Working Paper

Future Agricultures

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AfricaInteract: Enabling research-to-policy dialogue for adaptation to climate change in Africa

Review of Research and Policy for Climate Change Adaptation in the Agriculture Sector in Central Africa

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Table of Contents

Acronyms and Abbreviations

AAP	African Adaptation Program
AfDB	African Development Bank
APRM	African Peer Review Mechanism
CAADP	Comprehensive Africa Agriculture Development Programme
CAR	Central African Republic (Republique Central africaine)
CARPE	Central African Regional Program for the Environment
CCAA	Climate Change Adaptation for Africa
CED	Centre for Environment and Development
CERAD	Central European Weather Radar Network
CFC	Chlorofuorocarbons
CIFOR	Center for International Forestry Research
COMIFAC	Commission des Forêts d'Afrique Centrale
CORAF/WECARD	Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles / West and Central African Council for Agricultural Research and Development
CSA	Climate-smart agriculture
DFID	Department for International Development (UK)
DRC	Democratic Republic of the Congo
FAO	United Nations Food and Agriculture Organization
GCOS	Global Climate Observing System
GDP	Gross domestic product
GNP	Gross National Product
GESP	Growth and Employment Strategy Paper
GHG	Greenhouse gas
GIS	Geographic information system
HEVECAM	Hévéa du Cameroun
HIV/AIDS	Human Immunodeficiency virus/Acquired immunodeficiency Syndrome
ICRAF	World Agroforestry Centre
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute

IPCC	Intergovernmental Panel on Climate Change
IRAD	Institut de Recherche Agricole pour le Developpment (Cameroon)
IUCN	International Union for the Conservation of Nature
JICA	Japan International Cooperation Agency
LCBC	Lake Chad Basin Commission
MDG	Millennium Development Goal
MINADER	Ministry of Agriculture and Rural Development (Cameroon)
MINEP	Ministry of Environment and Nature Protection (Cameroon)
MINEPIA	Ministry of Livestock, Fisheries and Animal Industries (Cameroon)
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Programme of Action
NEMP (PNGE)	National Environmental Management Plan
NEPAD	New Partnership for Africa
NESDF	National Environment and Sustainable Development Fund
NGO	Non-governmental organisation
OECD	Organization for Economic Cooperation and Development
ONACC	National Observatory on Climate Change (Cameroon)
UAIC	Unite d'Afforestation Industrielle du Congo
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICONGO	Union patronale et interprofessionelle du Congo
WCS	Wildlife Conservation Society
WWF	World Wide Fund for Nature

Executive Summary

This report is the result of a review carried out to synthesise research and policies related to the adaptation of agriculture to climate change in the Central African region. Climate change poses serious challenges to the agriculture sector in the Central African region. Africa has generally been considered among the most highly vulnerable regions to climate change because of extremes of drought, flooding, inappropriate land tenure systems, over-dependence on rain-fed agriculture and widespread poverty.

All the countries of the region are signatories to the United Nations Framework Convention on Climate Change (UNFCCC); participate in regional institutions including the African Union's New Partnership for Africa's Development (NEPAD) with its Comprehensive Africa Agriculture Development Programme (CAADP) and African Peer Review Mechanism (APRM); have created structures for climate change issues (a National Climate Change Unit in Cameroon, a National Climate Council in Gabon and an Industrial Afforestation Unit in the Congo Republic); have ongoing policies, instruments and initiatives for climate change adaptation; and exhibit some awareness among stakeholders of the serious climate change impacts on agriculture, livestock, pastoralism and fisheries. However, many countries are yet to establish field research activities on adaptation. Also, governments appear to lack firm funding commitments on adaptation, arguing that financing of climate change adaptation should be carried by external donors or developed country partners.

Government and donor support is needed for the formulation of climate change adaptation strategies because climate change has brought many highly visible problems to agricultural production in the Central African region. For instance, research suggests that the farming calendar has shifted, the rains starting now much later than before; minor crop diseases like the *Colocasia* leaf spot have developed into catastrophic epidemics; the endemic African cassava mosaic disease has developed a highly virulent strain which is devastating this important crop in Central Africa; several high yielding varieties of crop plants have lost their productivity; and many diseases (such as the African swine fever) and related pests have become too severe for livestock, resulting in huge losses. Fish biodiversity, fingerlings for aquaculture, mangroves and coral reefs are being depleted or damaged at a rapid pace in some coastal and maritime areas because of floods, salinity, marine pollution, rise in surface temperatures of rivers and oceans and rising ocean waters.

Research should be supported to develop the necessary technologies in response to a changing climate. Stakeholder actions also need to be coordinated and policymakers committed to enhancing strategies for climate change adaptation. For effective technology dissemination, extension services need to be reinforced and should include the civil society, who, though relegated in some countries, play quite an active role in transferring results to users. The difficulty still remains in addressing these research-extension-policy gaps in a relatively new area like climate change adaptation, in which much theory is known through meetings and public pronouncements but in which there are few empirical thematic research results in crop production and protection, fisheries, livestock production or animal health. In some countries it is even doubtful which mechanisms of climate change adaptation are necessary, and which methods can effect them. Many actors, including policymakers, thus hear of the impacts of climate change but are not even convinced that they exist; and even those who are aware of climate change impacts are not aware that there is a need for adaptation. Until full awareness is achieved by all major stakeholders, the envisaged resilience and adaptation to climate change will remain an issue for the future.

The review shows that although policies exist, funding of adaptation of agriculture to climate change still appears to occupy a position of low priority in the political and economic agenda of the countries studied. This is perhaps why there are scant studies specifically treating adaptation to climate change in agriculture compared to forest conservation, which has received much more research attention because of its vital role in regional economies. Climate change adaptation appears to be quite complex even among the scientific community, and because it is highly contextualised, no single adaptive approach can provide an effective solution for all contexts. Therefore, the development of adaptation solutions may sometimes depend on inborn skills in problem solving. However, even if people are responding, they may not know what specific effective action they can take in response. In order for successful climate change adaptations to occur, a holistic approach needs to be developed. Adaptation measures have a much better chance of being appropriately planned, accepted and maintained if they originate in a process that involves stakeholder engagement.

In the absence of empirical research results, farmers in the region have so far been forced to cope with and adapt to climate change by employing climate-smart strategies – rationally using genetic resources for enhancement of crop genotypes; breeding locally adapted livestock species and breeds; using agro-forestry to enrich the soils and to obtain non-timber food products; practicing crop-livestock integration; exploiting wetlands for crop cultivation and forage production; diversifying livestock types; limiting catch size in fishing; and doing precautionary management of the ecosystem.

Many gaps in adaptation research and policy still exist and include building capacity for improved climate forecasting; developing regional competence in risk assessment; making policies for communal rangeland management; removing subsidies in fisheries, as is recommended in the Lake Chad Basin area; protecting wildlife through domestication, as has been done with the cane rat in Cameroon and Ghana; developing adaptive capacity of farmers; and conducting research

on adaptation of crops and livestock to the harsh environmental conditions of drought, floods and emerging diseases.

It is therefore recommended that, for crop farming adaptation:

(a) More investments should be made in genetic enhancement research so as to produce crop genotypes that are adapted to harsher climates (droughts or flooding).

(b) Technological barriers should be erected to prevent the movement of propagules of vegetatively propagated crops from disease-infested areas to free sites.

(c) Extension systems throughout the region should be reinforced, bringing in the civil society.

(d) Research should critically investigate cultural practices (such as dates of planting; length of growing season; and sensitivity to droughts, flooding, waterlogging, increased temperature, salinity, acidity and aluminium toxicity) with implications for crop performance in the face of climate change.

For livestock and pastoralism adaptation, the following is recommended:

(a) Investments should be made in research and communication to improve understanding of the complex relationship between livestock, pastoralism and climate change.

(c) Capacities should be built along with infrastructure for improved climate forecasting and warning and increase awareness of climate change and its consequences.

(d) Human capital should be strengthened through basic education and public awareness and information on adaptation options made widely available to all stakeholders.

(e) Collaborative research into both endogenous and exogenous adaptation options should be promoted.

For fisheries adaptation the study recommends:

(a) Regional governance of the fishery industry should be strengthened, especially in the Lake Chad Basin area, so as to reduce over-harvest in the region.

(b) Ecosystems (including mangroves and coral reefs) should be protected from degradation and pollution.

(c) Environmentally harmful subsidies should be removed.

(d) Rights-based management systems should be extended.

(e) Focus should be placed on aquaculture and on demand for sustainably caught seafood.

This study identifies good opportunities for collaboration with the various stakeholders. They need to be equitably treated and invited to negotiations right from the start. Given that each actor is somewhat specialised in a certain domain, these competences could be mobilised and brought together to achieve success in pushing forward adaptation strategies to climate change.

From this study, it is suggested that Central African countries, now already aware of the presence of climate change and its impacts, should not only create local instruments for climate change issues but take concrete concerted action to enhance adaptation strategies now so as to save farmers and populations from perishing. Countries will of course face challenges as to which strategies and mechanisms of climate change adaptation are necessary and how to effect them, within which time frame and at what cost.

This review concludes that relevant research is needed in climate change adaptation in the Central African region. The official country policies and instruments on climate change in the region should be followed by a commitment to funding and implementation so as to develop climate change adaptation strategies for the region. Finally, coordination of stakeholder actions could provide immense opportunities for collaboration among them, which will eventually enhance climate change adaptation in agriculture in the Central African region.

1 Introduction

Sub-Saharan Africa is often cited as one of the world's most vulnerable regions (Slingo et al. 2005) since it maintains the highest proportion of malnourished populations, has become more vulnerable, and is now the most exposed region in the world to the impacts of climate change (World Bank 2009). A significant portion of its national economies are dependent on agriculture (Schlenker and Lobell 2010; Benhin 2008), and most of its available water resources (85 percent) are used for agriculture (Downing et al. 1997). Farming techniques are also relatively primitive, the majority of the continent is already arid and the smallholder systems that dominate the agricultural landscape have very limited capacity to adapt (Muller et al. 2011).

The West and Central African Council for Agricultural Research and Development (CORAF/WECARD) recruited experts to synthesise research and policies related to climate change adaptation in the agricultural sector in Africa and make a review to enhance the knowledge base and support research-based policy formulation for climate change adaptation in the agricultural sector in the Central African region. The review, carried out from February through March 2013, had as objectives to (a) make a synthesis of research related to adaptation to climate change in the agricultural sector; (b) identify research and policy gaps related to climate change adaptation in the agricultural sector; (c) identify the key stakeholders as well as the opportunities for improving the research-policy interaction and collaboration in climate change adaptation in the agricultural sector; and (d) show the way research informs policymaking by decision-makers in the countries of the region.

Climate is not a new source of risk to Africa. Food and water security, livelihoods, shelter and health are all at risk, and widespread poverty, fragile ecosystems and weak institutions compound those challenges. A consequence of 200 years of excessive greenhouse gas (GHG) emissions from fossil fuel combustion in energy generation, transport and industry, deforestation and intensive agriculture (IPCC 2007), climate change has emerged as a new and unavoidable threat to agriculture in Central Africa. The GHGs carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), chlorofluorocarbons (CFCs) and water vapour are responsible for GHG emissions which may be reduced by man. Africa is projected to face an average temperature increase of 1.5 to 4°C, which is higher than the reported global average (IPCC 2007; World Bank 2009). Current projections suggest that Cameroon, for instance, will experience a moderate increase in temperature this century: 1.0 to 2.9°C by the 2060s and 1.5 to 4.7°C by the 2090s. Warming is expected to be faster in the interior and slower in the coastal areas, and to reflect an increase in the number of 'hot' days and nights and a decrease in 'cold' days and nights (McSweeney et al. 2008). Although temperatures will rise, there is no consensus among climate models on projected mean annual rainfall. Models are, however, consistent in projecting increases in the proportion of total annual rainfall that falls in heavy events (-2 to +15 percent) (McSweeney et al. 2008). This could have an impact on flooding. Sea level rise is also a concern for Cameroon; coastal areas could experience a rise in sea level of between 0.13 and 0.56 meters by 2090 (McSweeney et al. 2008), and by 2100, sea level rise could lead to the displacement of 580,300 people and the destruction of 39,000 homes (CMEF 2005). The same scenario exists in Gabon and Congo where national efforts are geared toward protecting the coastal and maritime areas where fisheries are highly threatened by climate change impacts. In that context, climate change has emerged as a key development issue for Africa, and Africans themselves have an important role to play in finding efficient solutions for adequate adjustment or adaptation to climate change.

Thus, in the past decade or so, there has been growing research interest in and support for adaptation of agriculture to climate change in Africa. The research is called upon to ensure that the findings emerging from relevant field investigations in this domain are actually applied and used to inform policymakers about the necessity of harnessing efforts to make the necessary adaptation to climate change. It is urgent therefore to make a stock-taking synthesis and to review research results from relevant sources and the way these feed into and influence policies for climate change adaptation in key sectors, particularly the agricultural sector which employs the bulk of the population. It is critical that the concerned ministries in the African countries make policies which are informed by the existing body of knowledge on climate change, climate variability and climate change impacts. Results generated by scientific research should hopefully enable the respective sectors to build resilience against climate change and climate variability through adequate adaptation strategies and contribute to mitigation of climate change impacts through the use of improved and innovative technologies and management practices.

2 Methodology and Definition of Concepts

2.1 Methodology

This report covers a review carried out on climate change adaptation in the Central African region, which is made up of Cameroon, Gabon, the Republic of Congo, the Democratic Republic of the Congo (DRC), Equatorial Guinea, the Central African Republic (CAR), Chad, São Tomé and Príncipe, Angola, Rwanda and Burundi. Particular focus was put on Cameroon, Congo Republic and Gabon, the three countries specified for the review, although owing to availability of information and for purposes of completeness, information on other countries of the sub-region such as DRC, CAR, Chad and Equatorial Guinea was also included in the review.

The methodology used was as follows: (a) a 28-point semi-structured questionnaire was developed and administered to key stakeholders to investigate their level of understanding of climate change and adaptation and what activities, if any, they were pursuing in their respective organisations; (b) visits were made to some of the accessible stakeholders, especially research institutes, to find out the programmes they had on climate change adaptation; (c) the internet was consulted to find out the amount of published information on climate change adaptation in Central Africa; and (d) grey literature was obtained from government ministries, research institutions and non-governmental organisations (NGOs) to identity the amount of unpublished documentation available on climate change adaptation in the Central African region.

2.2 Background

Climate change is threatening food production, food and water security, shelter and health, and has worsened Africa's vulnerability, making it the most exposed region in the world to the impacts of climate change (World Bank 2009). The aim of the review was to synthesise available information and identify gaps in research and policies related to the adaptation of agriculture to climate change in the Central African region, with a particular focus on Cameroon, Congo Republic and Gabon. We begin by defining a few related terms.

2.3 The Agriculture sector

The agriculture sector is considered in this report in its broad sense, to mean crop farming, livestock rearing, pastoralism, fisheries and aquaculture. The review covered adaptation of the crops sub-sector, as well as the subsectors of livestock rearing, pastoralist systems, fisheries (freshwater and maritime) and aquaculture with a special focus on Cameroon, Gabon and Congo Republic.

2.4 Definition of terms

These terms relate to climate change adaptation.

Climate-smart agriculture (CSA): This refers to agriculture that sustainably increases productivity, builds resilience (adaptation), reduces/removes GHGs (mitigation) and enhances achievement of national food security and development goals. It is an approach to identifying the changes in agricultural practices, technologies, management, policies, investments and financing resources needed to support food security under climate change (FAO 2010).

Vulnerability: Vulnerability to climate change refers to the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and adaptive capacity (IPCC 2001). The populations of the Central African region are highly vulnerable physically, socially and economically, especially with regard to climate impacts on agricultural development. Thus, the greater the exposure or sensitivity, the more a population is vulnerable. However, adaptive capacity is inversely related to vulnerability. So, the greater the adaptive capacity, the lesser the vulnerability (IPCC 2001). Some countries in the region have a fairly high adaptive capacity but others do not. The amount of environmental variation in terms of agro-ecological zones, as well as the state of the road infrastructure and commodity storage capacity in the country, highly determine the level of adaptive capacity in that country. Vulnerability usually has serious impacts on populations. Increased vulnerability of Central African societies may be due to their having: (a) a lower capacity to prepare; (b) lower capacity to cope; and/or (c) lower capacity to recover from climatic and non-climatic shocks and stresses (non-resilience).

Adaptation: Adaptation to climate change is a process of adjustments in natural or human systems to a new or changing environment. Adaptation to global warming and climate change is thus a response to climate change that seeks to reduce the vulnerability of biological systems to climate change effects. Adaptation can be categorised into 'internal' and 'external' measures (local and borrowed or adapted from elsewhere) (Maddison 2006). However, the Intergovernmental Panel on Climate Change (IPCC) classifies adaptive responses to climate change more broadly, as behavioural/managerial or policy-oriented (IPCC 2007). According to Klein et al. (2007), adaptation to climate change can be 'reactive' when applied to the current extreme climatic events or 'anticipatory' when implemented before the extreme events occur.

Adaptive capacity: A community's adaptive capacity refers to its ability to adjust to climate change and to moderate or cope with the impacts, including taking advantage of opportunities that may arise with climate change. Adaptive capacity is understood in terms of basic socio-economic factors (e.g. income, access to resources and services and literacy); a community's past and current experience in managing climate stress; the feasibility of past strategies for adaptation in the face of current trends (climatic and otherwise); availability and awareness of alternative adaptation strategies; and the conditions and barriers to adaptation. Adaptive capacity, when understood in the context of the relative vulnerability of a community, is determined by exposure and sensitivity to hazards (IPCC 2001).

Exposure: This is the degree of climate stress upon a particular country. It is defined by the magnitude, character and rate of climate change in a given geographical area. The populations of the countries of the Central African region are highly exposed to climate variation. Most often exposure may be represented as either long-term changes in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events (IPCC 2001). Populations, resources, property and so on can be affected by climate change.

Sensitivity: Sensitivity is the degree to which a community or a system will be adversely or beneficially affected by, or be responsive to climate-related stimuli (Smith et al. 2001; IPCC 2001). Sensitivity is greatly influenced by a community's livelihood activities and by the specific natural, physical, financial, human and social resources needed to carry out these activities (Riché et al. 2009). Sensitivity is basically the biophysical effect of climate change; but sensitivity can be altered by socio-economic changes. For example, new crop varieties could be either more or less sensitive to climate change.

3 Overview of Agriculture in the Central African Region

3.1 Overview of agriculture in the region

In Central Africa the share of arable land ranges from 0.4 percent in Congo Republic to 47 percent in Rwanda. Cameroon has 14.1m hectares of arable land. Agriculture in the region is characterised by a predominance of livestock production, grain legumes (groundnut and cowpea) in most of the north and roots and tubers (cassava, yam and cocoyam) and plantation crops (coffee, cocoa, rubber, banana and tea) in the forested south. Cassava is the main food crop in Congo Republic, DRC, Gabon and Equatorial Guinea, while sweet potato is the most important food crop in Rwanda. Cameroon enjoys a wider diversity of food crops, from cereal-based systems (sorghum, millet and rice) and cattle in the north; Irish potato, grain legumes and vegetables in the western highlands; and starchy staples (cassava, cocoyam, plantain and maize) as well as pigs, goats and poultry in the forest areas of the south. The indigenous people of Central Africa are hunter-foragers, collectively known pejoratively as the pygmies, and are quite distinct genetically and culturally from their Bantu neighbours who are mainly farmers. Agriculture is quite developed in Cameroon and DRC, less developed in Congo Republic and much less so in Gabon.

3.2 Climate challenges in the region

Africa has experienced a greater warming trend than other regions; about 0.5˚C per century since 1900 (Hulme et al. 2001). In the agricultural sector, the Central African region faces tremendous challenges. A generally low agricultural investment portfolio means that agriculture is extremely sensitive to climatic fluctuations. Agriculture is primarily rain-fed, and the onset of rainfall and precipitation levels have become highly variable, with some parts of the region experiencing decreases in annual rainfall that have made it impossible for farmers to be aware of when to plant or where to graze. Wildlife species have also been forced to migrate southward in search of water. Massive floods resulting in soil erosion in dry areas with fewer months of rainfall have made matters worse. New diseases have emerged and minor diseases have developed highly virulent strains. Deforestation is being enhanced by extensive agriculture to increase agricultural production, resulting in massive loss of biodiversity, depletion of water resources and extensive environmental degradation. Lastly, political conflicts have destabilised some countries, adversely affecting food production and making the region extremely vulnerable to climate change. Agriculture is characterised by stagnant yields, land degradation and recurrent droughts. Without a sound agricultural sector, the Central African region, already facing food insecurity and poor health, is unlikely to develop diversified economies that can cope with the impact of climate change. Consequently, the impact of climate change on agriculture and food security in the region over the next few decades will depend on progress in applied agricultural research and development (IPCC 2007).

