies, policies and actions towards alternative and renewable energy sources that would enable the transition away from fossil fuels to a low-carbon economy.
- **Industry:** this will ensure vast and reliable markets for farm produce and generate employment.
- **Commerce and trade:** this will keep the agriculture value chains fully functional and lucrative through pragmatic trade policies and marketing strategies.
- **Works and transport:** this will build the needed infrastructure, such as all-season and durable road networks that are critical for linking rural and urban economies.
- **Science and technology:** this can stimulate research that will inform policy development and underpin actions in the sector.
- **The Ministry of Finance:** this body will provide a catalysing financial and investment environment.

Cutting across these institutional boundaries are systems of private sector governance and civil society preferences and advocacy. There is obviously a need for harmonization or restructuring of the architecture for planning, programme formulation and implementation support across institutions with mandates relating to the many dimensions of food security, poverty eradication, sustainable development and climate change.

The links required to build an agricultural resilience platform suggests that it would be a good idea for the FMARD to host a ministerial-level dialogue prior to the implementation of this report, to focus the attention of various sectors of the national economy on the intertwined nature of the recommended actions and policies. This would also promote buy-in by other players deemed critical to the implementation process. The need for clear role assignments and cohesion among the various ministries, departments and agencies of government, the private sector, development partners, NGOs, CBOs and agricultural communities could not be stressed more.

Nigeria must navigate towards a 'safe operating space' that provides adequate food and nutrition security for everyone, while boosting robust economic growth and without crossing critical environmental thresholds. Charting a course towards this space will require innovative technologies, policies and institutions that will guarantee agricultural resilience to the impacts of current and future changes in the climate regime. While change will have significant costs, the implications of remaining on a 'business as usual' path is already enormous and growing. Given the already intolerable conditions of many livelihoods and ecosystems and the time lag between research and development and widespread application, urgent action must be taken now.

Whereas the present NARF report presents a robust framework for achieving agricultural resilience, the greater challenge is its implementation. Scoping an implementation plan that would encapsulate the building of competencies within the FMARD to routinely undertake the implied tasks and accomplish expected outcomes is the next critical mission for the ACARN. It will be crucial to the accomplishment of the objectives and targets of agricultural resilience in Nigeria.

Implementation of the NARF should be based on principles of adaptive management and participatory engagement as the central tenets of the overall implementation strategy. Adaptive management acknowledges uncertainty as a context of decision-making and builds flexibility into policy and decision-making to manage risk. It also allows for new knowledge input. This is important because agriculture sector investments are capital-intensive and long-lived; building climate change considerations into the design of these investments is necessary even with some degree of uncertainty in climate projections. Decisions made in other sectors almost always have an impact on the ability of the natural environment to adapt. It is important that adaptation activities for agriculture take into account the role of the natural environment and develop solutions that are in harmony with nature.

Annexes

Annex 1 Acronyms and Abbreviations

ACARN Advisory Committee on Agricultural Resilience in Nigeria

AEZ agro-ecological zone

ARCN Agricultural Research Council of Nigeria

ASAP Adaptation for Smallholder Agriculture Programme

ATA Agricultural Transformational Agenda

BNRCC Building Nigeria's Response to Climate Change

CAADP Comprehensive Africa Agriculture Development Program

CAK

CBO community-based organization

CCAFS Climate Change Agriculture and Food Security

CDM Clean Development Mechanism

CGIAR Consultative Group on International Agricultural Research

CILSS Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel / Permanent Interstates Committee for Drought Control in the Sahel

CMCC-MED Centro Euro-Mediterraneo sui Cambiamenti Climatici - Mediterranean

CMIP3 Coupled Model Intercomparison Project

CO2 carbon dioxide

COSMO-CLM COSMO Model in Climate Mode

CSO civil society organization

DSSAT Decision Support System for Agro-technology Transfer

ECOWAS Economic Community of West African States

EMBRAPA Brazilian Agricultural Research Corporation

EU European Union

FAO Food and Agriculture Organization of the United Nations

FDI Foreign Direct Investment

FFS farmer field school

FGN Federal Government of Nigeria

FMARD Federal Ministry of Agriculture and Rural Development

FME Federal Ministry of Environment

FMWR Federal Ministry of Water Resources

FORMECU Forestry Research Monitoring and Evaluation Unit

GCCA Global Climate Change Alliance

GCM General Circulation Models

GCTD Global Climate Technology Development

GDP gross domestic product

GEF Global Environment Facility

GIS geographic information system

ha hectare

IAR&T Institute of Agricultural Research and Training

ICI International Climate Initiative

ICRISAT International Crops Research Institute for the Semi-Arid Tropics

ICT information and computer technology

IFAD International Fund for Agricultural Development

IFC International Finance Corp

IFPRI International Food Policy Research Institute

IIGCC Institutional Investors Group on Climate Change

IITA International Institute of Tropical Agriculture

IPCC Intergovernmental Panel on Climate Change

ITD Inter-Tropical Discontinuity

JICA Japan International Cooperation Agency

KfW Kreditanstalt für Wiederaufbau / Reconstruction Credit Institute

LDC Least Developed Country

LDCF Least Developed Country Fund

M&E monitoring and evaluation

MDG Millennium Development Goal

mm millimetre

NAIC National Agriculture Insurance Company

NAMA nationally appropriate mitigation activity

NAPRI National Animal Production Research Institute

NARF National Agricultural Resilience Framework

NARP National Agricultural Research Project

NARS national agricultural research system

NASPA-CCN National Adaptation Strategy and Plan of Action on Climate Change for Nigeria

