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Climate Change Implications for Agricultural Development and Natural Resources Conservation in Africa

FAO Regional Office for Africa

Front Cover Photos:
Top: Fiery sunset

Middle from left: Cattles die in the drought, Ethiopia; A coastal erosion in West Africa; A group of children in a queue to be fed, Mozambique; Parched agricultural field in Africa, anonymous.

Bottom: Gorilla family in Volcano National Park – Rwanda

Back Cover Photos: Farmers cultivating rice in Senegal

Nature & *Faune* is a peer-reviewed open access international bilingual (English and French) publication dedicated to the exchange of information and practical experience in the field of wildlife and protected areas management and conservation of natural resources on the African continent. *Nature* & *Faune* has been in wide circulation since 1985.

Nature & *Faune* is dependent upon your free and voluntary contribution in the form of articles and announcements in the field of wildlife, forestry and nature conservation in the Region.

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Nature & Faune

Enhancing natural resources management for food security in Africa

Volume 25, Issue 1

Climate change implications for agricultural development and natural resources conservation in Africa

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Accra, Ghana
2010

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Contents

Message to Readers

Maria Helena Semedo[1]

The impact of climate variability and change on agricultural production and natural resources management is under further study by scientists at all levels and in developed and developing countries alike. There has been a call for technological and scientific innovations to mitigate the effects of climate change in order to fulfill one of the major Millennium Development Goals (MDGs) by 2015 – to eradicate extreme poverty and hunger. Today, Africa is seeking to identify and implement mitigation and adaptation strategies to counter the effects of climate change in the continent. In view of this challenge, this edition of *Nature & Faune* magazine explores climate change implications for agricultural development and natural resources conservation in Africa. It provides a rich menu spanning many dimensions of climate change as it relates to the African rural farmer, fisher-folk and herdsman who are on the frontline of managing and utilizing renewable natural resources.

This issue offers seventeen articles distributed among the following aspects of the climate change theme: two articles on *Climate Change Impact;* three articles on *Climate Change Mitigation;* nine articles on *Climate Change Adaptation;* and three articles that straddle all aspects of the climate change topic. The edition also presents specific information on aspects of climate change issues in individual countries including Cameroon, Chad, Ghana, Mauritania, Nigeria, Senegal, Sudan and Zimbabwe.

David Okali, Emeritus Professor of Forest Ecology, University of Ibadan, opens the debate with an earnest but light-hearted editorial that brings to light the realities of the implications of climate change for the African subsistence farmer. He argues that tackling climate change in Africa may, in the long, run stabilize land use and lead to more sustainable ways of managing natural resources in the region. In a special feature, Chris Gordon and colleagues examine the implications of climate change for food security and natural resource management. This special feature aims at shedding more light on the current state of knowledge and draws particular attention to what national governments can do to help populations adapt to and mitigate the effects of climate change, including application of traditional knowledge which assists some of the most vulnerable groups to "pre-adapt". This contribution stresses the need to minimise the "doom and gloom" approach and emphasise the various opportunities that exist for climate change issues to be a positive force for development in Africa.

The guest authors contributing two works to the *Opinion Piece* are Jeffrey Sayer, Professor of Development Practice, School of Earth and Environmental Sciences, James Cook University, (Australia) and Anada Tiega, Secretary General, the Convention on Wetlands, Ramsar Secretariat. Sayer's article on *Agriculture, climate change and nature in Africa* explores the various options of how to meet the challenge of feeding Africa's growing population in a context of great uncertainty about future climates and without

[1] *Maria Helena Semedo, Assistant Director-General/Regional Representative for Africa, Regional Office for Africa, United Nations Food and Agriculture Organization, P. O. Box 1628 Accra. Ghana. Tel: 233-302-675000 ext. 2704/ 233 302 7010 930 ext. 2704; fax: 233-302-668 427*

destroying the environment upon which all agriculture ultimately depends. Tiega's piece *The Impact of Climate Change on water and wetlands and the consequences for agricultural and other natural resources*, shows how global and regional climate change can in turn affect the interdependent relationships between wetlands, water management and agriculture. He shares his opinion on how climate change can affect human health and in turn agricultural production.

Fisheries and aquaculture are important sectors contributing to food security in Africa. In the article titled *The future is now*, Marie-Caroline Badjeck and Ndiaga Diop illustrate scenarios that can help Senegalese and Mauritanian fisheries adapt to climate change. They present fisheries situations requiring analysis of climate change for both countries; portraying how these scenarios might help policy makers. The authors argue that while fishery policymakers cannot foresee the future in a crystal ball, by imagining plausible scenarios and taking into account the likely impacts of climate change and other drivers, they stand a better chance of preparing the people to face the challenges ahead. The other article in the domain of Climate Change impact is that of Ramasamy Selvaraju and Michele Bernadi, on *Climate Change Impacts on Agriculture in Africa: Current Assessments and the Way Forward*, the objectives of which are: first, to present a summary of observed and predicted changes in climate of Africa and selected results of impact assessments and secondly, to present the priorities for in-depth impact assessments in the future and the way forward.