3.3 Agriculture in Gabon

The agriculture sector has always been a secondary activity and income source in Gabon. Since independence, the dominant position of the petroleum sector has greatly reduced the role of agriculture to eight percent of the gross domestic product (GDP), the lowest share in the region. Gabon's forest is dense and vast (22m hectares), with the result that only two percent of land area is suitable for agriculture and estimated to be under cultivation. In 2004, agricultural exports accounted for just 19 percent of all exports. The country's agricultural challenges are the instability of cassava yields (this is the main farm crop in the country) and the threat in the coastal areas and their fisheries, for which climate change adaptation strategies are highly urgent.

The country lacks self-sufficiency in staple crops and over half of food requirements must be imported. Gabon relies heavily on other African states (such as Cameroon) and Europe for much of its food and other agricultural needs. Cocoa, coffee, palm oil and rubber are cultivated for export. Animal husbandry, once hindered by the tsetse fly (*Glossina spp.*), is now rising with the introduction of resistant breeds. The fishing catch, at 45,000t, falls well below total demand, and about half of the total catch comes from marine waters.

In 2004, Gabon produced about 230,000t of cassava, 155,000t of yams, 61,800t of other roots and tubers, 270,000t of plantains, 35,410t of vegetables, 31,000t of maize, 235,000t of sugarcane, 600t of cocoa, 6,400t of palm oil and 11,000t of rubber.

Gabon has identified agriculture and food security, coastal zones and marine ecosystems, water resources and public health as key vulnerabilities. Potential adaptation measures in agriculture and food security are geared toward educational and outreach activities to change management practices to those suited to climate change; enhance irrigation efficiency and/or expand irrigation; and develop and introduce policy measures, including taxes, subsidies and the facilitation of a free market (IPCC 2007).

3.4 Agriculture in Cameroon

Agriculture in Cameroon is a huge industry with a lot of potential, providing 42 percent of GDP, 30 percent of export revenue and employment for about 70 percent of the economically active population, even though only about 15.4 percent of the country's land is arable. It was the main source of growth and foreign exchange until 1978 when oil production replaced it as the cornerstone of growth for the formal economy. Blessed with fertile land and regularly abundant rainfall in most regions, Cameroon produces a variety of agricultural commodities for export and subsistence crops for domestic consumption (UNDP 2010a; USDS 2010).

The most important cash crops are groundnut, cocoa, coffee, cotton, banana, rubber and oil palm. In 2004, Cameroon produced 630,000t of bananas, 130,000t of cocoa beans, 109,000t of cotton, 64,000t of palm oil, 60,000t of coffee (both *robusta* and *arabica* are grown) and 45,892t of rubber. Small amounts of tobacco, tea and pineapples are also grown and sold nationally and in international markets. The main food crops are plantain, cassava, maize, millet, cocoyam, sugarcane, sorghum, groundnut and sweet potato. Estimated 2004 production of food crops was 1,450,000t of sugarcane, 1,950,000t of cassava, 550,000t of sorghum, 750,000t of maize, 50,000t of millet, 265,000t of yams, 175,000t of sweet potatoes, 135,000t of potatoes, 95,000t of dry beans and 62,000t of rice.

Animal husbandry is practiced throughout the country. Cattle is particularly important in the northern regions, but monogastrics (goats, sheep, rabbits and poultry) are produced in almost all regions of the country. Pig husbandry, a major livestock activity in the southwest, has been hampered by the African swine fever, a pig disease which has been endemic in the region for quite some time now. The conversion of many hectares of rangeland into parks has grossly reduced the amount of grazing land available and encouraged migration of livestock from their traditional areas to newer areas where they and their grazers have to adapt.

Cameroon's Rural Sector Development Strategy (RSDS) projects increasing agricultural production by 50 percent by 2015, and considers increasing the yields of certain crops, especially oil palm, indicating that forestlands will be increasingly converted into farmland. The aim of Cameroon's Ministry of Agriculture and Rural Development (MINADER) is considering national consumption requirements and potential biofuel needs for the international market. But cutting down forests will reduce carbon sequestration and contribute to climate change, while at the same time increasing the loss of biodiversity (wild animals, non-timber forest products and seed dispersal) which contributes to human existence.

A World Bank study on the economic impact of climate change on agriculture in Cameroon showed that net revenues fall as precipitation decreases or temperatures increase across food crop farms, and that seasonality and the moisture availability limit agriculture in Cameroon, meaning that climate remains the dominant influence on the variety of crops cultivated and the types of agriculture practiced, although other physical factors, such as soil and relief, have an important influence on agriculture in that country (Molua and Lambi 2007).

3.5 Agriculture in Congo Republic

In Congo Republic, most agricultural activity is subsistence in nature. Although 62 percent of the country lives in urban areas, some 62 percent of the country's workforce is engaged in agricultural production. Generally poor soils and the lack of fertilisers limit field yields, and, like Gabon, the country is not self-sufficient in food production. Cassava is the basic food crop everywhere but in the south, where banana and plantain are prevalent. The diet is supplemented with yam, taro, sweet potato, maize, groundnut and fruit. Sugarcane and tobacco are major cash crops. Oil palm, cocoa and coffee are grown in more modest amounts. Other cash crops include rice, banana and cotton. Livestock consists of sheep, goats, pigs and poultry. The government has sponsored the raising of cattle since the introduction in the 1960s of N'Dama cattle, a breed resistant to the tsetse fly. Commercial agriculture of rice and cattle ranching are concentrated in the Niari Valley and in the north around Djambala. Forest products accounted for more than 60 percent of the total exports in the late 1960s.

Commercial marine fishing is concentrated off Pointe-Noire. The catch includes tuna, bass, sole and sardines. Freshwater fishing on the rivers, lakes and swamps is largely a subsistence activity. In the early 2000s, industrial and artisanal fishing activities yielded a roughly comparable catch.

Currently, Congo's agricultural adaptation to climate change falls under two projects: the multi-country, Japan-funded 'Supporting Integrated and Comprehensive Approaches to Climate Change Adaptation in Africa' (Africa Adaptation Program) and the Central Africa Forests Commission's (COMIFAC) current project on Climate Change Scenarios for the Congo Basin (IPCC 2007).

3.6 Agriculture in DRC

Agriculture is an industry with plenty of potential in DRC. The agricultural sector supports two-thirds of the population, although production has stagnated since independence. The principal crops are cassava, yam, plantain, rice and maize. In 2004, food crop production included 14,950,000t of cassava, 1,787,000t of sugarcane, 1,199,000t of plantains, 1,155,000t of maize, 364,000t of peanuts, 315,000t of rice, 313,000t of bananas, 224,500t of sweet potatoes, 193,000t of pineapples and 84,000t of yams. Domestic food production is insufficient to meet the country's needs, and many basic food products have to be imported. The country is not drought-prone but is

handicapped by a poor internal transportation system, which impedes the development of an effective national urban food supply system.

Annual and perennial crop cultivation occupies only 3.5 percent of the total land area. Subsistence farming, which employs most of the population, involves four million families on plots averaging 1.6ha, usually a little larger in savannah areas than in the rainforest. Subsistence farmers produce mainly cassava, maize, tubers and sorghum. The production of cash crops was severely disrupted by a civil disorder that engulfed the country between 1960 and 1967, and production fell again after many small foreign-owned plantations were nationalised in 1973-74. By the mid-1990s, the production of DRC's principal cash crops (coffee, rubber, palm oil, cocoa and tea) was mostly back in private hands. Commercial farmers number some 300,000, with holdings between 12 and 250ha. Coffee is DRC's third most important export (after copper and crude oil) and is the leading agricultural export. An estimated 33,000t were produced in 2004 (down from an average of 97,000t during 1989-91). 80 percent of production comes from the provinces of Haut Zaire, Equateur and Kivu. Only 10-15 percent of production is *arabica* coffee, the vast majority being *robusta*; coffee exports are mostly sold to Italy, France, Belgium and Switzerland. The collapse of the International Coffee Agreement in 1989 quickly led to a doubling of exports by the former Zaire, whereupon the surplus entering the world market drove down prices rapidly. Rubber is the second most important export cash crop. The plantation crop has been slowly recovering from nationalisation. Some plantations are now replanting for the first time in over 20 years.

3.7 Agriculture in CAR

Agriculture employs four-fifths of the labour force of the CAR and accounts for more than half of the total GDP (53 percent in 1999). After timber, coffee and cotton are the most important agricultural exports. Tobacco is also produced for export. The CAR usually produces about 50,000 tons of raw cotton, which is purchased and ginned by the state cotton company, SOCOCA. Cotton production suffered when prices fell during the 1980s, but it partially rebounded during the 1990s. Coffee farmers in central and southern regions produce 10,000 to 15,000t annually. Subsistence individual or small-scale farmers, using traditional agricultural methods, grow cassava, millet, maize and banana for their own consumption and for sale on domestic markets. Small amounts of palm oil and sugar are also produced for the domestic market.

Cassava is by far the biggest subsistence crop in the CAR. Farmers produce about 500,000t of cassava annually, greater than the combined output of millet, sorghum, rice and maize. Groundnut, yam and sesame are also cultivated for the domestic market. In addition, almost all farm families raise livestock for family consumption and to provide extra income. An assortment of cattle, goats, sheep, pigs and poultry are owned by most rural households across the country. Some farmers harness cattle to plough their fields and transport their crops, but most plough, hoe and harvest by hand. The entire family, regardless of age, helps in the long, hard work of farming.

3.8 Agriculture in Chad

Only 2.6 percent of Chad's land is cultivated. Agriculture engaged 76 percent of the active population in 1999, and accounted for 39 percent of GDP. Prolonged periodic droughts and civil war coupled with political instability have cut agricultural production and necessitated food relief. Chad's cereal production totalled 1,400,000t in 1999, but because of drought, annual cereal production can fluctuate widely.

Since the 1960s, cotton has accounted for a high percentage of Chad's export earnings. Cotton growing began about 1929 and spread gradually throughout southern Chad. Production was 103,000t in 1999, still far below the high of 174,062t in 1975/76. Production is dominated by the parastatal Coton-Tchad, which regulates output, operates the ginneries and cottonseed-oil works and markets and exports both cotton and cottonseed. Chad's medium staple cotton is sold to 20 different countries, notably Germany, Portugal and Japan. Although most cotton is exported, factories in Chad produce cottonseed oil for domestic consumption.

Production of groundnuts has rapidly increased since the early 1990s, rising from an annual average of 164,000t during 1989-91 to an estimated 471,000t in 1999. Millet is the basic foodstuff (except in the Lake Chad area, where maize is the main cereal). 1999 recorded production of 366,000t of millet, 275,000t of cassava, 240,000t of yams, 173,000t of maize, 100,000t of rice and 65,000t of sweet potatoes. Sugarcane production on a French-managed irrigated estate of about 3,000ha on the Shari River yielded 28,000t of raw sugar in 1999.

3.9 Agriculture in Equatorial Guinea

Agriculture is the main economic activity in Equatorial Guinea, involving about 71 percent of the economically active population and accounting for about 50 percent of GDP and 60 percent of exports. An estimated eight percent of the land is engaged in crop production. The island of Bioko has year-round rainfall, and the prevailing economic activity is cocoa cultivation. In Río Muni (on mainland Africa), where 80 percent of the population lives, food crops are the dominant economic activity and cash crop cultivation is secondary. The only efficient agricultural sector is the production and export of timber and timber products. Unfortunately, many environmentalists believe that the level of production may be unsustainable.

The main food crop is cassava, of which 45,000t was produced in 2004. Sweet potato is the second-largest food crop, with 36,000t in 2004, followed by banana with 20,000t. Before independence, the main cash crops were cocoa, coffee and palm kernels from oil palm. Guinean cocoa, of excellent quality, had an annual production of 38,000t in 1967. However, production experienced a sharp drop in the 1970s, falling to 4,512t by 1980. In 2004, production was estimated at 2,400t. Coffee of comparatively poor quality is grown in northern Río Muni, along the Cameroonian border. The pre-independence production of 8,959t in 1967 fell to 500t in 1978; the decline was mainly caused by forcible transfer of coffee farmers to the Bioko cocoa plantations. Coffee production was an estimated 3,500t in 2004. Actual cocoa and coffee production is higher, but official figures do not take into account quantities smuggled abroad rather than delivered to state marketing agencies.

4 Review of Climate Change Adaptation Research in the Agriculture Sector in Central Africa

Introduction

To meet current needs and plan for the future, Central Africa's agriculture has to address simultaneously the three intertwined challenges of ensuring food security through increased productivity and income, adapting to climate change and contributing to climate change mitigation (Beddington et al. 2012a; 2012b; HLPE 2012; Foresight 2011; FAO 2010). Addressing these challenges will require radical changes in our food systems which will have to become, at the same time, more efficient in resource use (using less land, water and inputs to produce more food sustainably) and more resilient to changes and shocks.

Development agencies have recognised climate change as one of the greatest threats facing mankind today (World Bank 2010; IFAD 2008; 2007) and highlighted how the poorest and most vulnerable will be disproportionately affected by its impacts (IFAD 2008). Central Africa's agriculture is seriously affected by the adverse impacts of climate change. However, food security and climate change can be addressed together by transforming agriculture and adopting practices that are climate-smart. Presenting the results of the first study of climate projections in the Congo Basin for the coming century, it was shown (Scholte 2013) that (a) low emissions predict a rise in temperatures of at least 2°C this century; (b) despite an expected increase in the frequency of strong rains, regions north of the Congo Basin will experience more droughts while the Congo Basin itself will experience no overall changes in rainfall; and (c) river flows will increase, but will also become more unpredictable. Adaptation is needed for gradual changes as well as to prepare for extreme weather events such as droughts and floods (Scholte 2013).

Numerous studies have shown that climate change is the result of human activity in the countries of the Congo Basin which rely heavily on agricultural production and are expected to be the most vulnerable (Gockowski and Sonwa 2010; Sonwa et al. 2009; Ickowitz 2006; Nolte et al. 2001; Gockowski et al. 1998; Kotto-Same et al. 1997). These anticipated climate changes pose great threats to food and water security, public health, natural resources and biodiversity. Closing the gap between climate change adaptation and poverty reduction is necessary (Prowse et al. 2009), and because agricultural production remains the main source of income for most rural communities in Central Africa, adaptation of the agricultural sector to the adverse effects of climate change will be imperative to protect the livelihoods of the poor and to ensure food security in the region. Adaptation can greatly reduce vulnerability to climate change by making rural communities better able to adjust to climate change and variability, moderating potential damages and helping them cope with adverse consequences (IPCC 2001). A better understanding of how Central African farmers perceive climate change, ongoing adaptation measures and the factors influencing the decision to adapt farming practices is needed to craft policies and programmes aimed at promoting successful adaptation of the agricultural sector. Adaptation will require the involvement of multiple stakeholders, including policymakers, extension agents, NGOs, researchers, communities and farmers. This chapter underscores some of the results obtained from climate change adaptation research in the agricultural sector in the Central African region. It begins by showing the effects of climate change in agriculture and the changes brought about in Central African agriculture, then explores CSA– a mechanism developed and being gradually used by farmers in some areas for adapting agriculture to climate change – and finally evaluates the contribution of the region's agriculture to climate change.

Effects of climate change on the agriculture sector in Central Africa: The unpredictable and erratic climatic patterns resulting from climate change pose a serious threat to the agricultural sector, affecting crop production and impacting on farmer livelihoods and food availability. These climatic effects on the agricultural sector in the region are related to variability in local climates rather than in regional climate patterns. Consequently, any assessment of climate change effects has to be individually considered in each country and even specifically to local areas in the country. Two major hazards for agriculture are temperature and precipitation which invariably affect livestock, fisheries and crop performance. The effect of temperature on crop performance varies with the species concerned. For instance, an assessment of adaptation of bambara groundnut, peanut, maize, sorghum and soybean in eight agricultural regions of Cameroon showed that for the future, substantial yield increases are estimated for bambara groundnut, soybean and peanut, while little or no change or even decreases are estimated for maize and sorghum yields, varying according to the climate scenario and the agricultural region investigated (Tingem et al. 2009). They found that for maize, sorghum and bambara groundnut,

changing sowing dates as an adaptation strategy may be ineffective in counteracting adverse climatic effects because of the narrow rainfall band that strictly determines the timing of farm operations in Cameroon. In contrast, the possibility of developing later maturing new cultivars proved to be very effective in offsetting adverse climate impacts, giving the highest increases in productivity under different scenario projections without management changes (Tingem et al. 2009). Their approach highlighted the benefit of using models as tools to investigate potential climate change impacts, where results can supplement existing knowledge. The findings also provide useful guidance and motivation to public authorities and development agencies interested in food security issues in Cameroon and elsewhere. Although similar studies have not been conducted elsewhere in the region, it is felt that the results of the study will be useful in similar agro-ecologies in those countries.

Generally, climate change is increasing drought in the arid areas while excessive precipitation is occurring in the forest areas, both of which are adversely affecting agriculture in those zones. In a recent survey in South Cameroon, for instance, maize farmers ranked climate change as the most important constraint causing perturbation in maize cultivation in the forest zone (Tandze 2013). High temperatures and irregular rains affected sowing dates, weeding frequency, maturity and harvesting. High temperatures have also been reported (Ngeve 2003) to increase soil cracking in the forest area, thereby favouring penetration of cassava roots by soil insect pests such as the African root and tuber scale (*Stictococcus vayssierei*) (Ngeve 2003), and this is now seen to be exacerbated by climate change. Severity of Striga infestation in cowpea, sorghum and maize farms in the Sudan-Sahelian zone of the region has been seen to increase as a result of high temperatures brought about by climate change.

Changes in Central African agriculture as a result of climate change: Climate experts now feel agricultural practices and land use systems in the region have to change or be adapted to reduce the agricultural sector's contribution to climate change, primarily through the production and release of the GHGs carbon dioxide, methane and nitrous oxide (UNEP 2011), and also by altering the region's land cover which can change its ability to absorb or reflect heat and light, thus contributing to radiative forcing (the difference between radiant energy received by the earth and energy radiated back to space) (IPCC 2007). Among the many changes that are occurring are the development and use of short-cycle crop varieties, cultivars resistant to logging (highly preferred in flood events), use of conservation agriculture efforts (no-till and organic farming), irrigation installations, shifts to aquaculture and use of alternative livestock breeds as strategies for climate change. Emphasis has been put on reducing inappropriate land use changes such as deforestation and desertification, major anthropogenic sources of carbon dioxide, but this appears unrealistic at a time when plans are also being made by various countries in the region to increase crop production by opening up new land for food and biofuel production. In Cameroon and Congo Republic, for example, oil palm cultivation is projected to increase many-fold in surface area so as to enhance palm oil and palm kernel availability for food and biofuel. This can only be realised by cutting down the same forests which efforts are being made to protect.

Climate-smart agriculture (CSA): Some farmers and herders in Central Africa are currently adapting to climate change impacts through endogenous CSA practices. CSA is an approach to identifying the changes in agricultural practices, technologies, management, policies, investments and financing resources needed to support food security under climate change; it seeks to address the major challenges of agriculture (climate change, loss of biodiversity, lack of water resources and environmental degradation) and is designed to identify and operationalise sustainable agricultural development within the explicit parameters of climate change (FAO 2010). It is composed of three main pillars: (a) sustainably increasing agricultural productivity and incomes; (b) adapting and building resilience to climate change; and (c) reducing and/or removing GHGs emissions, where possible. CSA seeks to enhance achievement of national food security and development goals, and does so by developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. The magnitude, immediacy and broad scope of the effects of climate change on agricultural systems create a compelling need to ensure comprehensive integration of these effects into national agricultural planning, investments and programmes. CSA ensures availability of food, access to food and stability in food resources and incomes. Mitigation is also important in CSA (FAO 2010). Given the many challenges of Central Africa's agriculture, there is a need to shift away from specialised high-input systems towards the design and adoption of more integrated production systems (crop-livestock, agroforestry and agropastoral) that will reduce inorganic fertiliser use and the resulting GHG emissions, and also diversify farm outputs, sustain yields and reduce vulnerability to climate change and other shocks.