NASRDA National Space Research and Development Agency

NCRS National Centre for Remote Sensing

NEMA National Emergency Management Agency

NEST Nigeria's Environmental Study/Action Team

NFACS National Framework on Application of Climate Services

NGO non-governmental organization

NIHSA Nigeria Hydrological Services Agency

NIMET Nigeria Meteorological Agency

NIOMR Nigerian Institute for Oceanography and Marine Research

NSIF-SLM Nigeria Strategic Investment Framework for Sustainable Land Management

NSPRI Nigerian Stored Products Research Institute

NTWG National Technical Working Group

ODA Overseas Development Assistance

PPCR Pilot Program for Climate Resilience

RBDA River Basin Development Authority

RCM regional climate model

REDD Reducing Emissions from Deforestation and Forest Degradation

REFILS Research Extension Farmers Input Linkage System

SCCF Strategic Climate Change Fund

UK United Kingdom

UNCTAD United Nations Conference on Trade and Development

UNDP United Nations Development Programme

UNFCCC United Nations Framework Convention on Climate Change

USAID United States Agency for International Development

US United States

WMO World Meteorological Organization

WECARD/CORAF West and Central African Council for Agricultural Research and Development / Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles

Annex 2 Definition of Key Terms and Concepts

Adaptive capacity: The ability of a system to adjust to climate change (including climate variability and extremes) and other stressors to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Agriculture: The use of water and soil for crop production, forestry, livestock and fisheries, including aquaculture.

Agricultural resilience: The capacity of agricultural development to withstand or recover from stresses and shocks and thus bounce back to the previous level of growth. A stress can be defined as a regular, sometimes continuous, relatively small and predictable disturbance, for example the effect of growing soil salinity or lack of rainfall. A shock, on the hand, is an irregular, relatively large and unpredictable disturbance, such as is caused by a rare drought or flood. Resilient agriculture creates agricultural growth out of knowledge, investment and innovation, while simultaneously building the capacity of farmers, particularly smallholder farmers to counter environmental degradation and climate change.

Agroforestry: A system of land use in which harvestable trees or shrubs are grown among or around crops or on pastureland, as a means of preserving or enhancing the productivity of the land.

Climate: Climate in a narrow sense is usually defined as the "average weather" or, more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often weather parameters such as temperature, precipitation and wind. The classical period is 30 years, as defined by the World Meteorological Organization.

Climate change: Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate change adaptation: The Intergovernmental Panel on Climate Change describes it 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. The United Nations Development Programme defines it as a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed and implemented.

Climate change mitigation: Refers to efforts to reduce or prevent emission of greenhouse gases. The Intergovernmental Panel on Climate Change defines it as human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Climate hazard: Any event or change in climate, such as a single extreme event that exceeds a critical threshold, or a complex combination of changes involving multiple climate variables and/or resulting in multiple impacts.

Climate impacts: Measurable outcomes of (or system responses to) changing climate and/or climate extremes that are typically modulated by changes in bio-geophysical and anthropogenic systems.

Climate model: A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties. Coupled atmosphere/ocean/sea-ice General Circulation Models provide a comprehensive representation of the climate system and they can be applied as a research tool, to study and simulate the climate, but also for operational purposes, including monthly, seasonal and inter-annual climate predictions.

Climate prediction: A climate prediction or climate forecast is the result of an attempt to produce a most likely description or estimate of the actual evolution of the climate in the future, e.g., at seasonal, inter-annual or long-term time scales.

Climate projection: A projection of the response of the climate system to emission or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based upon simulations by climate models. Climate projections are distinguished from climate predictions in order to emphasize that climate projections depend upon the emission/concentration/radiative forcing scenario used, which are based on assumptions, concerning, e.g., future socio-economic and technological developments, that may or may not be realized, and are therefore subject to substantial uncertainty.

Climate resilience: The capacity of an individual, community, or system to dynamically and effectively respond to current climate variability and future climate impact while continuing to function at an acceptable level. Simply put, it is the ability to survive and recover from the effects of climate variability and change.

Climate scenario: A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate. A climate change scenario is the difference between a climate scenario and the current climate.

Climate-resilient agriculture: Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals. Also referred to as climate- resilient agriculture.

Climate system: The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere, and the interactions between them.

Climate variability: Variations in the mean state and other climate statistics (standard deviations, the occurrence of extremes, etc.) on all temporal and spatial scales beyond those of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forces (external variability).

Conservation agriculture: A concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment.

Desertification: Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. The United Nations Convention to Combat Desertification defines land degradation as a reduction or loss (in arid, semi-arid, and dry sub-humid areas) of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation.

Extreme weather event: An extreme weather event is an event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called extreme weather may vary from place to place.

Greenhouse gases: Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere.

Integrated assessment: A method of analysis that combines results and models from the physical, biological, economic and social sciences and the interactions between these components, in a consistent framework, to evaluate the status and the consequences of environmental change and the policy responses to it.

Land use: The total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The social and economic purposes for which land is managed (e.g., grazing, timber extraction and conservation).

Land use change: A change in the use or management of land by humans, which may lead to a change in land cover.

Low-carbon economy: Refers to an economy that has a minimal output of greenhouse gas emissions into the biosphere.

Low-carbon development: Low-carbon development is generally used to describe forward-looking national economic development plans or strategies that encompass low-emission and/or climate-resilient economic growth.

Resilience: Ability of a system to cope with or absorb stress or impacts and bounce back, recover and adapt to change.

Uncertainty: An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections of human behaviour.

Vulnerability: Degree to which people, property, resources, systems and cultural, economic, environmental and social activity are susceptible to harm, degradation or destruction on being exposed to a hostile agent or factor. The Intergovernmental Panel on Climate Change defines it 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.

Water harvesting: A method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions.

Annex 3 Chapter Author Attributions

Chapter 1

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