Submissions on *Climate Change Mitigation* provide information on work to develop measurement techniques for community-based carbon-monitoring, John Schelhas and colleagues developed and tested a rapid appraisal approach for assessing opportunities and capacity for community-based forest carbon sequestration and monitoring in forest restoration projects in Ghana. In turn Kam-Yogo discusses the potential impact of forest policy on mitigation of climate change in Cameroon. This set of articles also explains a proposed environmental financial mechanism to simultaneously address forest conservation and climate change mitigation within the framework of sustainable development.

In the category of papers focussing on *Climate Change adaptation*, the central theme is that rainfall variability is a persistent constraint to rain-fed agricultural production. As a consequence, the authors discuss various options that need to be explored to meet Africa's nutritional needs, especially in the context of a growing population. They stress that the impact of climate change on agriculture, forestry, livestock, wildlife and water resources can increase vulnerability of fragile ecosystems. Faced with these problems peasants have already developed adaptation strategies that need to be reinforced in order to cushion the effects of climate change. The papers identify future priorities with respect to data, methods and tools for climate change impact assessment.

In this edition, the Country Focus turns its attention to the Republic of Chad, a landlocked country in north central Africa. Lake Chad, after which the country is named, is the second largest wetland in Africa (Okavango Delta in Botswana being the largest wetland in Africa). In an interview, Mr Nadji Tellro Waï, Director, Conservation of Biodiversity and Climate Change adaptation, Ministry of Environment and Fisheries, Chad talks to *Nature & Faune* about the key issues of climate variability in his country.

Finally, FAO, in a bid to contribute to the climate change debate, has launched a new book in the last quarter of 2010 entitled "*Climate-Smart" Agriculture - Policies, Practices and Financing for Food Security, Adaptation and Mitigation*. The new book defines "climate-smart agriculture" as agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes Green House Gases (mitigation), and enhances achievement of national food security and development goals. You would want to look up the "*LINK"* section for links to other publications and write-ups on Climate Change implications for agricultural development and natural resources conservation in Africa and elsewhere.

Many thanks to our community of subscribers and contributors; we look forward to continuing to work with you to expand the reach and impact of the magazine in Africa and beyond.

Editorial

Climate change and its implication for agricultural development and sustainable natural resources management in Sub-Saharan Africa (SSA)

David Okali[1]

Agriculture, both crop and pastoral, dominates natural resources management in sub-Saharan Africa (SSA), at least in terms of the number of people engaged in the enterprise. But agriculture is so closely integrated with forestry and other land uses for gaining ecosystem services that consideration of the implications of climate change, illustrated primarily with agriculture, can readily be related to the implications for the other land uses. Climate change-induced loss of livelihood in agriculture, for instance, drives farmers to fall back on more intensive exploitation of forest resources with consequences for biodiversity.

Chinua Achebe, the celebrated Nigerian writer, in his book 'Things Fall Apart' (1958) vividly captured the impact of the vagaries of weather, as is projected to happen with climate change, on a farming community in the African setting. The principal character of the story, Okonkwo, being a conscientious farmer, had planted his yams with the first rains of the season as was normal practice. The first rains were, however, immediately followed by scorching drought that lasted many market weeks. Okonkwo tried to protect his yams by mulching with sisal leaves; he prayed all night and watched the sky all day, for the rains to return. The rains did not come. The sisal leaves were scorched and the yams were killed. That yam crop failed. When the rains returned Okonkwo sought to make a fresh start by planting what remained of his seed-yams. But the year had gone mad. Rain fell as it had never done before and washed away yam heaps. When the rains stopped the sky remained cloudy all day; the spell of sunny weather that marks the August break never came. Without sunshine, the yams grew luxuriantly but set no tubers. 'That year the harvest was sad, like a funeral and many farmers wept as they dug up the miserable and rotting yams. One man tied his cloth to a tree branch and hanged himself.'

The above story underscores the fact that climate change could be a matter of life and death for the African farmer. The plight of the crop farmer is paralleled by that of the pastoralist losing livestock from drought and water scarcity. Of the many expected impacts of climate change, few surpass, in directness, immediacy and relevance to African agriculture and livelihoods, those mediated through water - either there is too little water, leading to drought and reinforcing desertification, or there is too much water causing flooding, inundation of farmlands and crop failure. Much of the adverse effect of climate change-induced sea level rise on agriculture occurs through flooding, and some of the effects of temperature rise occur through excessive water loss by heightened evapo-transpiration. Sub-Saharan African agriculture being mostly rain-fed is highly vulnerable to variations in rainfall.