Contribution of agriculture to climate change: The agricultural sector in the region is considered a driving force, although a relatively minor one, in gas emissions and its impact on climate change is as a result of land use effects thought to cause climate change, the consumption of fossil fuel during cultivation and the direct production of crops and livestock (IPCC 2007).

Agriculture and livestock contribute to GHG increases through land use in four main ways: (a) carbon dioxide releases linked to deforestation; (b) methane releases from crop (especially rice) cultivation; (c) methane releases from enteric fermentation in cattle and from manure; and (d) nitrous oxide releases from inorganic fertiliser application. Livestock activities also contribute disproportionately to land-use effects, since crops such as corn and soybean are cultivated in order to feed the animals (FAO 2006). Together, these agricultural processes comprise 54 percent of methane emissions, roughly 80 percent of nitrous oxide emissions and virtually all carbon

dioxide emissions tied to land use. Land-clearing methods such as slash and burn in Central Africa compound these effects by burning biomatter, which directly releases GHGs and soot into the air. Although it is generally agreed (IPCC 2001) that agriculture makes a smaller contribution to GHG emissions than other sources, such contribution differs from country to country. Among the Central African countries, Gabon's agriculture is rudimentary and as a result should contribute less to GHG emissions. The country's booming oil activities from processing of fossil fuels may be contributing much more to global warming than crops and livestock, while these may be making larger contributions to GHGs in Cameroon and Congo, other oil producing countries. Because of this, a recent decision was taken by the Gabonese government, through its National Climate Council, to curb emissions from oil refineries as a major mitigation strategy, although it is not clear whether this decision has become operational.

How changes in Central African agriculture affect its sensitivity to climate change. Many arable pieces of land in Central Africa have a rugged topography; land preparation is difficult and destroys topsoil fertility. As a result, appropriate soil preparation and conservation techniques such as using organic material (organic agriculture) instead of inorganic fertilisers to help restore the topsoil, no-till to maintain soil structure, contour ploughing across slopes and terracing to catch topsoil and water and save soils from erosion are now being employed to contribute to making agriculture less sensitive to climate change. Yet, new techniques in soil conservation are now seen to harbour weed seeds and expose the land to soil cracking thereby favouring root penetration by insects and the fungi they carry. Extra-early maize, cowpea and sorghum varieties have been developed to cope with changing climates, yet some of these are very sensitive to weeds, diseases and insects. The necessity to irrigate as farm water supply declines in some arid areas has increased farming costs in these areas. These have brought additional problems to farming communities and to the region's agriculture.

All this has happened because changes in the region's agriculture (through variety change, conservation farming, irrigation installation and others) are affected by temperature, radiation, precipitation, water vapour pressure in the air and wind speed, which in turn affect a number of physical, chemical and biological processes that drive the productivity of agricultural, livestock and fisheries systems. The latitudinal distribution of crop, pasture and forest species is a function of the current climatic and atmospheric conditions, as well as of photoperiod (Leff et al. 2004). Total seasonal precipitation as well as its pattern of variability (Olesen and Bindi 2002) are both of major importance for agricultural, pastoral and forestry systems. Crops exhibit threshold responses to their climatic environments which together affect their growth, development and yield (Porter and Semenov 2005). Multiple stresses such as limited availability of water resources, loss of biodiversity and air pollution are increasing sensitivity of the region's agriculture to climate change, and reducing resilience in the agriculture sector (Porter and Semenov 2005). Yield-damaging climate thresholds that span periods of just a few days for cereals and fruit trees include absolute temperature levels linked to particular developmental stages that condition the formation of reproductive organs, such as seeds and fruits (Wheeler et al. 2000; Wollenweber et al. 2003). This means that yield damage estimates from coupled crop-climate models need to have a temporal resolution of no more than a few days and to include detailed phenology (Porter and Semenov 2005). The recent heat wave and drought in Central Africa illustrate the potentially large effects of local and/or regional climate variability on crops and livestock. Sensitivity to multiple stresses, such as limited availability of water resources, loss of biodiversity and air pollution, are increasing sensitivity to climate change and reducing resilience in the agricultural sector.

Response of the agricultural sector to climate change: Crop farming, fisheries, aquaculture, livestock and pastoralism are rapidly changing in response to climate change. Some growers have been forced to adopt new and less preferred crop and animal species or breeds as they discover declining yields of their main crops or animals. Topsoil erosion has left many arable plots in the Sahelian region inappropriate for food cultivation, causing farmers to diversify into less sensitive and resilient animal breeds. Mitigation efforts have been put into soil conservation techniques such as practicing no-till cultivation. Endomycorrhizal fungi which aid in phosphorus uptake by plants have become ineffective in the heat-baked soils, provoking symptoms of nutrient deficiency in planted crops. This has forced farmers to use other forms of phosphorus fertilisers to supplement declining native fertility. Without depleting the region's land resources, low-input farming techniques using less energy, pesticides, fertiliser and water are being encouraged in some parts in the region. Aquaculture (raising fish in artificial environments) is another direct response of agriculture to climate change.

The challenges: Hence, the challenge in the Central African region is how to strike a balance between increasing food production to ensure food security and alleviate poverty, and at the same time reduce GHG emissions and the resulting climate change. To adapt to climate change, choices will have to be made at some point on intensifying agriculture on already exploited land (to avoid further deforestation) and rational use of fertilisers (mainly organic) to maintain productivity on existing exploited lands.

The state of research on challenges, options and barriers to adaptation: The present state of research in the region does not give us enough information on how to address the many challenges posed to agriculture by climate change. The options of introducing new crop genotypes and animal breeds may be inappropriate in some cases and unnecessarily costly because new genotypes which do not meet the dietary needs of populations (in terms of organoleptic qualities) may face consumer acceptance problems. In this regard, acid-tolerant genotypes now

being developed in the region to address soil acidity may meet with limited success when transferred to growers.

4.1 Adaptation of crop farming systems to climate change in the Central African region

In all countries of the region, the crops most affected by climate change are maize, cassava, groundnut, bean, yam and upland rice, which require climate-smart practices for increased field productivity. Climate-smart crop production practices provide management options to farmers to both adapt to and mitigate climate change (FAO 2010). Sustainable crop production seeks to reduce reliance on non-renewable external inputs (e.g. inorganic fertilisers) and capitalise on and enhance natural biological processes (e.g. manures) to improve production in a more environmentally-friendly way which avoids degradation of natural resources. To cope with the challenges of climate change, crop production must adapt through, for instance, good selection of crop varieties, plant breeding, cropping patterns and ecosystem management approaches, and become resilient to greater frequency and intensity of changes.

By reducing the use of inorganic fertilisers, avoiding soil compaction or flooding to reduce methane emissions (prominent in paddy rice systems) and sequestering carbon (e.g. planting perennial crops and grass species), crop production can contribute to mitigating climate change by reducing GHG emissions. Because farmers are the primary custodians of knowledge about their environment, agro-ecosystems, crops, cropping patterns and local climatic patterns, adapting cropping practices and approaches will relate strongly to local farmers' knowledge, requirements and priorities. Hence, sustainable crop production provides farmers with options for farming sustainably, taking into account the local ecosystem. Integrated approaches – such as crop-livestock systems, rice-fish systems and agroforestry– diversify food sources and consequently strengthen the resilience of farmers' livelihoods, and also provide opportunities for mitigating climate change.

Climate change impacts on food crop smallholder farming in Central Africa are producing huge economic losses to growers. Although farmers now know that changes have occurred in the amounts of rainfall and onset of rains, changes have been rather abrupt, making non-resilient farming groups in the region face difficulties in adapting to them. Major crops like sorghum in the drier zones of the region have been most hit, with productivity dwindling massively because of high sensitivity of existing varieties to drought. This has prompted plant breeders to breed short-cycle varieties which are adapted to drought conditions (IRAD 2008). In other countries new varieties of tomatoes, cassava and groundnuts have also been bred to cope with the changing climatic conditions.

4.1.1 Autonomous adaptation and coping measures

Food security and climate change can be addressed together by transforming agriculture and adopting practices that are climate-smart. Unrecognised, a number of production systems considered climate-smart are already being used by farmers and food producers in the Central African region to reduce GHG emissions, adapt to climate change and reduce vulnerability. These include:

(a) *Conservation Agriculture:* CA includes minimal mechanical soil disturbance (i.e. no tillage and direct seeding); maintenance of a mulch of carbon-rich organic matter covering and feeding the soil (e.g. straw and/or other crop residues including cover crops); and rotations or sequences and associations of crops including trees, which could include nitrogen-fixing legumes. CA offers climate change adaptation and mitigation solutions while improving food security through sustainable production intensification and enhanced productivity of resource use.

(b) *Agroforestry:* The use of trees and shrubs in crop and/or animal production and land management systems is practiced in many forms, including improved fallows, taungya (growing annual agricultural crops during the establishment of a forest plantation), home gardens, growing multipurpose trees and shrubs, boundary planting, farm woodlots, orchards, plantation/crop combinations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, trees on pasture and tree apiculture (FAO 2010). For instance, *Faidherbia albida*, a tree commonly found in agroforestry systems in the Central African region, thrives on a range of soils and occurs in ecosystems from deserts to wet tropical climates. It fixes nitrogen and has the special feature of reversed leaf phenology, meaning it is dormant and sheds its leaves during the early rainy season and leafs out when the dry season begins (FAO 2010). This feature makes it compatible with food crop production, because it does not compete for light, nutrients or water during the rainy season. Farmers have frequently reported significant crop yield increases (6-100 percent) for maize, sorghum, millet, cotton and groundnut when grown in proximity to *Faidherbia*. Like many other agroforestry species, *Faidherbia* tends to increase carbon stocks both above-ground and in the soil and improves soil water retention and nutrient status. With maize being the most widely cropped staple in Central Africa, the potential for adopting this agroforestry system is tremendous.

The review showed that the use of non-timber forest products is one important coping mechanism practiced by farmers to adapt to climate change

impacts in agriculture. The use of diversified and multi-purpose tree species has been shown to enhance adaptation of agricultural crops to climate change. By supporting the integration of high-value tree species, a programme in West and Central Africa funded by the International Fund for Agricultural Development (IFAD) helped farmers produce marketable forest products, enabling them to diversify their sources of income, improve their nutritional base and restore the region's biodiversity (IFAD 2011). The programme led to a gradual reduction in slash-and-burn agriculture and deforestation in these humid tropical areas. To avoid damaging young trees, smallholder farmers have now stopped the practice of burning fields that have been left fallow for several years. Farmers have been trained on agroforestry tree propagation techniques and integration, and now plant trees on their farms. This has significantly reduced the need for them to deplete the forests by cutting down trees. In addition to the benefits of enhanced soil conservation and fertility, the greater number of trees also increases carbon sequestration. Using farmers' indigenous knowledge as well as local community participation in agricultural systems in the region has led not only to the improvement of soil quality (soil structure and soil organic matter), but also efficient water use and soil moisture retention. In some areas crop yields have been substantially increased through the use of such soil conservation and fertility measures (FAO 2011).

(c) *Exploitation of wetlands:* Another finding of the review was that farmers of the region cope with drought by exploiting wetlands for agricultural production. They adapt to drought conditions by using inland valleys and watersheds, especially in vegetable production and food crop cultivation.

(d) *Other cultural practices:* These include shifting planting dates, modifying cropping patterns and rotations, mulch and cover cropping, crop diversification or the uptake of pre-existing crop varieties, using high quality seeds and planting materials of adapted varieties, using integrated nutrient management, integrated pest management, integrated weed management, water and irrigation management, landscape-level pollination management, organic agriculture and land fragmentation of riparian areas and forest land within the agricultural landscape. All of these help to offset some negative impacts of climate change at different levels in the farming systems of Central Africa.

4.1.2 Use of genetic resources and enhancement

Genetic make-up determines a plant's or animal's tolerance to shocks such as temperature extremes, drought, flooding, pests and diseases. It also regulates the length of growing season/production cycle and the response to inputs such as fertiliser, water and feed. The preservation of genetic resources of crops and breeds and their wild relatives is therefore fundamental in developing resilience to shocks, improving the efficient use of resources, shortening production cycles and generating higher yields (and quality and nutritional content) per area of land. Generating varieties and breeds which are tailored to ecosystems and the needs of farmers is crucial. The selection of clones and crop cultivars with tolerance to biotic and abiotic stresses (e.g. drought, high temperatures, flooding, soil aluminium toxicity, high soil acidity, insect pests and diseases) is providing an opportunity for genetic variability to enhance the improvement and development of new crop varieties which offer hope in adaptation to climate change. National and international research institutes and NGOs in the region are also promoting the use of indigenous and locally adapted crop genotypes and selecting, multiplying and popularising these crop varieties and landraces adapted to, tolerant of or resistant to adverse climatic conditions.

4.1.3 Response of crop species in adaptation to climate change

The greatest benefits in food insecure regions like Central Africa are likely to arise from more expensive adaptation measures including the development of new crop varieties (which takes a long time) and uptake of costly new technologies such as the expansion of irrigation infrastructure (especially for irrigated rice cultivation). Farmers of the sub-region agree that among the roots and tubers, cassava (the basis of the diets of most populations) is the hardest hit, and its field yields and disease resistance have been most affected by climate change. High yielding cassava varieties which were yielding upwards of 35t/ha under on-farm conditions have seen their yields reduced to a bare 15t/ha. New diseases like the cassava root rot have developed in synergy with root insects such as the African root and tuber scale (*Stictococcus vayssierei*). African cassava mosaic disease, endemic in the region, has developed more virulent strains such as the Ugandan variant. At the same time, a minor cocoyam leaf spot (caused by *Phythophtora colocasiae*) has turned into a yield devastating blight for the crop. The severity of maize and sorghum *Striga* has made these crops less productive in the north, leading scientists to produce extra-early maize and sorghum varieties to curb hunger in that agro-ecological zone. In the forest region, plantain fungal diseases have increased in severity because of increasingly heavy precipitation in that ecozone. Maize has been seen to be the most vulnerable cereal, followed by rain-fed rice. Groundnut and common bean are the grain legumes most affected by a changing climate in the sub-region. All these have seen substantial losses to agricultural production. There is need to support research in the region to enable farmers to adopt measures and strategies for adaptation of their agriculture to these climate-induced changes.

A recent study showed substantial yield increases for bambara groundnut, soybean and groundnut, and little or no change and even decreases of maize and sorghum

yields, varying according to the climate scenario and the agricultural region in Cameroon. The yields of maize and sorghum are expected to decrease by 14.6 and 39.9 percent, respectively, across the whole country. The results also show that the effect of temperature patterns on climate change is much more important than that of precipitation. Findings call for monitoring of climate change/variability and dissemination of information to farmers, to encourage adaptation to climate change (Tingem et al. 2008).

Taking the 'no regrets' principle in considering specific adaptation strategies for three crops, maize, sorghum and bambara groundnut, showed that changing sowing dates may be ineffective in counteracting adverse climatic effects because of the narrow rainfall band that strictly determines the timing of farm operations in Cameroon. In contrast, the possibility of developing later maturing new cultivars in some regions proved to be very effective in offsetting adverse impacts, giving the highest increases in productivity under different scenario projections without management changes (Tingem et al. 2009).

4.1.4 Role of national governments

Governments of the Central African region must recognise that the projected impacts of climate change have to be included and be given a high priority in their countries' development agendas, because in order to reduce their vulnerability to disasters, planning in land-use systems, natural resource management and even the design of road, water and energy infrastructure must be done. This should lead to reform in public policy, development of technology measures and an adaptation to management systems. In the region, provision of financial resources and willpower from governments will assist in building adaptive capacity and adaptation management, all of which is necessary for adapting the agricultural systems to climate change.

4.2 Adaptation of livestock systems to climate change in the Central African region

Livestock provide food and livelihoods for one billion of the world's poor, especially in dry and infertile areas where other agricultural practices are less practicable. They play an important multifunctional role in many developing regions providing food, income, draught power for ploughing and transport. They can also provide valuable asset functions, such as collateral for credit and emergency cash flow when sold in times of crisis (FAO 2010). In Central Africa, livestock breeding (some 50 percent of which is in the hands of smallholders) plays a major role in the livelihoods of the populations where they are used for food, for transport, for fertility enhancement and even for social events like marriage. Livestock grazing influences soil fertility and the distribution and diversity of plants, as animals scarify seeds in their guts, transport them over large distances, and fertilise grounds where seeds are deposited. The vegetation maintained through grazing activities in turn captures carbon, reduces erosion, maintains soils, facilitates water holding capacity and provides habitats for wildlife (CBD 2010). Yet the livelihoods of livestock grazing and pastoralism are at risk from rising surface temperatures, more intense rainfall and more frequent droughts, the latter being the major factor causing mobility of grazers and pastoralists, who unfortunately are not exposed to weather or seasonal forecasting to warn them of imminent danger to their lives and those of their animals.

Livestock in Central Africa can make a large contribution to climate-smart food supply systems. Mitigation options, mostly targeted to feed production, enteric fermentation and manure management, are available along the entire supply chain. Livestock adaptation practices relate primarily to the management of organic matter and nutrients and the diversification of incomes. Several CSA practices are readily available for implementation but not yet widely used in the region. These practices include grassland restoration and management (e.g. sylvopastoral systems), manure management (e.g. recycling and biodigestion) and crop-livestock integration. Barriers to adoption of adaptation strategies are most often related to a lack of information, limited access to technology and insufficient capital. Overcoming these barriers requires specific policy interventions, including extension work and financing mechanisms, and schemes for improving access to credit and payment for environmental services. A CSA approach that considers the entire food supply chain is particularly relevant to the livestock sector, given the sector's strong interrelationship with crop production (FAO 2010).

4.2.1 Zonal livestock species distribution

In the semi-arid areas, the Guinea savannah and western highland agro-ecological zones, cattle rearing predominates. In the forest region small ruminants and poultry are more important. These species provide the protein component of the diets of these people and support the populations economically. Yet they are very vulnerable to climate change impacts. Massive floods in cattle breeding areas have consistently destroyed rangelands forcing cattle out of their niches and reducing animal populations as they migrate away (Jahnke et al. 1988).

4.2.2 Livestock production challenges

The main constraints in livestock production are (a) low productive potential of local breeds; (b) seasonal feed scarcity and low feed quality; (c) declining grazing areas and the problem of access to water; (d) low and declining soil fertility and land degradation; (e) climatic change and variability (e.g. drought) impacts; (f) institutional and policy-related constraints; (g) diseases, especially trypanosomiasis in sub-humid and humid zones; and

(h) market access. Additionally, the drivers of change in livestock production are climate change and variability, occupational diversification and sedentarisation of pastoralists. (Ayantunde et al. 2008; Jahnke et al. 1988).

4.2.3 Animal pests and diseases and climate change

Although climate is an important but not the only driver of change in disease distribution (population, intensification of systems), major global changes in the distribution of vector-borne diseases to new 'warmer' habitats (for example 'highland' malaria in parts of Central Africa) have been reported (Jahnke 1982). Bacterial or viral diseases such as rinderpest are obstacles in the arid zones. Parasitic diseases become more important as humidity increases. Trypanosomiasis is a major constraint to livestock husbandry and production in the sub-humid and humid zones. The tsetse fly, transmitter of trypanosomiasis, has almost completely eliminated cattle rearing in the forest region, and the situation has been exacerbated by climate change. Pig production, formerly a major industry in the forest zone, has drastically dwindled because of the African swine fever, also exacerbated by climate change. Farmers have adapted by enclosing their animals in pens and by vaccinating animals to reduce mortality, as opposed to the cheaper free-range systems in which pigs were reared in the past. Chicken attack by coccidiosis has also resulted in huge losses to the industry and the higher frequency and increased severity of this disease has been attributed to changing climatic conditions. Unfortunately, as more and more animals get confined the opportunities offered by rainfed crop-livestock integration systems in the humid and sub-humid areas of the region have been forfeited (Ayantunde et al. 2008; Jahnke 1982).

4.2.4 Key questions on climate change adaptation relating to livestock

Questions that face livestock rearers in their exploitation are: (a) What type of livestock management is suited to changing climates and where? (b) Which animals (species and breeds) should be kept in which areas and what are the trade-offs? (c) Which animal diseases should we focus on? and (d) How can we add value to existing livestock-based adaptation strategies? These questions all need answers from the research if appropriate adaptation measures are to be developed.

4.2.5 Specific impacts of climate change on livestock production

The main impacts of climate change on livestock production include declines in livestock productivity and forage resources, and growing problems of access to water, which have led to restricted livestock mobility. Diseases have emerged and re-emerged, and there have been observed shifts in livestock species and breeds that can be kept; for instance, some have been forced to make the shift from cattle to small ruminants in the Sahelian zones of the region as a result of droughts. Climate change has brought about conflict over natural resource use, and livestock markets have seen strong fluctuations in prices.

4.2.6 Adaptation strategies to climate change in the region

In the Central African region, the many adaptation strategies are context-specific, dynamic and often an integral part of current livelihood systems. They are often a mixture of available livelihood options (crop, livestock, off-farm activities, etc.) (Ayantunde et al. 2008). The benefits from adaptation strategies are highly localised; the focus is usually on short-term adaptation (reactive) measures, and these depend mainly on indigenous knowledge and social safety nets. They are also often inadequate in the event of severe climatic shocks such as prolonged droughts. Herders, in response to drought conditions, exploit wetlands, especially inland valleys and watersheds where they find green pastures for grazing their animals.

There are other coping mechanisms that are adopted by agro-pastoralists in the region. For crop-based households, pastoralists plant drought resistant cultivars; use short cycle crop species and cultivars; plant in widely dispersed fields; pursue intricate re-seeding calendars; and collect and eat wild plants and animals for their survival. For livestock-based households, pastoralists sell animals to buy cereals; invest in multiple livestock species; entrust animals to other herders to maximise herd dispersal; move animals to maximise access to pastures; and some seek assistance from well-to-do members of their families.

The following adaptation strategies have also been formulated at the community level in the region:

(a) *Traditional adaptation strategies:* Rural livestock producers have a high degree of adaptive capacity and have only survived or emerged as livestock keepers due to this capacity. In some cases livestock keeping is defined by adaptability, as in the case of African pastoral systems, which have elaborate systems for managing climatically unpredictable dryland environments. In other cases, livestock production is itself an adaptation strategy that people have adopted as a means of diversifying their livelihoods, preserving assets and harnessing marginal resources. It is significant that, in the context of climate change, the combination of weakening existing adaptive capacity combines with the inadequacy of existing capacity in the face of new and severe threats.

(b) *Breeding locally adapted livestock species:* The overwhelming majority of livestock in Africa is locally bred and kept by small-scale livestock keepers and pastoralists. These breeds may be less productive than their high-yielding 'exotic' relatives, but they are supremely adapted to the harsh environments where they dwell and they can produce under conditions where other breeds cannot survive.

Indigenous breeds are more disease resistant and drought tolerant; furthermore, they are crucial to the effective management of the environments in which they were developed. Without resilient livestock that can cope with the rigors of transhumance, rangelands systems collapse and environmental degradation often ensues (WISP 2008a). In the 12,000 years since livestock were first domesticated more than 7,000 breeds have been developed, all of which adapted to a specific habitat and were shaped, often over centuries, by the cultural preferences of a particular community (FAO 2007). Examples of local adaptation are the N'Dama cattle in Central Africa, the West African dwarf goats and the Djallonke sheep and goats of Central Africa, which were bred in the tsetse-infested humid and subhumid zones of West and Central Africa. These breeds have demonstrated resistance in the tsetse infested zones of West and Central Africa where trypanosomiasis is prevalent (Bosso 2006). These breeds have a proven ability to survive, reproduce and remain productive without recourse to drugs. The raising of these indigenous, trypanotolerant livestock is one approach to control disease, reducing the risk of inducing drug resistance in trypanosome strains. It has also been reported that trypanotolerant cattle, especially the N'Dama breed, show superior heat tolerance to zebu cattle. Plus, they metabolise water with greater economy, making them better adapted to the hot and water-stressed regions of Africa, conferring obvious advantages in the face of climate change.

(c) *Diversifying livestock types*: Most Central African pastoral systems consist of a diversity of livestock species that includes some combination of goats, sheep, cattle, camels and donkeys. Maintaining a diverse herd has a number of advantages and it represents a critical adaptation measure. A diverse herd is an adaptation to a diverse ecology in which vegetation can be highly varied in both space and time (WISP 2010a). One area might be dominated by grasses whilst a neighbouring area is dominated by shrubs, or alternatively the same area may shift from one dominance to another and back over the course of time (Behnke et al. 1993). In general, cattle and sheep are better suited to grazing pasture whilst goats and camels thrive on shrub land. In addition to ecological motives, pastoralists change their stock type according to market forces, with cattle and sheep often highly saleable. Various species also have different production attributes and uses, with camels providing transport in addition to milk and meat; goats providing rapid rates of post-drought herd recovery; sheep providing seasonal income opportunities related to Islamic festivals; and camels and cattle providing prestige and social status in some communities. Change in livestock species is not a new phenomenon and has been reported in the past as a periodic shift, driven by climatic factors, change in land cover (e.g. between browse and pasture) and shifting market demand. During drier periods, for example, pastoralists may shift from cattle to sheep and goat husbandry, as the latter's feed requirements are lower, feeding habitats broader and reproduction rates higher.

(d) *Resource management practices:* Setting aside grazing areas for either seasonal use or for production of certain animals (e.g. calf-grazing paddocks) has been widespread in eastern Africa, but the loss of such resource management practices in recent years in Central Africa is due to factors such as sub-division of land, changes in resource tenure (including nationalisation of land in some cases) and the breakdown of the mechanisms for governing communal resources effectively. Pastoral mobility, which is a means of reducing pressure on low-capacity grazing areas, continues in much of Africa. Although it has been widely curtailed, the practice allows domestic herds to replicate the grazing pattern of native herbivores by performing bouts of intensive grazing followed by periods of rest and recuperation.

(e) *Feed production technologies:* Many non-rangeland livestock businesses rely on crop residues, scavenging or purchased inputs to feed livestock. The pressure for land to produce food for human consumption means that innovative ways such as use of agricultural by-products or household and industrial waste products are needed to produce feed. Central Africans have developed various techniques to produce alternative feed inputs for poultry, although on a small scale.

4.2.7 International research support on climate change adaptation

The International Livestock Research Institute (ILRI) intervenes in this domain by providing a framework for climate change adaptation work. Scientists at ILRI do so by conducting analytical and diagnostic studies; identifying hotspots of climate change and vulnerability; conducting vulnerability assessment to identify intervention options; exploiting climate change scenarios; and assessing ex-ante adaptive responses and impacts on livestock communities and ecosystems. They also test the feasibility of promising adaptation options; support the design and formulation of adaptation strategies; assess feasibility of index-based livestock insurance for large populations facing covariate risks linked to climate change; and identify institutional arrangements to deliver livestock insurance products to the poor, particularly women (Ayantunde et al. 2008). ILRI also intervenes in building the capacity of research and non-research actors; supports implementation of adaptation projects; pilot tests adaptation interventions; and does results-based monitoring and evaluation, focusing on what works, what does not work, and why, lessons learned and issues for scaling up.

There is also indispensable support and partnership provided by other actors such as the IPCC (involved in the making of inventories of GHGs), UN Food and Agriculture Organization (FAO), the CGIAR Centres, NGOs, industry

and the private sector. These organisations provide adaptation options, while advanced research centres and universities carry out climate prediction and modelling. Unfortunately, livestock adaptation issues in developing countries are not well articulated or well studied, resulting in a dearth of information in this domain in the Central African region.

4.2.8 Conclusions

We conclude this section by saying that in Central Africa, livestock represent the major stores of wealth that are mobilised in response to climatic shocks, e.g. shocks brought about by drought. Adaptation strategies in response to climate change at the community level in the region involve a mixture of livelihood options that are essentially the same as those required for sustainable development; these are location-specific, and recommendation domains are of limited scale. Hence, adaptation to climate change needs to be considered in the context of other significant drivers of change.

4.2.9 Recommendations

For livestock adaptation in the region, the following recommendations can be made: (a) Invest in research and communication to improve understanding of the complex relationship between livestock and climate change; (b) Promote understanding of the importance of the livestock sector to the adaptation strategies of rural poor people in Central Africa; (c) Treat adaptation as a generic capacity rather than specific only to climate change and focus on building adaptive capacities among all stakeholders in the livestock sector; (d) Avoid overspecification of climate change projections and the risk of only equipping livestock keepers to adapt to specific scenarios; (e) Develop adaptive capacity making an informed assessment of threats, making informed choices about response measures from a range of options, deploying the preferred response measure and creating an enabling environment to implement this measure; (f) Build capacities for improved climate forecasting and warning and increase awareness of climate change and its consequences; (g) Strengthen human capital through basic education and public awareness and make information on adaptation options widely available to all stakeholders; (h) Build capacity of extension workers through community-based and participatory processes whilst promoting collaborative research into both endogenous and exogenous adaptation options; (i) Develop the skills, resources and infrastructure in the livestock sector that are needed to enable various stakeholders to act on the information available to them; (j) Increase livestock keepers' quality of engagement in policy processes and maintain policy dialogue beyond the confines of the livestock sector itself; and (k) Promote climate change mitigation to harness new sources of funds for development, in full consultation with livestock keepers.

4.3 Adaptation of pastoralist systems to climate change in the Central African region

Pastoralism is animal husbandry, the subsistence practice in agriculture in which people care for and domesticate animals, such as camels, llamas, cattle, reindeer, sheep and goats for the production of meat, milk and other animal products. Pastoralism is a traditional extensive system in which availability of grazing dictates the herd movements; this is called either nomadism (in which there is random movement with the herder's family) or transhumance (in which there are seasonal movements following precise routes). Pastoralism is usually practiced in non-arable marginal areas where crop production is extremely difficult or not possible. It has been considered a successful strategy to support a population on less productive land (WISP 2008b). Sixty-five percent of global drylands consist of grassland used for livestock production, contributing to the livelihoods of 800 million people (Mortimore 2009). Pastoralists are found well established in the Sahelian arid, semi-arid and savannah environments of the region where, as the most prevalent land-use system, the pastoral systems serve as extremely important drivers in national economies and fundamental and ecologically sustainable food providers (Wiese 2004).

Nomadic pastoralists have a global food-producing strategy depending on the management of herd animals for meat, skin, wool, milk, blood, manure and transport, and nomadic pastoralism is practiced in different climates and environments with daily movement and seasonal migration, for which reason pastoralists are considered to be among the most flexible populations in the region (WISP 2008a). It is estimated that some 50 million pastoralists live in arid or semi-arid parts of sub-Saharan Africa (Rass 2006), and about a third of the arid surface area in Central Africa is occupied by pastoralists. Although the stereotypical pastoralists are desert nomads, modern pastoralists are found in every part of the world. In some cultures in Central Africa, the name pastoralist is usually considered pejorative, the pastoralists themselves being politically and economically marginalised. They should however be encouraged in their exploitations because of the role their activities play in food security and poverty alleviation in the region.

Because of the necessity for and the complexities of communal resource management and transhumance, pastoral systems demand a high degree of social organisation and control. The capacity to self-govern is pivotal to the resilience of pastoral communities and many of the challenges that Central African pastoral societies face today can be traced to weakening of self-governance capacity. Pastoralists manage rangelands through a complex system of common and individual property rights and where their land has become degraded, it is usually through a combination of the

weakening of customary management institutions and the loss of key resources that make up the pastoral system (Niamir-Fuller 1999). Both of these factors are closely linked with insecurity of land tenure, which is perhaps the single most important challenge facing African pastoral producers.

4.3.1 Pastoral livestock mobility

Pastoralism generally has a mobile aspect, moving the herds in search of fresh pasture and water (in contrast to pastoral farming or agro-pastoralism, in which non-nomadic farmers grow crops and improve pastures for their livestock). Pastoral production in the Central African region is generally characterised by some form of herd movement or transhumance, which allows herds to access seasonally available resources (e.g. wet season pastures, dry season forests or pastures available in inland valleys and watersheds) and evade seasonal stresses (such as parasites). Pastoralists and their animals gather when rainwater is abundant and the pasture is rich, then scatter during the drying of the savannah. Access to markets or services, the need to avoid conflict, and the opportunity to make political alliances or fulfil social obligations are other factors driving mobility. Mobility is, economically and ecologically, essential for the sustainable management of rangeland resources in the region. Herd mobility enables pastoralists to adapt to changing vegetation patterns in environments described as 'non equilibrium', in which vegetation is in constant flux and does not arrive naturally at a climax vegetation state. Climate change is likely to increase this variability among natural resources, making herd mobility an increasingly important survival strategy (WISP 2010b).

Mobility has recently been affected by some loss of pasture in the region. For instance, about 42 percent of northern Cameroon (6,000km^2) which used to be natural grassland, receiving pastoralists from neighbouring countries (Nigeria, Chad and CAR), has been classified as either national parks (Bénoué, Bouba Njida and Faro) or game reserves that attract foreign tourists. Livestock is prohibited in these areas and herders who invade such terrain fear being shot by the guards. Furthermore, the three main national parks cut Cameroon into two, from east to west, preventing livestock from moving southwards to benefit from the abundant grasslands of the Adamawa Region.

4.3.2 Climate change impacts on pastoralism in the region

Livestock production depends on natural resources–mainly pasture and water. Climate change therefore affects livestock production in myriad ways, both directly through impacts on livestock performance, and indirectly through impacts on the environment, society and economy. Impacts are experienced on forage yield, livestock productivity, ecological processes and farm-level profitability, possibly leading to modification of regional and national food production and incomes, quality and quantity of vegetation, availability of fodder and water and an increase in climate-related diseases and their vectors. In livestock in the region climate change has appreciable impacts on heat stress, water supply and consumption, changes in the pattern of livestock diseases, pathogens, vectors of livestock diseases and forage quantity and quality.

Although livestock is a better buffer than crops against extreme events such as heat and drought, it is uncertain that elevated mean temperatures and increased frequency of extreme heat stress of the coming decades are within the range that can be tolerated by existing livestock genotypes in the Central African region. It is clear, however, that temperature increases above the thermal comfort zone can induce reduced growth and reproduction rates and higher mortality. High temperatures reduce feed intake and thus milk production, leading to energy deficits and decreased cow fertility, fitness and longevity (Erickson et al. 2011).

Livestock water consumption will increase with both temperature and drought. Climate change may reduce farm-level water use, groundwater recharge rates and increase the incidence of diseases in areas of increased rainfall.

There are also social impacts. Climate change may hasten or change the course of ongoing social transformations in the region; an observable effect of drought which is quite frequent in the region is the transfer of livestock ownership to crop farmers, which is partially the result of capitalisation of agricultural surpluses, especially in the cotton producing areas of these countries. Herders have sought to contain the risks of increased competition in the marginal lands between pastoral and crop producing zones by diversifying into crop production themselves.

Although the public is sometimes blamed for poor handling of climate impacts on pastoralism and inability to ensure demographic surveillance and to do climate forecasting and warning, pastoralism itself is practiced in challenging environments. Sampling and registering mobile pastoralists, necessary steps for public interventions, are difficult, and meteorological data in their areas of activity to enable government action are not usually available. Pastoralists are thus highly vulnerable to climate shocks.

4.3.3 Vulnerability of pastoral systems to climate change

During harsh environmental conditions, such as periods of prolonged drought, agro-pastoral systems are put under serious stress and the people of the Central African region and livestock that depend on these systems experience increased vulnerability including reduced levels of food security. Increased frequency of extreme weather events including floods and droughts may overwhelm adaptive capacity and the existing resilience of pastoral systems. Governments, the scientific community, development organisations and the private sector increasingly recognise that drylands, grasslands

and rangelands deserve greater attention because of their widespread degradation, limited resilience to drought and desertification, and for their potential capacity in carbon sequestration in soils while supporting sustainable pastoral and agro-pastoral livelihoods for millions of people (FAO 2009a).

4.3.4 Adaptation of pastoral systems to climate change

A community's adaptive capacity refers to its ability to adjust to climate change and to moderate or cope with the impacts, including taking advantage of opportunities that may arise with climate change. Adaptation of pastoralism to climate change can be categorised into 'internal' and 'external' measures (local and borrowed or adapted from elsewhere) (Riché et al. 2009; Maddison 2006). However, adaptive responses in pastoralism to climate change can be classified more broadly, as behavioural/managerial or policy-oriented (IPCC 2007) and can be 'reactive' when applied to the current extreme climatic events or 'anticipatory' when implemented before the extreme events occur (Klein 2002).

4.3.5 Adaptation strategies in pastoralism in the region

In the region, adaptation strategies that pastoralists apply in times of drought include the use of emergency fodder in the form of grazing enclosures, culling of weak livestock and keeping more than one species of stock. During drought, pastoral women also harvest wild food and other products that have market value such as honey, thereby playing a particularly important role in natural resource management. Barriers and constraints to adaptation such as lack of information about short-term climatic variation, lack of knowledge of appropriate adaptation measures and lack of credit or savings to effect adaptation measures have been identified which hinder the adoption of adaptation strategies in the region.

4.3.6 Conclusions and recommendations

Pastoral systems in Central Africa are undergoing major social transformations, many pointing to a decline and painting a bleak picture for pastoral societies. The main drivers of this tendency towards growing pressure on pastoralism are population density; pressure over and loss of key pastoral resources and resource tracts; and almost static livestock populations. Communities that used to be considered as nomadic, migrating en masse with their herds, are now less mobile, remaining divided throughout most of the year, and are more likely to have settled homesteads, with women, children and some of the elders remaining in the homesteads while younger men herd the livestock. This brings both benefits in terms of access to services as well as challenges such as natural resource degradation and reduced economic potential. Less than 15 percent of pastoralists in the Central African region are now classified as nomads.

As in livestock production in the region, certain recommendations can be formulated. There is need to: (a) Invest in research and communication to improve understanding of the complex relationship between pastoralism and climate change; (b) Promote understanding of the importance of the pastoralism sector to the adaptation strategies of rural poor people of the Central African region; (c) Treat adaptation as a generic capacity rather than specific only to climate change and focus on building adaptive capacities among all stakeholders in the pastoralism sector; (d) Develop adaptive capacity in making an informed assessment of threats, making informed choices about response measures from a range of options, deploying the preferred response measure and creating an enabling environment to implement this measure; (e) Build capacities for improved climate forecasting and warning and increased awareness of climate change and its consequences; and (f) Strengthen human capital through basic education and public awareness, making information on adaptation options widely available to all stakeholders.

4.4 Adaptation of fisheries and aquaculture to climate change in the Central African region

The fisheries sector provides essential nutrition, supports livelihoods and contributes to the region's development. However, the sector is facing significant challenges in maintaining its crucial contribution to these areas. Climate change is emerging as the latest unavoidable threat to the fast declining fish stocks, which could affect millions of people in the climate-vulnerable region who depend on the oceans for food and income (Cochrane et al. 2009; FAO 2009a; 2008a; 2007; UNEP 2008). The impacts of the accumulation of GHGs in the atmosphere and water relate to a number of physical phenomena including gradual changes in water temperature, acidification of water bodies, changes in ocean currents and rising sea levels. These physical changes affect ecological functions within aquatic systems and the frequency, intensity and location of extreme weather events (Cochrane et al. 2009). A range of impacts on fisheries and aquaculture, both direct and indirect, can be expected. In addition, increasing global demand for fish and aquatic foods is adding to these challenges.

Climate change implications for fisheries in Central Africa affect the four dimensions of food security: (a) *availability* of aquatic foods will vary through changes in habitats, stocks and species distribution; (b) *stability* of supply will be impacted by changes in seasonality, increased variance in ecosystem productivity and increased supply variability and risks; (c) *access* to aquatic foods will be affected by changes in livelihoods and catching or farming opportunities; and (d) *utilisation*

of aquatic products will also be impacted and, for example, some societies and communities will need to adjust to species not traditionally consumed (Cochrane et al. 2009). The coastal ocean areas of Gabon, Congo Republic and Cameroon are warming and the combined effect of temperature and salinity changes due to climate warming are expected to reduce the density of the surface ocean, increase vertical stratification and change surface mixing (Barange and Perry 2009). There is also evidence that inland waters in the region are also warming, with differential impacts on river runoff. Increased vertical stratification and water column stability in oceans and lakes is likely to reduce nutrient availability to the euphotic zone (uppermost layer of the ocean) and thus primary and secondary fish production (Barange and Perry 2009).

Coastal fishing communities in Douala and Limbe (Cameroon), Pointe Noire (Congo Republic) and Mandji Island area (Gabon) face a double blow of reduced fisheries resources and increased risks of coastal flooding and storm surges (FAO 2007). Hence, impacts of climate change are an additional burden to other poverty drivers, such as declining fish stocks, HIV/AIDS and lack of savings, insurance and alternative livelihoods. Projections suggest that these combined pressures could also result in coral reef loss and a decline in fish availability for per capita consumption by approximately 15 percent by 2015 (FAO 2007).

Small-scale fisheries and aquaculture have contributed little to the causes of climate change but will be amongst the first sectors to feel its impacts. Some anticipated consequences include falling productivity, species migration and localised extinctions, as well as conflict over use of scarce resources and increased risks associated with more extreme climatic events such as hurricanes. These result from direct impacts on fish themselves as well as from impacts on the ecosystems on which they depend, such as coral reefs. In general the consequences of climate change will be negative for fishers at low latitudes. In contrast, fish-farmers may benefit from expansion of the areas where aquaculture is viable due to increased temperatures and rising sea levels. However, these benefits may be tempered by reduced water quality and availability, increased disease incidence and damage to freshwater aquaculture by salinisation of groundwater.

The precise and localised impacts of climate change on fisheries are, however, still poorly understood (FAO 2009b; Stern 2007; WorldFish Center 2007). This is because 'the inherent unpredictability of climate change and the links that entwine fishery and aquaculture livelihoods with other livelihood strategies and economic sectors make unravelling the exact mechanisms of climate impacts hugely complex' (WorldFish Center 2007). Furthermore, tropical fisheries, which are the most important to small-scale fishers in the Central African region, have received less scientific study than those in the waters of developed countries (Roessig et al. 2004). This uncertainty means that direct adaptation is difficult; the focus must therefore be on boosting adaptive capacity and resilience to shocks by improving the health of fish stocks, freshwater, marine and coastal ecosystems and the communities that depend on them.

This section of the report reviews the expected consequences of climate change for fisheries and aquaculture in the Central African region, starting with gains in adopting climate-smart fishery practices, then focusing on the consequences for the rural poor, and highlighting some practices and adaptation measures that can be taken in anticipation of the consequences of climate change in the region.

Climate-smart fisheries and aquaculture will require: improving efficiency in the use of natural resources to produce fish and aquatic foods; maintaining the resilience of aquatic systems and the communities that rely on them to allow the sector to continue contributing to sustainable development; and gaining an understanding of the ways to reduce effectively the vulnerability of those most likely to be negatively impacted by climate change. The sector is guided by the Code of Conduct for Responsible Fisheries and the ecosystem approach to fisheries and aquaculture which outlines the principles and approaches that are central to ensuring the sustainability of the sector. However, the application of these principles and approaches is not keeping pace with the increasing need for their implementation. Although lately the general understanding of the implications of climate variability and change is improving, information on local-level impacts and vulnerabilities is lacking, which hampers adaptation planning in the region. Improved capacities for decision-making under uncertainty are required. Examples of win-win tactics for attaining climate-smart objectives that are available to the sector include: the reduction of excess capacity and the implementation of fishing activities that are linked with improved fisheries management and healthy stocks, increased production efficiency through better integrated systems, the reduction of post-harvest and production losses; and the further development of regional trade. The transition to CSA in fisheries will need to take place at all levels (individual, business, community, national and regional) and time scales. All stakeholders from the private and public sectors will need to be involved in the development of context-specific options to ensure that the fisheries and aquaculture sector is climate-smart. To make the transition to CSA in fisheries and aquaculture, it will be necessary to ensure that the most vulnerable states, production systems, communities and stakeholders have the potential to develop and apply CSA approaches. Markets and trade may help buffer the impact of changes in production that affect food security, consumer prices and supply-demand gaps. However, the implications of climate change impacts and climate change policies on the entire supply and value chain need to be better understood. Appropriate policy measures need to be defined and implemented.

4.4.1 *Climate change impacts on freshwater fisheries*

In the short term, climate is expected to affect freshwater fisheries through changes in water temperature, nutrient levels and lower dry-season water levels. Dry-season flow rates in rivers are predicted to decline in the Congo Basin leading to reduced fish yields (FAO 2011). In the longer term, larger changes in river flows are anticipated, reducing their capacity to sustain regular and controlled water flows.

It has been found that lake fisheries (such as in Lake Chad) have already begun to feel the impact of climate variability, affecting fish production. Climate change is also affecting fish and their habitats in the region. Warmer temperatures are influencing the abundance, migratory patterns and mortality rates of wild fish stocks and determining what species can be farmed in certain parts of the region. These climatic effects on fish are already having social and economic consequences for people dependent on fisheries and aquaculture – workers, coastal communities and fish consumers.

4.4.2 *Climate effects on aquaculture*

The impacts of climate change on aquaculture are more complex than those on terrestrial agriculture owing to the much wider variety of species produced (Brander 2007), and because we are in an era of finite resources (Naylor et al. 2009), but more immediate progress can be made in aquaculture than in wild fisheries because of the greater level of control possible over the production environment (WorldFish Center 2007). Greater control can be exerted over the production environment (e.g. by providing food and controlling breeding and disease), and over environmental conditions (e.g. by controlling water flows, temperature and water quality), thus reducing dependence on ecosystem services. However, many small-scale fish farmers in the Central African region practise a low-input, low-output form of aquaculture depending heavily on ecosystem services and naturally available feed to support their fish. Many forms of aquaculture still depend heavily on wild stocks for food and seed (FAO 2008b). The future supply of fishmeal and oils from capture fisheries, used as feed stock in aquaculture, is far from certain (Brander 2007; Roessig et al. 2004; Naylor et al. 2009).

Changes in rainfall will cause a spectrum of changes in water availability ranging from droughts and shortages to floods and will reduce water quality, while salinisation of groundwater supplies and the movement of saline water further upstream in rivers caused by rising sea levels will threaten inland freshwater aquaculture (IPCC 2007). Increased run-off bringing in nutrients from sewage or agricultural fertilisers may cause algal blooms which in turn lead to reduced levels of dissolved oxygen and fish kills. Rising temperatures similarly reduce levels of dissolved oxygen and increase metabolic rates of fish, leading to increases in fish deaths, declines in production or increases in feed requirements while also increasing the risk and spread of disease (FAO 2009b). Coastal aquaculture will be exposed to major economic losses from extreme weather events and red tides, the frequency and severity of which are likely to increase (Roessig et al. 2004).

However, not all of the changes will be negative. As sea levels rise, flooding of low lying areas and salinisation of groundwater and soil will create ideal conditions for aquaculture in many areas (MAB 2009), while simultaneously rendering them unsuitable for regular agriculture. Other benefits of rising water temperatures and sea levels include reduced cold water mortality of valuable fish and expansion of areas suitable for brackish or saltwater aquaculture such as shrimp and mudcrab (WorldFish Center 2007). Likewise, increasing investment in water storage infrastructure such as dams, on-farm ponds and irrigation systems to retain reduced levels of precipitation and buffer variability in supply will create many potential sites for aquaculture production (MAB 2009). In currently cooler areas, such as those at higher altitudes or in more northerly latitudes, rising temperatures may result in increased growth rates and food conversion efficiencies, longer growing seasons, reduced cold water mortality and expansion of areas suitable for aquaculture (Brander 2007; IPCC 2007).

Despite the advantages, the aquaculture industry has experienced very limited expansion in the Central African region because of the cost involved, and climate change adaptation strategies are not yet properly understood by farmers.

4.4.3 *Climate change impacts on marine systems*

There are five major stressors that threaten the marine fishing environment in the Central African region, namely: (a) Climate change; (b) Coastal pollution; (c) Fragmentation and loss of habitat, especially from dredging, trawling and use of explosives in fishing on coral reefs; (d) Infestation of invasive species, such as the water hyacinth; and (e) Over-harvest from fisheries. These stressors may individually or combined result in severe impacts on the biological production of the world's oceans and the services they provide to billions of people today. If climate change accelerates, the impacts on marine life from the other stressors will become severely exacerbated and the ability of ecosystems to recover will be impaired (OECD 2011).

Climate change is projected to slow down the global flow of ocean currents, which flush and clean the continental shelves and are critical to maintaining water quality, nutrient cycling and the life-cycle patterns of fish and other marine life in more than 75 percent of the world's fishing grounds. Projections of possible direct impacts of sea level rise in Cameroon indicate that a 15 percent increase in rainfall by the year 2100 would likely decrease the penetration of salt water in the Wouri estuary. With an 11 percent decrease in rainfall, the salt water could extend up to about 70 km upstream. In the Gulf of Guinea, sea-level rise could induce overtopping

and even destruction of the low barrier beaches that limit the coastal lagoons, while changes in precipitation could affect the discharges of rivers feeding them. These changes could also affect lagoonal fisheries and aquaculture (IPCC 2007).

4.4.4 The economics of adapting fisheries to climate change

While most work on climate change in fisheries has focused on fisheries science, the Organisation for Economic Co-operation and Development (OECD) highlighted the economic and policy aspects of adapting the fisheries sector to climate change (OECD 2011). Fisheries policymakers need to develop adaptation strategies that take into account the economic consequences of climate change – strategies that must themselves be adaptable to the uncertainty of climate change. OECD analysis and policy advice aims to ensure that the fishing and aquaculture sectors are environmentally and economically sustainable. The OECD (2011) outlines the actions that fisheries policymakers must undertake in the face of climate change. These include: (a) strengthening the global governance system; (b) a broader use of rights-based management systems; (c) ecosystem protection; (d) industry transformation through the ending of environmentally harmful subsidies and a focus on demand for sustainably caught seafood; and (e) in particular, using aquaculture as a key part of the response to climate change.

4.4.5 Adaptation and coping strategies

Raising awareness of the impacts of climate change to ensure that the special risks to the fishery sector are understood and used to plan national climate change responses may be an effective adaptive strategy in the fisheries sector in the region (FAO 2011). The main focus of development efforts aimed at fishers and fish farmers must be on helping them to build their capacity to adapt to climate change in ways that allow them to moderate potential damages, to take advantage of opportunities or to cope with consequences (Prowse et al. 2009; IPCC 2007).

Small-scale fishers and fish-farmers may consider limiting catch size and effort as an adaptation measure. However, other adaptation options are available, such as the direct adaptations to specific changes and actions that increase the resilience and adaptive capacity of communities and ecosystems, particularly by reducing other stresses such as social (poverty, inequality) and environmental (over-fishing, habitat destruction, pollution) stresses that can significantly increase vulnerability of communities and ecosystems to the impacts of climate change (IPCC 2007; Walther et al. 2002).

Many fishing communities are dependent on stocks that exhibit regular fluctuations and so have already developed considerable coping capacity. Development agencies should direct efforts to documenting and understanding existing adaptation mechanisms in the region and, where these prove successful, supporting and strengthening them and applying them elsewhere. Examples of such mechanisms include diversification of livelihood systems, such as switching between farming and fishing in response to seasonal and inter-annual variation in fish availability, and seasonal migration to locations where fish are available; and flexible institutional and management strategies, such as integration of land and sea tenure to control access to fisheries and flexible redistribution of fishing rights between neighbouring areas (Allison and Ellis 2001). However, although traditional management systems may support sustainable livelihoods, they may also reinforce the social positions of those who oversee them, at the expense of less privileged members of the community (Neiland et al. 2005) and thus may not meet the requirements of equitable development.

In the Lake Chad Basin area, there are interesting adaptation measures which have been adopted by fisherfolks and the populations. For reduced fisheries productivity and yields, populations increase efforts or fishing power, or resort to migration and mobility. When they experience increased variability of fish yields they diversify their livelihood portfolio with farming, animal husbandry and small-scale aquaculture; undertake precautionary management for resilient ecosystems; and carry out implementation of integrated and adaptive management. When the impact is one of reduced profitability, they diversify livelihoods. If the impact is one of trade and market shocks they diversify markets and products or rely on information services for anticipation of price and market shocks. When the impact on their fisheries is one of displacement of populations leading to an influx of new fishers, they solicit support from existing local management institutions (FAO 2012; Ovie and Emma 2011).

Mangroves provide vital coastal defence and support local fish stocks by providing food, shelter and habitats (UNEP-WCMC 2006). They are also very effective at absorbing excess nutrients from wastewater, sequestering carbon and providing fuel wood, building material and fodder for animals. However, due to overexploitation, extreme weather and unsustainable aquacultural development, a good proportion of the region's mangroves have been lost over the last 20 years, rising to 80 percent in some areas (TEEB 2008). The conservation, rehabilitation and afforestation of mangroves are important means of both adapting to and mitigating the effects of climate change. This can involve raising community awareness of their importance, reducing stress from other environmental threats, preventing overexploitation of mangroves for animal fodder, house building or firewood and planting and fertilising new mangroves artificially.

The effects of mangrove planting and rehabilitation on the marine environment and fisheries are analogous to agricultural activities that improve soil fertility, increase supply of fodder for livestock and increase herd sizes.

Efforts will need to be directed at preserving the wetland 'hinterland' of Central African inland fisheries and deep sections of shallow lakes as refuges for fish when water levels fall. With the exception of large, deep lakes, changes in climate, rainfall in particular, are the main cause of stock changes in these fisheries, not fishing effort. In such cases reductions in fishing effort have little effect on stocks and serve only to reduce the incomes of fishers (Allison et al. 2007).

The World Wide Fund for Nature (WWF) is testing its approach to build resilience in tropical mangroves and associate coral reefs in Cameroon and three other countries (Fiji, Tanzania and India) in a project which aims to build the capacity of nature resource managers to assess vulnerability and to adapt management strategies to respond to expected climate change impacts. Initial vulnerability assessments and adaptation planning point to the need for mangrove protection, reforestation with climate-smart species, integrated land-use and marine planning, as well as activities to improve resource use technology. Coordinating the testing of adaptation methods in geographically diverse locations within a common habitat type aims to increase the replicability so that the project results can be transferred to other conservation efforts around the globe (WRI 2007).

4.4.6 Recommendations for the Central African region

From this review, the following recommendations can be made. (a) There is need to strengthen regional governance of the fisheries industry; this will reduce over-harvest in the region. A United Nations Environment Programme (UNEP) report found that up to 80 percent of the world's primary fish-catch species are exploited beyond or close to their harvesting capacity: advances in technology, combined with subsidies, mean the world's fishing capacity is 2.5 times bigger than can harvest fisheries sustainably (UNEP 2008). (b) It is necessary to communicate clearly with stakeholders, and the public, on how climate change will affect fisheries, in the short-term and in the long-term. (c) It is urgent to protect ecosystems from degradation and pollution. UNEP found that the number of marine dead zones – oxygen deficient areas – has increased from 149 in 2003 to over 200 in 2006, mostly in coastal waters (UNEP 2008). These zones are linked with pollution and the projected growth in coastal development, and this number is expected to multiply in a few decades. The degradation of traditional fishing grounds will also have commercial effects on the fishing industry sector and fleets, and more direct effects on coastal communities and populations, which depend on marine resources for sustenance and livelihoods. (d) It may be beneficial to end environmentally harmful subsidies made in the fishery sector. (e) Rights-based management systems should be extended. (f) Mangroves need to be restored and coral reefs protected, which will contribute to carbon dioxide absorption, coastal protection, fisheries and livelihoods. (g) Focus should be put on aquaculture and on demand for sustainably caught seafood.

4.4.7 Conclusions

Although there are very few scientific studies in the Central African region to support this, there are growing indications from similar situations in other regions that climate change will have significant impacts on fisheries and aquaculture in Central Africa. At low altitudes it is likely to be largely negative for fisheries, damaging important ecosystems such as coral reefs and mangroves and causing reductions in fish stocks due to rising water temperatures and reduced primary production. This could have significant effects on food security and employment in areas dependent on fisheries that are particularly vulnerable to the impacts of climate change. These include reef fisheries, fisheries in shallow lakes or wetlands and fisheries in other enclosed or semi-enclosed bodies of water. However, some areas may experience localised increases in fish stocks due to in-migration of species from other areas of the region and rising primary production. Brackish and saltwater aquaculture could benefit from rising sea levels, and freshwater aquaculture in some parts of the region could benefit from increased feed efficiency and reduced cold water mortality, though reductions in availability of wild fish for feed and seed, increased spread of disease and reduced water quality will still pose threats.

Responses to climate-related changes must centre on boosting adaptive capacity and resilience both of communities and the ecosystems on which they depend. The heavy dependence of small-scale fishers and fish-farmers in the region on ecosystem services must be recognised and measures taken to increase the health of these ecosystems by reducing other stresses such as over-exploitation and pollution. Communities themselves must be strengthened through provision of services such as insurance and weather warnings to reduce risk, support for participatory natural resource management and sustainable fishing operations, and assistance in post-harvest processing and preservation to maximise value-added and employment and minimise waste from both fisheries and aquaculture. Adaptation in the fisheries sector need not be restricted to altering catch size and effort (Easterling et al. 2007), but should focus on building adaptive capacity and resilience, contributing to additional goals of improved fisheries management and poverty reduction, and by improving the livelihoods of those poor rural people most at risk from the effects of climate change.

4.5 Major climate change adaptation projects and programmes in the Central African region

As noted above, at the moment there is scant research on climate change adaptation in the region, but we are hopeful that the many ongoing regional projects listed below, some of which include agricultural adaptation, will generate some information on climate change as it affects agriculture and hopefully contribute towards adaptation to climate change in the region.

(a) *Agroforestry:* A programme funded by IFAD and implemented in Cameroon, Nigeria, Congo Republic and Gabon by the World Agroforestry Centre (ICRAF) aimed at adapting farming to climate change by promoting rural innovation through participatory tree domestication in West and Central Africa for carbon sequestration and the use of non-timber forest products as food (IFAD 2011). The project attempts to mitigate the impacts of climate change through tree planting in the two regions.

(b) *Africa Adaptation Program (AAP):* Funded by the Japan International Cooperation Agency (JICA) at US$92.1m over three years, implemented by UNDP, and fully titled 'Supporting Integrated and Comprehensive Approaches to Climate Change Adaptation in Africa', this programme uses an innovative approach to climate change adaptation in Africa by assisting 20 African countries, including the focus countries in Central Africa, in implementing adaptation and resilience actions. The project ensures that national development processes incorporate climate change risks and opportunities to secure development gains under a changing climate; helps countries establish an enabling environment and develop the capacity required to design, finance, implement and monitor long-term and cost-effective adaptation policies and plans; and funds national activities supported by regional services.

(c) *AfricaAdapt:* This network aims to facilitate the flow of climate change adaptation knowledge for sustainable livelihoods in all sectors, including agriculture, between researchers, policymakers, civil society organisations and communities who are vulnerable to climate variability and change across the continent. Governments will make informed decisions based on results from the research.

(d) *Climate Change Adaptation in Africa (CCAA):* Jointly funded by the International Development Research Centre (IDRC) and UK Department for International Development (DFID), the CCAA research and capacity development programme, aims to significantly improve the capacity of African populations and organisations to adapt agriculture and other sectors to climate change in ways that benefit the most vulnerable.

(e) *Mangroves and Coral Reef Conservation Project:* Mangroves and coral reefs are coastal habitats required by marine species for their survival. Some 80 percent of fish species absolutely rely on mangroves for some stages of their life cycles. Hence their disturbance and over-exploitation will destroy marine life to some extent. This climate-proofing project, funded by the World Resources Institute (WRI) and implemented by the World Wide Fund for Nature (WWF) in Fiji, Cameroon and Tanzania, is working to develop a generalisable approach to building the resilience of mangrove forests, and by extension, associated coastal ecosystems and coral reefs. To enhance adaptation of fisheries to climate change impacts, the project aims to build the capacity of natural resource managers and communities to assess vulnerability to climate change and to develop management strategies to decrease vulnerability (WRI 2007).

(f) *Lake Chad Sustainable Development Support Program:* Populations in the Lake Chad Basin area heavily rely on this lake and its watershed for fisheries and other sectors. To promote sustainable development in the Basin, the African Development Bank (AfDB) partially funded a six-year, US$95m Lake Chad Sustainable Development Support Program which aims to (a) clean out the Vrick Canal to augment the volume of water flowing into the lake; (b) undertake feasibility and implementation studies on transferring waters from the Oubangui River in CAR to the lake; (c) undertake studies to reduce the water losses provoked by the many small dams built on the waterways feeding the lake; and (d) try to restore the fish productivity of the lake's ecosystems by fixing sand dunes over 8,000ha and attempting to combat erosion over 27,000ha, and also trying to stop the proliferating vegetation that is choking the lake. Judicious, integrated management of the basin's natural resources is expected to enhance adaptation to climate change; increase the incomes of the target populations, particularly women, by 67 percent on average; and improve food security.

(g) *Climate Change and Forests of the Congo Basin (COBAM):* A project implemented in Cameroon, Congo Republic and Gabon by the Center for International Forestry Research (CIFOR) to document profiles and efforts of the Congo Basin countries to foster mechanisms of reducing carbon dioxide emissions coming from deforestation and forest degradation, which contribute to climate change mitigation.

(h) *Congo Basin Forests and Climate Change Adaptation (COFCCA):* a project funded by COMIFAC and implemented in Cameroon, CAR and DRC, aimed at promoting conservation and sustainable management of the Central Africa forest ecosystem so as to enhance mitigation and adaptation to the effects of climate change.

(i) *Institutional Capacity Reinforcement Project for Better Adaptation to Climate Change in the Coastal Zone of Gabon:* This project, piloted by the Gabonese Ministry of Housing, Town Planning, Environment and Sustainable Development and implemented by UNDP with funding from the government of Japan, aims at developing early warning systems against vulnerability in the littoral area of Gabon for a better adaptation of fisheries and urbanisation to climate change. The project focuses on acquiring

and installing equipment for marine measurements which will facilitate scientific data collection on climate-related issues and enable a better follow-up of the impacts of climate change in Gabon's littoral zone, particularly Mandji Island.

(j) *AfricaInteract:* A project funded by IDRC which aims at providing an appropriate forum for interaction between major stakeholders, particularly researchers and policymakers in climate change adaptation involving agriculture, health and water sectors as well as urban issues. The project is being coordinated from CORAF/WECARD headquarters in Dakar, Senegal, and links with various partners in Africa through sub-regional sister organisations: the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) in East Africa; the Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) in Southern Africa; COMIFAC in Central Africa; and Enda Energie-Environnement-Développement in West Africa, under the auspices of the Forum for Agricultural Research in Africa (FARA).

5 Agricultural Policies for Climate Change Adaptation

Introduction

Climate change is viewed as one of the gravest threats to the future of humanity. Debates and commitments relating to climate change in Africa date back to the G8 summit in Gleneagles, Scotland in 2005 (Niang 2007). During that summit, it was noted that Africa was having difficulties in achieving the Millennium Development Goals (MDGs) by 2015. Decisions were made to support the reduction of African countries' vulnerability to climate change by strengthening the existing climate institutions and centres in Africa through the Global Climate Observing System (GCOS), and a commitment was made by the World Bank to take account of climate risk in its investment portfolio. West Africa, confronted with desertification, has several institutions with clear and distinct mandates on climate change issues, including the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), the Agro-Hydro-Meteorological (AGRHYMET) Regional Centre, the Centre for Medical and Health Research (CERMES), research institutes, universities and NGOs. In Central Africa, where the chief concerns are linked to climate change as it affects agricultural production, deforestation, depleting water resources, loss of biodiversity and environmental degradation, sub-regional institutions are still in gestation. In a summit of the African Union African Heads of states were asked to integrate climate change issues into their national development policy agendas, and since then an interest in climate change is beginning to develop, especially at the level of the Economic Community of Central African States (ECCAS) (Niang 2007). This view was reinforced in a meeting of the Assembly of the African Union in Addis Ababa (Ethiopia) (29-30 January 2007), during which a decision was made that specifically urged all of the governments in the region to integrate climate change considerations into development strategies and programmes at national and regional levels and to implement the Plan on Climate Change and Development in Africa.

5.1 Institutional support for adaptation policy in the region

5.1.1 IDRC/DFID

The CCAA programme, financed by DFID and IDRC, may be seen as a product of the G8's commitment to support Africa, especially in its efforts to reduce vulnerability to climate change (Lafontaine et al. 2012; IDRC/DFID 2007). Launched in 2006 and completed in 2012, the CCAA contributed to building organisational capacity and improving the adaptation capacities of African researchers and local communities and organisations; helped increase to some extent the adaptation capacities of decision-makers; raised awareness among targeted local communities and local and national decision-makers with respect to climate change issues, vulnerability assessment and adaptation strategies; and also significantly contributed to the knowledge base and the development of knowledge-sharing mechanisms at various levels, providing some benefits at the local level for at-risk communities and the most vulnerable.

5.1.2 New Partnership for Africa's Development (NEPAD)

Agriculture, somewhat neglected yet required for economic growth and for the attainment of the MDGs in Central Africa, caused NEPAD, the economic programme of the African Union, to decide to boost Africa's growth through agriculture-led development. Since many countries in the region are lagging behind in official climate change policies, the Conference of African Ministers of the Environment (ACMEN), in the second Assembly of the African Union at Maputo in July 2003, prepared and adopted a plan of action for the NEPAD environment initiative which included early warning systems for natural disasters, identification of climate-vulnerable ecosystems and regions and regional and sectoral development of adaptation strategies. Here again, adaptation of agriculture to climate change was just faintly addressed.

The structural adjustment programmes of the 1980s and 1990s, spearheaded by the International Monetary Fund (IMF) and the World Bank, distorted agricultural incentives such as inorganic fertiliser and pesticide subsidies. This necessitated the establishment within NEPAD of the Comprehensive Africa Agriculture Development Programme (CAADP) and African Peer Review Mechanism (APRM). CAADP addresses, among other things, the improvement of national agricultural policy frameworks, whereas APRM concerns national governance and institutional settings, partly influencing the agricultural sector and adaptation to climate change

as well. Both of these initiatives had a major weakness: when implemented at the national level, they were not well linked to ongoing, national policy processes. The connections of agricultural adaptation to climate change, food security and trade policies are not yet fully taken into account in setting the agenda.

5.1.3 United Nations Economic Commission for Africa (UNECA)

UNECA addresses regional integration, achieving the MDGs and science and technology for development. In this context, it shares a secretariat with the African Union Commission and AfDB, which predisposes it to play a role in raising the awareness of various African decision-makers about climate change issues. Here again, climate change adaptation in agriculture is not explicit.

5.1.4 Lake Chad Basin Commission (LCBC)

This consortium is made up of Cameroon, CAR, Chad, Niger and Nigeria, and its main mission is to provide policy in the management and exploitation of the Lake Chad Basin. It has developed, among others, strong policies to support a better understanding of the contribution of fisheries to local, national and regional economies, including the sector's contributions to food, nutrition and livelihood security.

All these instruments and institutions have one thing in common: They do not address specifically the adaptation of the region's agriculture, livestock and fisheries to climate change impacts.

5.2 National climate change policies

5.2.1 Cameroon

In the tropical forest zone of Cameroon, changes in temperature will affect natural regeneration of forests and the water balance. If well managed, overall food security in terms of agriculture and inland fisheries may be affected positively in this area. The coastal and maritime zone is predicted to be particularly affected by sea level rise due to climate change. Sea level rise may threaten the natural forests through inundation and more intense wave activity. In the savannah zone, climate change impacts are predicted to lead to more extreme inter-annual climatic variability and increasing aridity and more frequent droughts. Such changes would potentially impact negatively on both agricultural and pastoral productivity, as well as the hydroelectric developments. Food security, water availability and health are somewhat lacking in the Sudano-Sahelian zone of Cameroon, and climate change impacts will likely further exacerbate this situation, calling for massive efforts in adaptation of the communities.

(a) *National agriculture sector policies and strategic documents:* The agriculture and livestock sectors feel the pinch of climate change impacts, although two Ministry of Environment, Nature Protection and Sustainable Development (MINEP) structures, the National Environmental Management Plan and the National Climate Change Unit (NCCU), oversee the entire climate change strategy. In this regard it will be useful to improve cohesion between these MINEP structures and the Ministry of Agriculture and Rural Development (MINADER) and Ministry of Livestock, Fisheries and Animal Industries (MINEPIA), which cater to the farmers and their production.

Agriculture sector policies set by MINADER aim at enhancing agricultural productivity by increasing cultivable areas, irrespective of whether or not these affect climate change. Increasing the area for cultivation of crops certainly brings challenges– it will lead to deforestation, decreased carbon sequestration, increased carbon dioxide release through decaying vegetation and a direct increase in warming. Other important agricultural policies which call for or will affect adaptation to climate change are (i) the projected oil palm development for food and biofuel; (ii) enhancing mangrove and coral reef protection, and by implication marine fisheries, and the coastal zone improvement through appropriate zoning, proper resettlement, resilient housing and improved protection through the construction of dikes; and (iii) the imminent National Programme for Food Security, run in conjunction with FAO, whose goal is to increase production and productivity of the agricultural sector to ensure national food security. Lastly, as a policy, climate change adaptation and mitigation considerations, and those that relate to agriculture, have been integrated into the country's National Environmental Management Plan under MINEP, which aims at drastically reducing GHG emissions, and which has identified coastal zone management for fisheries, mangrove and coral reef protection as a major component. With Cameroon's high vulnerability to sea level rise, coastal adaptation strategies will be included under the plan (CMEF 2005). The main challenge is that these policies, to be implemented by MINADER and MINEPIA, are likely to lead to institutional conflicts in financial governance between these two ministries and MINEP.

The Government of Cameroon has also established a regional Climate Change Observatory (ONACC), an institutional home for climate change-related research and information for the sub-region (CMEF 2005), and has plans to establish a country-wide multi-sectorial approach to adaptation, including agricultural adaptation, in the different agro-ecological zones, taking a poverty reduction focus and integrating gender-sensitive approaches. The NCCU has been mandated to (a) create an inventory of national GHG emissions and adaptation measures; (b) put in place an information system and database on climate change, and establish an online home for this information to ensure its accessibility and dissemination; (c) design sectoral

projects addressing priority actions for climate change prevention, mitigation and adaptation; (d) evaluate the impacts and policies associated with adaptation and mitigation; and (e) coordinate a multi-institutional National Climate Change Committee. Based on the momentum in place, these policies are likely to enhance adaptation of agriculture to climate change in the future.

(b) *Adaptation needs and priorities:* The diverse ecological zones of Cameroon reflect the country's array of climate regimes. The northern plains and Sudano-Sahelian zones are semi-arid, with a dry season that lasts for seven months, and have significantly higher temperatures in comparison to the rest the country. The central and western highlands are cooler, with a shorter dry season. Conditions become more tropical in the south, with the southern tropical forest region being warm with a limited four-month dry season and the coastal tropical forest being warm and humid year-round. The wet season typically occurs between May and November, depending on the West African Monsoon winds blowing from the south-west (McSweeney et al. 2008). Since the 1960s, mean annual temperatures have increased by 0.7oC and mean annual precipitation has declined by 2.2 percent per decade. Rainfall was particularly low in 2003 and 2005 (Crawford et al. 2011; McSweeney et al. 2008).

Given these projected changes in climate, Cameroon has identified a number of key vulnerabilities for two of its regions – the coastal zone and the Sahel. Concerns within its coastal zone, and thus adaptation needs, include the potential for sea level rise to adversely affect mangrove forests by causing flooding, coastal erosion, sedimentation and increased salinity. Along with the change in temperatures, this process could change the mangrove ecosystem and the flora and fauna contained within it – and by extension affect the local shrimp fisheries. Sea level rise is also expected to cause saltwater to intrude into the Dibamba and Wouri rivers, and into coastal aquifers, negatively impacting agriculture industries (CMEF 2005). In Cameroon's interior Sudano-Sahelian zone, agricultural productivity is already expected to grow at a slower rate than populations. Agricultural and livestock production will be most affected by any future changes in temperature, with agricultural production projected to decrease by between 10 and 25 percent depending on the warming scenario (CMEF 2005).

Growers feel that more effective policies should be made for cartographic mapping out climate-disturbed crisis zones and that this information should be made available to farmers. Also, new farming methods should receive some financial assistance from the government. In addition, it is believed that there should be better coordination of the flow of research results to users.

(c) *Current adaptation action:* Cameroon has more adaptation activities underway than any other country in Central Africa. Nearly all of these initiatives are regional or global in scope. Ongoing projects are focused on a number of sectors, covering forests, water, coastal zones, agriculture, energy and natural resource management. They are designed as research, capacity building, knowledge sharing, awareness raising, vulnerability assessment, policy formation and community based adaptation projects. Programmes and projects active in Cameroon include the following. In an AfricaAdapt nationally focused Knowledge Sharing Innovation project, the Association for the Promotion of the Environment and Sustainable Development implemented a small project to increase awareness and improve the capacities of the country's Pygmy communities to adapt to climate change (AfricaAdapt 2009). On a regional level, Cameroon is participating in the AAP as described above (UNDP 2010b). Cameroon, alongside CAR and DRC, is also participating in the CCAA programme 'Altering the Climate of Poverty under Climate Change', co-financed by IDRC and DFID, which aims to underscore the importance of the Congo Basin forests in climate change adaptation efforts. Under the same regional CCAA programme, Cameroon is participating in the regional project 'Advancing Capacity to Support Climate Change Adaptation', that aims to reduce the vulnerability of poor populations in sub-Saharan countries to climate change by mobilising scientists and other stakeholders to inform political decision-making (IDRC/DFID 2007). Cameroon (along with Tanzania, Fiji and India) is involved in the global WWF-executed project on building resilience to climate change in tropical mangroves and associated coral reefs as they affect fisheries and other marine life. As part of the Lake Chad watershed, Cameroon is also participating in a five-country, six-year 'Lake Chad Sustainable Development Support Program' for promoting sustainable development in the Lake Chad Basin to reverse the watershed's decline and improve the adaptive capacity of the lake's productive systems to climate change. The extent of activities being undertaken in Cameroon under the project is unclear (AfDB 2009). Although the extent of activities being carried out in Cameroon under the project is unknown, as a member of COMIFAC, Cameroon will also benefit from the Commission's current project on Climate Change Scenarios for the Congo Basin. It is hoped that these scenarios will enable decision-makers in the country and throughout the COMIFAC region to adapt and prepare their agriculture and natural resource management strategies to meet the regional challenges of climate change (BMU 2010). Lastly, Cameroon's First National Communication (CMEF 2005) lists a number of indigenous climate change adaptation activities that have been undertaken by farming communities in the Benoue Valley, including stockpiling, changing crops, scheduling

changes and damming the Benoue River for improved water management.

Recent activities that have been undertaken within the AAP alone include: (a) development of a climate change risk map and three studies on climate extremes, multi-sector vulnerability and coastal integrated management, whose objective is to present the vulnerability of the five agro-ecological zones of Cameroon, and at least five development sectors in the country; (b) a study on the elaboration of a soil occupation map and the cartography of the vulnerability of Cameroon to climate change, with the objective being to present the state of soil occupation according to the classification of the FAO, and one map on the geographic information system (GIS) format which presents a cartography of the vulnerability to climate change of Cameroon's agro-ecological zones; (c) establishment through the AAP of the National Observatory on Climate Change (ONACC) as Cameroon's Centre of Excellence for Climate Change Adaptation; (d) establishment of inter-ministerial working groups on climate change adaptation and parliament taskforces; (e) completion of studies on adaptation costs, costs of non-action, long-term investment and financial needs for priority sectors (e.g. impact on the cocoa industry and coastal infrastructure); and (f) establishment of new regional knowledge sharing networks through Teamworks.

In spite of all these instruments, Cameroon has been criticised by some for not yet having a fiduciary fund for climate change.

(d) *Assessment of adaptation measures already taken:* It is generally felt that the Government of Cameroon has been quite active in integrating climate change into national environmental strategies (such as the National Plan for Environmental Management) and formulating a country-wide approach to adaptation (Crawford et al. 2011). It has also submitted its Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), which identified three main areas of climate change vulnerability: health, agriculture (specifically in the Sudano-Sahelian zone) and the country's coastal zone. To respond to needs in these and other areas, Cameroon has been able to attract adaptation funding from diverse sources, including multilateral (AfDB), bilateral (DFID, JICA) and non-governmental organisations (IDRC, AfricaAdapt). Current adaptation activities are concentrated on a number of diverse sectors, including policy formation, forests, energy, mangroves, watershed management and climate scenarios. Agriculture, health and (to a somewhat lesser extent) the country's coastal zone are largely confined to proposed adaptation strategies, rather than implemented activities. This represents an opportunity for future adaptation investment. It is encouraging that the government has included gender-sensitive approaches in its plans to establish a country-wide approach to adaptation, making it the only country in the region to include such considerations (Crawford et al. 2011).

5.2.2 Gabon

Agriculture policies and climate change: Gabon's agriculture and food security policies are geared toward enhancing food security and protecting coastal areas for increased fish production, and the country is well aware of the implications of climate change if nothing is done. Firm policies are already being made on an obligatory carbon balance sheet which will have to be incorporated in every new environmental impact project; the obligation of an impact assessment of biodiversity; and a land use plan which will enable strategic decision-making on land allocation for agriculture, forest exploitation and urban development. Apart from these, and the many official pronouncements showing commitment to combat climate change effects on agriculture and other sectors, there appear to be no major climate change policies with anything to say about agriculture, nor agricultural sector policies with anything to say about climate change. The obstacles appear to be at the level of national priorities and manpower availability, as the country's economy has been dominated by oil. Consequently, there are boundless opportunities in climate change policy development which could improve agriculture in the country and its adaptation to climate change. The country has therefore identified vulnerabilities around which adaptation will be required.

Gabon's key vulnerabilities to climate change: These include agriculture and food security, improvement of the coastal zone and marine ecosystems, water resources and public health. For agriculture and food security, Gabon plans to conduct educational and outreach activities so as to change management practices to those suited to climate change; enhance irrigation efficiency and/or expand irrigation; and develop and introduce policy measures, including taxes, subsidies and facilitation of the free market. For water resources, the country plans to increase water supply, e.g. by using groundwater, building reservoirs, improving or stabilising watershed management and desalinisation, as well as developing and introducing flood and drought monitoring and control systems. To improve the coastal zones and marine ecosystems, Gabon plans to develop integrated coastal zone management, develop planning efforts, support new investment requirements and protect the coastal areas by building sea walls, undertaking beach nourishment and conducting research and monitoring on the coastal ecosystem (IPCC 2007).

Gabon's climate change commitments and engagements: Gabon made some commitments in December 2009 at the United Nations Conference on Climate Change in Copenhagen, Denmark. To meet these engagements, Gabon took the following measures on its climate change policy: (a) creation in April 2010 of the National Council on Climate Change; (b) creation in July 2010 of the Gabonese

Agency for Spatial Studies and Observations; and (c) the prohibition of petroleum gas torching.

Gabon's President, Ali Bongo Ondimba, mandated the National Climate Council with developing and strategically directing national policy on climate change. The council's ultimate goal is the drafting of a National Climate Plan. He reaffirmed his commitment to fight against climate change during the second meeting of the National Climate Council held in the presidential state room, attended by some 200 participants including the Prime Minister and members of the Government, Presidents of constitutional institutions, the heads of the diplomatic corps in Gabon, representatives of civil society, representatives of the private sector and development partners. He noted that because of their high impact on the daily lives of the Gabonese people, environmental problems such as climate change and the fight against the loss of biodiversity were major political, economic and geopolitical issues, and that fighting against climate change was not a choice but was compulsory. Climate change, according to him, had become an inevitability, because Gabon was subject on a daily basis to its harmful consequences. He concluded that rather than suffering from it, the country should grasp the opportunities it presents.

The Chairman of the National Climate Council added that climate change is a global issue and an economic opportunity, and saw these, and the vulnerability of the ecosystem and populations, as factors contributing towards the launch of a strategic climate plan. Therefore, efforts had to be made (a) in resolving and anticipating the vulnerability of the region and its populations to climate change; (b) to fight against climate change; (c) to support the government's development policy by adopting an integrated approach; and (d) to respect international commitments made by Gabon on combating climate change.

Mr. Massard, Chairman of the Managing Committee of the National Climate Council, focused on Gabon's vulnerability to climate change, and more specifically on the impact of rising sea levels on the country's coastal area. Gabon has more than 800 kilometres of coastline, where more than two-thirds of the population are concentrated as well as the majority of the country's economic activities. According to measurements taken in Port-Gentil by the CNDIO (National Centre for Oceanographic Data and Information), between 1958 and 2008 the coastline in the Mandji Island area receded by 4m per year, in other words 200m in 50 years. If this rate was to accelerate, the coastline risks losing up to 10m per year. The consequences of climate change will therefore have a significant social and economic impact on Gabon, requiring a rethink of town planning and land use policies. Mr. Massard also focused on the fact that Gabon's ambition to develop a Climate Plan could only be achieved if the different actors were committed to respecting the schedule for developing it. The aim was to be able to present a first version of the Climate Plan during the 17th Conference of the Parties to the UNFCCC to be held in Durban, South Africa.

Gabon's willingness to fight climate change: Between 2009 and 2013, the following five initiatives underlined Gabon's willingness to fight climate change: (a) the Official declaration during the Copenhagen Summit of December 2009 by President Bongo Ondimba of Gabon's commitment to fight climate change; (b) his pronouncement in the National Climate Council meeting, presided by him, in May 2011; (c) President Bongo Ondimba's position in the World Economic Forum in Africa, South Africa, in May 2011, during which he urged African governments to speak with one voice on the fight against climate change; (d) the signing of three conventions by Gabon and the French Development Agency in January 2011, to the tune of €10.5m, relating to the sustainable management of forest ecosystems (from the global amount, €1m will be used in the creation of a study fund for the preparation of the project, €9m for the installation of satellite image reception antennas and a centre for remote sensing and €500,000 to support the elaboration of Gabon's climate strategy which is intended to include agricultural adaptation); and (e) the holding of a roundtable by the NGO Brainforest and the Club des Journalists Verts on 27 February 2013 to let climate change experts clarify the issue of climate change and its implications to the population.

Climate change projects: Although not specifically treating agricultural adaptation, there are also some externally funded projects which address the issue of climate change. One of these is the Institutional Reinforcement Project for Institutional Capacity for a Better Adaptation to Climate Change in the Coastal Zone of Gabon. This project, funded by the Government of Japan to the tune of US$2.5 million and implemented by UNDP, integrates with the AAP, whose objectives are to reinforce the adaptive capacity of vulnerable populations to climate change risks, promote short-term adaptation actions which have succeeded elsewhere and put in place measures favouring resilience or long-term adaptation.

5.2.3 The Republic of Congo

As policy, Congo Republic plans to expand its oil palm and groundnut industries. No firm policies are available on agriculture and adaptation. However, Congo Republic's socio-economic and political history renders it vulnerable to the effects of climate change. Climatic conditions in Congo Republic vary from sub-equatorial to humid. As a result of climate change, the country is likely to face an increase in annual temperatures, a decrease in the dry season and an increase in annual average rainfall.

Key vulnerabilities: Key vulnerabilities for climate change in Congo Republic can be found in the agricultural, coastal and marine infrastructure. Congo Republic's First National Communication to the UNFCCC identified agriculture as a vulnerable sector due to increased seasonal variability, although it was also noted that climate change could have positive impacts by allowing the introduction of

new cash crops (like oil palm). Also mentioned in the communication were freshwater resources, particularly impacts on hydroelectricity generation; coastal zone management, particularly saltwater intrusion and flooding caused by sea level rise, which would affect fisheries and aquaculture; forestry; and energy, with increased demand (due to population growth) matched with uncertain generation given rainfall fluctuations.

(a) *National Communications:* Congo Republic produced its First National Communication in 2001 and its Second National Communication in 2009. Within the Second National Communication, agriculture is considered a key vulnerable sector, and components of a project currently being implemented by the government with the Food and Agriculture Organization (FAO) show that Congo Republic has identified key vulnerable sectors in need of climate change adaptation (Sassou-Nguesso 2009; 2011). These are freshwater resources, coastal zone management, agriculture, forestry, human settlements and human health, all of which were highlighted in the First and Second National Communications. In spite of the negative impacts of successive conflicts, which have disturbed ecosystems and infrastructure as well as the country's development, Congo Republic has accorded environmental issues and sustainable management of natural resources a high priority in its development process. No policies have yet been enacted on adaptation. However, the establishment of the Ministry of Environment and many related departments and the signing and ratification of the UNFCCC are signs of promise.

Adaptation actions to stop environmental degradation have already been undertaken by the government in the past, particularly through the establishment of the Industrial Afforestation Unit (UAIC). Tree planting activities were intensified, coupled with the effort to reduce fuel wood consumption, as part of its adaptation strategy. In the FAO-funded National Programme for Food Security the goal is to increase production and productivity of the agricultural sector to ensure national food security. The first phase of the project was from 2008 to 2012. No mention of climate change adaptation is made in the country's most recent Poverty Reduction Strategy Paper progress report (March 2010).

(b) *Current adaptation action:* A low level of adaptation programming is being undertaken in Congo Republic at present relative to other Central African countries. The country appears to have no national projects underway, but is part of two regional programmes. It is one of four Central African countries participating in AAP, the US$92m initiative funded by JICA since 2008. The Congolese component of the programme is worth US$2.975m, and is by far the most significant adaptation activity underway in Congo Republic. The Congolese project is focused on the health, economy, agriculture, water and energy sectors, and is designed as a capacity building, knowledge sharing and policy formation and integration project (UNDP 2010b). As a member of COMIFAC, Congo Republic will also benefit from the current project on Climate Change Scenarios for the Congo Basin. The extent of activities being carried out in Congo Republic under the project is unknown, but it is hoped that these scenarios will enable decision-makers in the country and throughout the COMIFAC region to adapt and prepare their natural resource management strategies to meet the regional challenges of climate change. Strategies laid out in the FAO-funded National Food Security Program to ensure domestic food security through increased agricultural production and productivity are described as 'adaptation strategies' in Congo Republic's Second National Communication. As a result of the limited number of adaptation projects in Congo Republic, funding at the moment is strictly from bilateral sources (Japan and, to a lesser extent, Germany).

(c) *Future adaptation plans:* Research and policy are required on the impact of long-term temperature increases on the country's perennial crops (such as oil palm and various fruits). The observed changes in Congo Republic's climate have already affected the country's main agricultural zone. As temperatures continue to rise, increased rates of evapotranspiration are expected to affect cultivation of certain crops, including groundnuts. Other anticipated changes include altered growing and harvesting cycles with changes in the length of the wet and dry seasons.

It is felt that major policy issues are still lacking. Firstly, existing policy texts are weakly applied. Secondly, texts creating agricultural university institutions did not take into account the specific area of climate change, making it difficult to allot funds for climate activities. Thirdly, human capacity building in research teams and basic infrastructure development (for climate forecasting and drought research) are weak and their improvement is urgently needed to foster work on agro-climatic data collection on climate change, as well as plant resistance to climate-induced drought in some areas of the country.

5.3 Recommendations

(a) In some countries, such as Chad, it is felt that women, who contribute immensely to agricultural production and who are therefore the most vulnerable to climate change impacts, are not consulted or made to participate effectively in climate change policy decisions, making their role rather passive in the execution of field activities. Information, communication and advocacy for gender participation in the COMIFAC countries need to be improved so as to create a favourable environment for policy development and enhancement on climate change matters.

(b) There is need for the development of coordination mechanisms (frameworks) for exchanges between the different institutions working in areas related to climate change. The aim here is to establish relationships to ensure coordination and exchanges between political institutions, research institutions and the grassroots level (civil society, NGOs, etc.).

(c) There should be support for the creation of centres of excellence in climate change policies on adaptation.

(d) Much effort should be put into raising awareness of actors at various levels, in setting up awareness strategies and in developing suitable communication tools to meet the needs of the different actors on climate change issues.

(e) Development of strategies should improve national and individual capacities to respond to the impacts of climate change.

(f) At the regional level, the initiative of developing a regional strategy to combat the impacts of climate change is favourable for the development of coordination frameworks between organisations working on the issue. It is also important that institutions of the region, the existing programmes and international organisations operating in the sub-region are involved and integrated in coordination and exchange processes, thereby allowing them to rationalise their experiences and investments.

(g) Partnerships should be reinforced and extended. This could involve one or more formal structures, which could be housed in one of the institutions in the region, but also the development and operationalisation of networks that would enable the different actors, on different levels, to exchange more informally and perhaps more regularly.

(h) It is useful to understood that the need for knowledge about climate change scenarios and about the impact and potential for adaptation to climate change is still very substantial and somewhat determines the positions of decision-makers. Taking account of traditional knowledge (especially in the area of adaptation) is an important element in the development of such a body of knowledge. It is therefore necessary to reinforce the existing university structures and attempts to build networks.

(i) Considerable efforts to raise awareness need to be made at various levels. It has been recognised that the different actors (essentially political decision-makers and local partners) are generally little informed about climate change and its impacts on national policies but also on their everyday lives. This is partly due to the complexity of climate change. Communication tools need to be developed that are tailored to the needs of these different actors to sensitise them to climate change issues. This would suppose setting up real awareness strategies that are based on needs, levels of understanding, national languages and cultures, so as to develop appropriate communication tools (theatre, video, film, radio, music, etc.) according to the different targets.

6 Gaps in Climate Change Adaptation Research and Policy in Agriculture in the Central African Region

In the Central African region there are at least seven areas of concern reflecting huge gaps in climate change adaptation research, namely: (a) adaptation in forestry, where forest ecosystem goods and services are found to be indispensable in planning adaptation in all other sectors (Nkem et al. 2007); (b) adaptation in agriculture; (c) adaptation in fisheries development; (d) adaptation in livestock and pastoral production; (e) adaptation in water resources; (f) adaptation in public health; and (g) adaptation in urbanisation. Much work has been done on climate change adaptation in forestry (especially on mitigation efforts and the reduction of GHG emissions resulting from deforestation and forest degradation), and it is here also where international partners have put the most emphasis, probably because of the importance of forest resources in the region. But even here, there are still areas of concern, such as the GHGs (fluorocarbons) utilised in the domestic fridges, which are manufactured in developed countries but sold to developing countries.

6.1 Gaps in agricultural research and policy

In agricultural research, the main gaps relate to identifying how to tackle climate change scenarios (precipitation, floods, temperature and drought) on crop farming and making the necessary government policies to implement adaptation. Major gaps in agricultural research are: (a) the adaptation of annual crop (maize, sorghum, millet and wheat) cultivar responses to drought in drier zones given the shortened water regimes in the Sahel, and the need for new crop varieties required by growers to bring resilience in the agricultural community in that zone; (b) tackling emergent crop diseases in the wake of a changing climate; (c) countering increases in small animal diseases and pests in the forest-savannah transition areas in response to global warming and regional climate change; and (d) addressing fragile, highly depleted soils which are very vulnerable to climate change (Knox et al. 2012). Policies on these issues, accompanied by appropriate funding, need to be made, especially as climate change adaptation studies in agriculture are just beginning to be perceived as high priority issues and unavoidable threats to food security.

6.2 Gaps in Fisheries adaptation research and policy

Major gaps in fisheries research and policy include: (a) research to support data collection of fishery and climate information to facilitate a regional data bank, and collate information and data already existing in the region; (b) climate change risk assessments with costed adaptation plans, with special consideration to the most vulnerable actors; (c) documentation on the status and strength of disaster risk management and early warning systems in the region; (d) integrating research into climate change effects on the region-owned systems such as the Lake Chad Basin; (e) conducting research on prevention strategies for further reduction of water in the major lakes (such as Lake Chad) which serve populations from many countries in fisheries and recreation; (f) practical research and effective policies to restore fish biodiversity with rising sea levels and increasing pollution in the coastal maritime ecosystems, including production of fingerlings, phytoplankton and zooplankton; and (g) investigating measures to protect mangroves and coral reefs, important ecosystems which are currently in danger of destruction and pollution.

6.3 Gaps in livestock research and policy

Major gaps in research and policy in the livestock sector include: (a) making effective policies on communal rangeland management systems so as to reduce conflict among livestock keepers; (b) enhancing studies and policies on crop-livestock integration so as to extend the lives of and enrich pasture lands and enable livestock rearers to adapt easily to climate change; (c) addressing emergent livestock diseases and pests in a changing climate; (d) adopting policies to enhance and protect wildlife through domestication of livestock species (a notable example worthy of emulation is the domestication of the cane rat which is now a popular sub-industry in some countries like Cameroon); (e) treating adaptation in the livestock sector as a generic capacity rather than specific only to climate change; (f) developing adaptive capacity in making an informed assessment of threats, making informed choices about response measures from a range of options, deploying the preferred response measures and creating an enabling environment to implement these measures; (g) building capacities for improved climate forecasting and warning and increasing awareness of climate change and its consequences; and (h) strengthening human capital through basic education and public awareness and making information on livestock adaptation options widely available to all stakeholders.

6.4 Gaps in pastoralism research and policy

Like in the livestock sector new research and policy should focus on: (a) enhancing research and communication to improve understanding of the complex relationship between pastoralism and climate change; (b) promoting understanding of the importance of the pastoralism sector to the adaptation strategies of rural poor people of the Central African region; (c) developing adaptive capacities among stakeholders in the pastoralism sector; (d) building capacities for improved climate forecasting and early warning, and increasing awareness of climate change and its consequences on pastoralism; and (e) improving pastoralist education and public awareness.

6.5 Policy gaps in climate change adaptation

Adaptation policy in the region appears to be low because of the apparent low commitment of governments to support adaptation. As the main stakeholders, governments should be ready to play the major role of rallying all other stakeholders; bring them to the negotiating table so as to make a clear evaluation and identification of adaptation issues and strategies; and fund the adaptation activities. The research results obtained should be transferred to the end users through appropriate mechanisms and workable stakeholder training.

6.6 Research-policy gaps in the region

Research-policy gaps also exist. Research activities could be formulated, but if not funded, adaptation will not be enhanced. In developed countries industry funds most of the research; in Africa, the main research support comes from governments, making the latter a very important actor in the adaptation development process. Research must therefore undertake the necessary advocacy to attract government funding for its initiatives.

6.7 Research and Policy gaps in the various countries of the region

(a) *Inadequate scientific infrastructure and manpower:* Many national research systems are not sufficiently staffed and do not have the appropriate infrastructure. Because funding is usually inadequate, the governments of the region could

pool resources together and establish regional institutions, centres or laboratories of excellence to serve the countries of the region, especially for complex issues like climate change. Scientists could also be trained or retrained in climate change research and on current areas like GIS, remote sensing, climate forecasting, monitoring and evaluation, and these skills could similarly be shared in the region. Unfortunately, because national institutions cannot adequately fund research, many research scientists have resorted to doing consultancies and other things to occupy themselves and make ends meet.

(b) *Improvement of extension systems:* Regional extension systems need to be reinforced. It should also be regional policy to include the civil society in the public extension services so as to tap into their competence, willingness and availability in the dissemination of climate- and adaptation-related results.

6.7.1 Cameroon

Cameroon's Institute of Agricultural Research for Development (IRAD), the national agricultural research institution, has as one of the 49 research projects in its five-year strategic research plan a major project on climate change. But no funding has been allotted for its execution despite the willingness of multi-disciplinary teams of scientists to conduct the studies. At the higher level, this is compounded by the issue of coordination between the ministries in charge of environment, agriculture and livestock, which may cause perturbations in project execution because of financial governance issues.

A well-structured National Agricultural Research and Extension Program in MINADER is responsible for dissemination of agricultural results. Dissemination of livestock and fisheries results is done by the Extension Agents of MINEPIA. But all these agents have been made to work together, as they may have a common farmer engaged in both crop cultivation and animal husbandry. Yet policies may still differ, since each Ministry is bound to have its own set of policies to enhance its execution domains.

6.7.2 Gabon

Gabon has recently established a National Climate Council which develops and strategically directs national policy on climate change, with the ultimate goal of drafting a National Climate Plan. Although it is generally felt that climate change is considered inevitable by the Gabonese authorities, it is not clear what policies have been formulated to effect climate change adaptation. Policies are being put in place to establish agroforestry projects in rural areas to increase soil fertility as well as to invest in and improve weather stations to observe changes in the climate. Agricultural organisations are also training farmers in the techniques needed to restore soils.

The main gaps in policy lie in the implementation of this commitment and follow-up of measures taken, which may be partly because the country has a rather fragmented research system which is not sufficiently staffed and does not appear to cover all the ecological zones of the country. Hence, policies on climate change handled by the National Climate Council as well as the activities of the Gabonese Agency for Spatial Studies and Observations appear to be lagging in execution. From this perspective, the following need to be achieved: (a) resolve and anticipate the vulnerability of Gabon and its population to climate change; (b) fight against climate change as it affects all sectors of the economy; (c) partners should support the government's development policy by adopting an integrated approach; and (d) the government should respect international commitments made by the country to its partners.

6.7.3 Republic of Congo

Agriculture is considered a key vulnerable sector in Congo Republic. However, apart from a project currently being implemented by the government with FAO, no policies have yet been enacted on agricultural adaptation and no mention of climate change adaptation is made in the country's most recent Poverty Reduction Strategy Paper progress report (March 2010). However, as part of its adaptation strategy, adaptation actions to stop environmental degradation had been already undertaken by the Government in the past, with tree planting activities through the UAIC.

Research needs more organisation in the country. Research gaps include the impact of seasonal rainfall and long-term temperature increases on the country's perennial crops (such as oil palm, olive and various fruits), and studies to develop resilience to these crops which are considered most vulnerable to climate change impacts. Impacts on deforestation as new oil palm fields are opened need to be considered within the context of decreasing carbon sequestration. Studies and policies are also needed to address altered growing and harvesting cycles with changes in the length of the wet and dry seasons because changes in the Congo Republic's climate have already affected the country's main agricultural zone. As temperatures continue to rise, increased rates of evapotranspiration are expected to hurt cultivation of certain crops, including groundnuts.

Other gaps in research and policy have to do with improving the inadequate agricultural extension coverage, logistical support for agricultural extension staff and resources for improved technologies, which all contribute to other gaps. The structural adjustment of the 1980s and early 1990s worsened the situation by eliminating most of the earlier government support to agriculture (subsidies, tax exemption, adequate staffing, etc.) which would have perhaps reduced the country's vulnerability to climate impacts.

The limited number of climate change projects and programmes in the country indicates that there

is considerable scope for an expansion into a number of different areas. These include undertaking more community-based adaptation projects; initiatives to date have been implemented primarily at the government level by government ministries and external partners, suggesting that there is a need to improve the capacity of domestic civil society to implement adaptation programmes.

7 Analysis of Stakeholders and Opportunities for Collaboration

Introduction

A stakeholder is a person, group or organisation that has interest or concern in an organisation or in a certain issue. In climate change issues, stakeholders are the various actors involved in or affected by the impacts of climate change. Key stakeholders on climate change issues are government, civil society, NGOs, research organisation, the donor community and farming communities; they are diverse, and this diversity could prove useful and provide boundless opportunities for collaboration which should lead to success in climate change adaptation.

7.1 Regional and international stakeholders

A good number of regional, international, donor and NGO stakeholders are strong actors in climate change negotiations. FAO, UNEP, UNDP, the World Bank, IFAD and the French Cooperation Mission are all important international organisations in climate change matters. NGOs such as WWF, the International Union for the Conservation of Nature (IUCN), the World Conservation Society (WCS), Living Earth, the Central African Regional Program for the Environment (CARPE), Centre for Environment and Development (CED), Central European Weather Radar Network (CERAD) and Regional Action on Climate Change (RACC) are all serious actors on climate change issues. Some NGOs are externally funded and so carry out the mandated activities of their sponsors irrespective of their utility in the country in which they operate. In the region, some of the private sector institutions are Fipcam, Pallisco, Wijma logging company, and Alpicam industries, Cameroon.

COMIFAC is the regional body set up by the Heads of State of the Central African region to regulate forest development policy as well as issues relating to climate change in the forest zone. There are also the international agricultural research centres which have active programmes and thus have a great stake in climate change matters in the region, notably CIFOR and ICRAF. CIFOR carries out work mainly on climate change policy on forest management, whereas ICRAF is more involved in climate change mitigation efforts. As regional actors, they are involved in internationally funded research projects involving many countries in and out of the region.

7.2 Climate change stakeholders in the Central African countries

7.2.1 Cameroon

The ministries in charge of the environment, forestry, agriculture, livestock and fisheries; civil society (Service d'Appui aux Initiatives Locales du Developpement [SAILD], etc.); NGOs (WWF, IUCN, etc.); national and international agricultural research institutes; international organisations and donor agencies; and university institutions are all involved in climate change adaptation because it affects their activities in one way or the other, and all should be included in the discourse.

In Cameroon, IRAD is the national research institute for agriculture, livestock, fisheries, forestry and environment. It has an ongoing project on climate change, but unfortunately this is yet to be funded or see its activities take off. The Universities of Dschang, Yaounde I and Buea also have institutional capacity and are interested in conducting research on climate change, but work may be slow in these institutions for reasons related to funding.

ICRAF and CIFOR operate in Cameroon and have projects on mitigation and forest policy and management, respectively. The main policy actor is the government. Most of the power is vested in MINEP, the ministry in charge of the environment and nature protection. The scientific actor is the Ministry of Scientific Research and Innovation through IRAD. Although MINADER and MINEPIA are directly affected by climate change, and participate in National Climate Change Unit meetings, they are represented by MINEP in discussions taken at the international level.

A few small civil society organisations, which have sprung up recently because of the current interest in environmental matters, are at the lower power level and feel frustrated that they are not usually directly involved in climate change discussions, either because they are too small to have a voice or are too weak to make a contribution.

In Cameroon, funding appears to be at the forefront of the research-policy dialogues and discussions in the agricultural sector. If research projects in the domain of climate change adaptation are funded adequately, the expected results will be produced and these will guide policymakers in making informed decisions on strategies which will help the farmers. In the country there is quite a problem with horizontal stakeholder coordination, which appears to be exacerbated by funding control. Evidence from the many studies shows what can rightly be considered a coordination tragedy of institutions in Cameroon. This can be illustrated by the following three factors: 1) the ministries' reflex to

keep a tight hold over their respective fields, i.e. each seeks full control over its own niche and, although they attend meetings, they seldom work together; 2) the creation of a large number of mostly non-functioning inter- and intrasectoral coordination committees and structures; and 3) institutional instability characterised by changes in – or even the breakdown of – government structure through ministerial reorganisations that very often undermine coordination processes. Climate change adaptation in agriculture will require the alignment of sectoral policies. It will also require that decisions to take actions (at the central level) and to implement them (at the local delegate level) be effectively coordinated. Coordination should also mean that the actors are treated equitably regarding levels of intervention and the sharing of transaction costs. Finally, to be efficient, the national strategies in their design and implementation must be aligned with other strategies connected to the UNFCCC, such as Nationally Appropriate Mitigation Actions (NAMAs) and National Adaptation Programmes of Action (NAPAs). Hence, to ensure coherency and save resources, discussions on the formulation of the national strategies on climate change should not be dissociated from the formulation of the NAMAs and the NAPAs.

7.2.2 Gabon

Government is also the main stakeholder in climate change issues in Gabon. However, in addition to the Gabonese civil society agencies, international NGOs intervening in climate issues are the WWF, the IUCN, the WCS, Living Earth, CARPE, CED, CERAD and RACC. A good number of research institutions such as ICRAF and CIFOR, as well as the university, have a few programmes on climate change in Gabon. Civil society is organised under the Organization of Civil Societies (OSC) which represents those actors in meetings.

7.2.3 The Republic of Congo

The adaptation process in Congo Republic is presently coordinated by the project 'Support to the putting in place of integrated and global approaches for adaptation at the wake of climate change', which has a multi-stakeholder steering committee, a platform which is made up of representatives of 14 ministerial departments (housing, energy, transport/civil aviation/merchant marine, health, agriculture and livestock, territorial development, tourism, industry, gender, fishing, scientific research, meteorology, finance and budget, forestry and environment), three delegates from national civil society associations and organisations (Association Femme-Energie, Réseau national des peuples autochtones [RENAPAC] and Projet Evangélique de Développement Communautaire (PEDC), and three delegates of the private sector, notably a representative from the workers' syndicate Union patronale et interprofessionelle du Congo (UNICONGO), a representative from a forestry company (CIB) and a representative from a hydrocarbons company (Société Maurel & PROM – Congo). The committee is under the Ministry of Sustainable Development, Forest Economy and the Environment (MDDEFE). Representatives of these sectors and populations define with the Ministry the necessary actions to put in place. The steering committee has as principal role approving work plans and annual budgets proposed by the project management unit. The members are appointed by an order of the Minister in charge of the environment. As members, they participate in different workshops and meetings organised by the project management unit. These ministries and institutions were chosen because of their direct link with the priority sectors targeted by the project (water resources, marine resources, agriculture, forestry, fisheries and energy).

Thus the main beneficiaries of the project, who are all represented in this steering committee, are the public, the private sector, NGOs and the scientific milieu, all of them implicated in the debate on climate change adaptation. UNICONGO represents the interests of the main private companies present in Congo Republic, including the mining and petroleum corporations.

So far, no major decision has been taken by this steering committee, apart from the approval of workplans and budgets for the year 2012. It is worth noting that some government ministries are not represented in this committee, for example the general delegation of heavy projects, the main contracting authority for structural projects (such as bridges, roads, airports, hydroelectric dams and so on), the ministry in charge of humanitarian action and solidarity, the ministries of local councils, information and communication, and primary, secondary and higher education. The project is supported by a scientific committee called the Adaptation Unit which is made up of experts recruited through open tenders, steered by the Office of Human Resources of UNDP. The experts are in the following fields: adaptation, systems modelling, a resource economist, a soil scientist, a plant pathologist, a veterinarian, a lawyer, an ecologist, a climatologist, a meteorologist, a development planner, an expert in catastrophe risk reduction, an agronomist, a civil engineer and an expert in GIS. This group of experts plays the role of preparing terms of references and validating the different reports produced by the consultants recruited by the project.

7.3 Opportunities for collaboration

There are boundless opportunities for collaboration between partners for the attainment of state goals. In each country natural catastrophes (floods and erosions) should bring together various stakeholders as well as the government to make decisions on climate change impacts.

(a) *Tapping of stakeholder expertise:* Firstly, stakeholders are usually specialised, although sometimes their mandates overlap. However, bringing these competences and expertises together may provide the synergy required in fostering a complex process like climate change adaptation. As said earlier, collaboration will be fostered if there is mutual consideration and respect among stakeholders.

The governments of the region should play that role of forging collaboration of stakeholders to work together to achieve a common objective – that of adaptation to climate change. When stakeholders work together they get to know each other, they interact to understand the process more deeply, are comforted that they are part of the process, and that if it fails they will have themselves to blame. And if it succeeds, the joy will be shared by all of them.

(b) *Benefit sharing:* This is another issue that may come up when collaboration in a project as complex as climate change adaptation is concerned. If funds are needed for meetings, workshops and other activities, they should be shared equitably to avoid the frustration that is habitually noticed when some key partners usurp issues and appropriate benefits for themselves. All stakeholders must have a say in the strategies and be involved in negotiations right from the start. The funds within each partner are used differently because each partner has a different set of objectives. But these objectives overlap, and there are many issues which cut across and affect each partner. To avoid duplication, the partners have to be brought together so that the various issues in climate adaptation are shared among the partners and funds are not wasted in doing things which other partners may be doing or could do better.

(c) *Gender and Public-Private Partnership:* Undoubtedly, there are boundless opportunities for collaboration between stakeholders which could be harnessed to make the strategies in climate change adaptation succeed. For instance, women's advocacy groups and private sector societies could be trained and used to pass on climate change-related technologies which have been developed by researchers. Collaboration involving gender recognition may also receive appreciated support from donors, who usually appear to be more comfortable funding projects in which women participate actively. Furthermore, the donor community appreciates projects which clearly show public-private partnerships, the two sectors working together harmoniously for the achievement of project goals. Lastly, pooling of resources from the various stakeholders enhances success.

7.4 Recommendations and conclusions

(a) *Use of women's groups:* Women's groups are sometimes not given the place they deserve. Women's advocacy groups have developed somewhat and grown in strength in recent years. Yet in many projects they are not given the opportunity to effectively participate. Since food crop farming is principally a woman's domain in the Central African region, it is therefore logical that women's civil society groups be associated with discussions on sensitive issues like climate change; they interact better with their female farmer colleagues and could help disseminate extension messages faster if they are active stakeholders in the process.

(b) *Research-extension partnerships to be encouraged:* In some countries (e.g. Cameroon) agricultural research is in a different ministerial department from extension. Strong links should be forged between research and extension so that they can approach the farmers with interventions at the same time.

(c) *Research-university partnerships should be encouraged:* In developed countries the distinction between research scientists and university professors is not evident. Every university teacher is a scientist and the two groups work together harmoniously to produce results. But in Africa, most of the time this is not true. The two groups do not usually work together, failing thus is pooling required expertise and resources for the development of technologies and the attainment of results. This kind of collaboration should be fostered as it provides an immense opportunity to achieve more with fewer resources in less time.

8 Conclusions and Recommendations

This report synthesises research and policies related to climate change adaptation in the agricultural sector in Central Africa with the objective of enhancing the knowledge base and to support research-based policy formulation for climate change adaptation in the agricultural sector. Whereas there is abundant information on climate change in the developed countries, there very few studies and thus very scant information from the Central African region. Among the three countries covered in this report, there was some data from Cameroon and the Congo Republic but very little information from Gabon.

8.1 Conclusions

Based on this current review the following conclusions can be made.

Review of climate change research and policy in the region

8.1.1 Research

The review showed that although much is known on climate change and its consequences in each country of the region, there were not many field studies on adaptation to climate change in agriculture in the region. The few studies were interviews of stakeholders on their views of climate change adaptation and coping mechanisms. Crop farming relies on conservation agriculture, use of agroforestry, exploitation of wetlands,

use of cultural practices (e.g. modifying planting dates) and diversification of genetic resources. In livestock rearing, herders use locally adapted breeds, diversify breeds, do rational resource management and use agricultural by-products for feed production. In fisheries and aquaculture, farmers use precautionary natural resource management, migration and diversification of livelihoods when conditions are adverse. Some countries have identified areas in crop farming, livestock and pastoralism and fisheries and aquaculture for which adaptation is needed, but the effective execution of field research activities is yet to start. For instance, in almost all the countries in the region the crops most affected by climate change are maize, cassava, rain-fed (upland) rice and groundnut. Most of the literature is on planned activities and policies. There is much more information on climate change impacts on forestry (especially on mitigation efforts and reducing emissions from deforestation and forest degradation) than in agriculture. However, some of the countries like Cameroon are involved in a wide range of projects (although many of these concern awareness and capacity building) which when completed will provide substantial information on climate change in the region.

8.1.2 Policy

Regional organisations and programmes such as NEPAD, CAADP, LCBC and COMIFAC have strong policies and instruments (AAP, CCAA, AfricaAdapt, etc.) regarding climate change to work with, showing the importance of the issue in Africa. Every country in the region was seen to have signed and ratified the UNFCCC, and each had policies and a public agency on climate change. Gabon has a national climate council, Cameroon has a national climate unit, and Congo Republic has a climate change programme under deforestation. There are also a good number of internationally-funded projects which finance research, training and advocacy projects on climate change. AfDB, JICA, DFID, IFAD, FAO, the World Bank and many others have active projects in the region. From the review, what was seen lacking was the effective and practical implementation of policies by the instruments which have been created in each country and the meeting of the commitments agreed upon with donors and regional and international partners.

8.1.3 Gaps in climate change adaptation research and policy

(a) *Gaps in research:* The review found major gaps in research on adaptation to climate change in the agricultural sector. In crop production, manipulation of genetic resources to generate climate-smart genotypes and the refinement of climate-smart farming practices need to be studied. Investigations on natural resource management, effects of livestock mobility and exposure of livestock to diseases and pests as they migrate from their original niches to others in search of pasture and water need to be intensely investigated to enhance livestock and pastoralism. Ocean and river warming and sea level rise as they affect the different fish species and other marine life and inland fisheries and aquaculture need to be studied. Studies are also urgently needed on the protection of mangroves and coral reefs as these relate to marine life, fisheries and aquaculture. Research gaps also exist in the areas of climate forecasting of imminent climate changes and in remote sensing, which call for improved manpower capacity, technical know-how and solid infrastructure development in the region. Capacity to design effective field adaptation strategies probably needs the retraining of available manpower or the training of new scientists in the area.

Enhancing resilience and adaptive capacity and exploitation of traditional coping measures are, among others, those areas to be easily improved in adaptation research. The process will probably become easy as knowledge unfolds in the projects which are presently underway, but for now, the issue of adaptation still throws doubt on many actors in the Central African region. Actors (especially the scientific community) face the challenge of developing the adaptation concept broadly so that all players will have a clear understanding of adaptation. This will then be followed by the laying down of concrete experiments to obtain the results that will guide policymakers. It is then that adaptation will be considered an issue of today, not one whose impacts will take several years to be felt.

(b) *Gaps in policy:* The policy gaps found in the review relate mainly to the slow or non-implementation of agreements with international partners (UNFCCC, AAP, etc.); the apparent lack of commitment by governments in providing the necessary funding for climate change adaptation research; and a dearth of equipped local and regional institutions, as well as regional and national policies to do effective climate forecasting which could lead to early warning to farmers, fishers, livestock rearers and pastoralists about imminent climate changes and the dangers they may cause. In Cameroon a Climate Change Observatory has been created but is not yet functional. In Gabon a Climate Change Council has been established but it is yet to start operations. Efforts should be made by the various countries to operationalise these bodies beyond the level of holding meetings and voting budgets.

8.1.4 The way research informs policymaking

There is an urgent need to design field experiments using concrete crop, fisheries, livestock and pastoral examples to study the effects of climate change on performance of crops, livestock and fisheries so that visible results will be produced which will guide adaptation measures and strategies to be put in place. Research should also advocate for aquaculture research, which unfortunately has been neglected somewhat, knowing that fish cultivation in controlled environments could go

a long way in supporting our adaptation efforts. Research, with accompanying partners, should be supported to produce a package of practical recommendations which will guide policymakers as well as end users. Research must also strive to make its results visible through the organisation of open days, television debates and radio programmes where research results and products are exposed to policymakers and the general public. Until this is done, the issue of adaptation, whose impacts appear for now to be long-term, will remain an issue for the future.

8.1.5 The ways that gaps in research and policy could be closed

Some ways that these gaps could be closed are: (a) improving coordination among partners so that the work is shared among them, each one making a contribution in an area in which it finds itself more competent; (b) making the necessary investments in the region to establish specialised institutions to conduct research on climate change for the benefit of all the countries of the region; (c) allocating the required funding for adaptation research at the local level, which could be done by specialising some countries in a specific aspect, thereby avoiding duplication and saving already scarce resources; (d) governments should attempt to bear the initial burden to fund adaptation, instead of depending on the international donor community, which may be glad to come in with the needed resources but with strings attached; (e) reducing bureaucracy and excessive meetings on an issue like adaptation which needs practical implementation in the field, so more time will be spent on execution, monitoring and evaluation of the process in the region.

8.1.6 Key stakeholders and collaboration

(a) Major stakeholders: The study showed that there are quite a good number of actors in climate change in the region, and in the various countries. The international organisations, international NGOs, international research institutes, universities and civil society were found to be the key stakeholders in climate change adaptation. The frustration expressed by some stakeholders interviewed indicated that all must be treated as equal partners, be at the same level of understanding of climate change issues, be made to perceive the effects of climate change, and be aware that what they are perceiving is actually caused by a changing climate. Those who eventually gain awareness of climate change effects should also be aware that there is a need to adapt to the change. Unfortunately this frustration was noted with some actors, especially in civil society, giving the feeling that they could even act as blockers in a process of this nature, whereas this group of actors could be very useful in disseminating information to the end users if they are given their place.

Funding was noted as a problem in climate change adaptation issues. Many governments in the Central African region still feel that funding for adaptation should come from outside, either through loans or through bilateral funding from international organisations. And because the real impacts of climate change appear to be distant, governments do not consider the process urgent enough to commit funds to it; as a result adaptation is given a very low priority in terms of national funding.

(b) Possible opportunities for research, policy formulation and collaboration aimed at enhancing adaptation to climate change: All stakeholders appear to have a role in climate change matters. Stakeholders could assist immensely in disseminating and popularising research results to the users (the farmers). There are mechanisms for integrating research findings into agricultural sector policies. The research-user interface has the extension service as an intermediary or liaison organ, which, although not very effective in some countries, does a good job of disseminating results. Extension is quite well developed in Cameroon and less so in the other countries of the region. It was found that although research results eventually reach the users (farmers and processors), it is still problematic when a new area like climate change adaptation is involved; the stakes are either unknown or poorly mastered or are yet to be clearly identified.

There are good opportunities that exist for collaboration because many of the stakeholders appear to be somewhat specialised, making the roles they could play in climate change adaptation complementary, if they are brought together as equal partners right from the start so that each stakeholder is at the same level of understanding of the entire process of adaptation, and are treated in the same way in benefit sharing. Actors who are neglected may end up with the unfortunate impression that climate change and the need to adapt to it is a government issue, and not an issue that concerns them directly.

Opportunities for collaboration between stakeholders may also be affected by misconceptions about climate change. Firstly, climate change adaptation strategies should be designed to address and bridge the knowledge gap. Secondly, simply conveying information, data and facts about a process such as climate change is not enough; information alone may not change stakeholder or farmer behaviour or alter misconceptions. It is also important to acknowledge the range and diversity of values that drive decisions. Consequently, for climate change adaptation to become integrated into policy, the facts need context and they need to be brought to life.

8.2 Recommendations

8.2.1 For crop farming adaptation:

(a) Make more investments in genetic enhancement research so as to produce crop genotypes that are adapted to harsher climates (including droughts and flooding).

(b) Establish technological barriers to prevent the movement of propagules of vegetatively propagated crops from disease-infested regions to those not yet having infestations.

(c) Reinforce the extension systems throughout the region, bringing in civil society, to be aware of possible threats of epidemics.

(d) Support research to investigate cultural practices such as changes in the dates of planting, length of growing seasons, sensitivity to increased droughts, flooding, periodic water logging, increased temperature, salinity, acidity and aluminium toxicity which are likely to negatively affect crop performance.

8.2.2 Livestock and pastoralism adaptation:

(a) Invest in research and communication to improve understanding of the complex relationship between livestock, pastoralism and climate change.

(b) Treat adaptation as a generic capacity rather than once specific only to climate change, and focus on building adaptive capacities among all stakeholders in the sectors, deploying the preferred response measures and creating an enabling environment to implement these measures.

(c) Build capacities and infrastructure for improved climate forecasting and warning and increase awareness of climate change and its consequences.

(d) Strengthen human capital through basic education and public awareness and make information on adaptation options widely available to all stakeholders.

(e) Build capacity of extension workers through community-based and participatory processes whilst promoting collaborative research into both endogenous and exogenous adaptation options.

8.2.3 Fisheries adaptation:

(a) Strengthen regional governance of the fishery industry; this will reduce over-harvest in the region.

(b) Communicate clearly with stakeholders, and the public, on how climate change will affect fisheries in the short-term and in the long-term.

(c) Protect ecosystems from degradation and pollution.

(d) End environmentally harmful subsidies made in the fisheries sector.

(e) Extend rights-based management systems.

(f) Restore and protect mangroves and coral reefs, which will contribute to carbon dioxide absorption, coastal protection, fisheries and livelihoods.

(g) Put focus on aquaculture and on demand for sustainably caught seafood.

The general impression from the review is that Central African countries are aware of the presence of climate change. They are also aware that climate change impacts are here to stay; that action must be taken now to save farmers and populations from perishing; and that to avoid perishing, some sort of adaptation is necessary. But which strategies and mechanisms of climate change adaptation are necessary and how to effect them, within which time frame and at what cost, are still the subjects of discussion and experimentation.

This review concludes that enormous research is needed in climate change adaptation in the Central African region, but the hope is that the many projects underway in the region will throw light to adaptation in the very near future. There are official policies on climate change in the region but little commitment by the governments; governments should make a firm commitment to include climate change adaptation high on their political and economic agendas, which will enable them to allocate funds necessary for climate change adaptation strategies. Finally, the problem of stakeholder coordination in the various countries needs to be addressed so as to provide the immense opportunities available for collaboration among them for the enhancement of climate change adaptation in agriculture in the Central African region.

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