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To plan an effective response it is necessary to have a good picture of the present and expected impacts of climate change. Recent studies by Speranza (2010) suggest that the observed impact of climate change in SSA is increased variability, , both decreases and increases, in rainfall and temperature. No clear spatial or temporal patterns are discernible, but rainfall amount is predicted to decrease in most parts of SSA, while rainfall variability and intensive rainfall events will increase. Going beyond the present to the future, we find that serious account has to be taken of the socio-economic and political contexts in providing useful data. Speranza (2010) points out that climate projections for SSA do not fit the spatial and temporal scales of agricultural processes, practices and planning and cannot yet produce the details needed for impact assessment. Planning for climate change impacts is, therefore, to a large extent a question of planning with uncertainties. The difficulties include the fact that, the time horizons of modelling projections for climate change impacts (commonly over 20 years) are far too distant to be of priority to current political regimes, and there is insufficient local data to downscale global modelling projections to yield information that can be meaningfully applied to small geographical areas. Dealing with the impacts of climate change for the pursuit of sustainable agriculture and natural resources management in SSA thus still has many challenges that require urgent research attention.

The *close* link between agriculture, forestry and other land uses in SSA offers opportunities for integrating adaptation and mitigation responses to climate change, without compromising food production. Now that developing countries are being encouraged to contribute more than before to mitigation, countries of SSA should take advantage of the traditional close link between agriculture and forestry to earn mitigation credit from practices already being promoted for adaptation. The organic farming practices of soil nutrient management, multiple -cropping and agro-forestry practices being promoted with small-holder farmers, for adaptation to climate change, can become avenues for earning mitigation credit and revenue for improving agriculture while avoiding deforestation. In this regard , agro-forestry practice is particularly relevant as an approach for sequestering carbon on a large scale and over a long time, while contributing nutrients if nitrogen fixing trees are used, and enhanced income if fruit trees like *Irvingia spp.*, or high value medicinal trees like *Prunus africana* or *Moringa oleifera* are used.

Agriculture in SSA occurs mostly in the context and within a landscape of trees and forests. It is dominated by small scale farmers operating commonly less than 2 hectares of crop farming. Lacking the economic means to embark on costly fertilizer use or mechanization, they use environment-friendly practices that conserve the soil. Promotion of these practices so that food production is enhanced while climate change is mitigated is clearly a desirable option. The emerging mechanism of Reducing Emission from Deforestation and Forest Degradation (REDD) if designed to apply to the whole of Agriculture, Forestry and Other Land Uses (AFOLU) can help to achieve this. The economic gain from this approach could be used to stabilize agriculture further, through improvement in water management to free agriculture from climate change induced vagaries of rainfall, and the development of appropriate mechanization practices following a low carbon path (Speranza, 2010).

If not addressed, climate change will adversely affect agriculture and natural resources management in Sub-Saharan Africa. But tackling climate change may in the long run stabilize land use and accelerate the adoption of sustainable ways of managing natural resources in the region.

REFERENCES

Achebe, Chinua 1958. Things Fall Apart

Speranza, Chinwe Ifejika 2010. Resilient Adaptation to Climate Change in African Agriculture. German Development Institute. Studies 54.

Drought: Livestock death and loss of livelihood

ANNOUNCEMENTS

"Climate-Smart" Agriculture – Policies, Practices and Financing for Food Security, Adaptation and Mitigation. FAO has published a new book entitled "Climate-Smart" Agriculture – Policies, Practices and Financing for Food Security, Adaptation and Mitigation. For further information and to order contact: Food and Agriculture Organization of the United Nations (FAO). Viale delle Terme di Caracalla. 00153 Rome, Italy.
Website: www.fao.org/climatechange Email: climate-change@fao.org
Source: www.fao.org

Developments in the REDD+ arena. Focali (Forest, Climate and Livelihood research network) has released a new report on the latest developments in the REDD+ arena, focusing on the multilateral initiatives. The report is called "*Getting ready for REDD+*" and was written by Lisa Westholm. It can be downloaded from: http://www.focali.se/en/articles/artikelarkiv/getting-ready-for-redd It is also accompanied by a summarising policy brief called "*High hopes and fast pace in the REDD+ arena*" which can be downloaded using the same link. This, and other publications of Focali, as well as more information about the network, can be found on the website www.focali.se/en
Source: Lisa Westholm, Research Assistant Focali. Department of Economics, Environmental Economics Unit University of Gothenburg, Sweden. Email: lisa.westholm@economics.gu.se

Agriculture and deforestation: what role should REDD+ and public support policies play? IDDRI has released a new publication: **"Agriculture and deforestation: What role should REDD+ and public support policies play?".** It builds on existing research on agricultural technologies and their impact on forest cover, and critically assesses the Borlaug hypothesis (**land sparing**), in order to derive implications for an effective REDD+ mechanism. The English version can be downloaded from: http://www.iddri.org/Publications/Collections/Idees-pour-le-debat/Agriculture-and-deforestation-What-role-should-REDD+-and-public-support-policies-play
Source: Romain Pirard, Project Manager Forests, IDDRI, www.iddri.org

Impact of and Adaptation to Climate Change in Relation to Food Security in Africa. The Network of African Science Academies (NASAC) is organizing a conference on *Impact of and Adaptation to Climate Change in Relation to Food Security in Africa*, hosted by African Academy of Sciences (AAS) and the Royal Netherlands Academy of Arts and Sciences (KNAW). The conference will be held from 23 to 25 February 2011 in Nairobi, Kenya. The conference brings together the very best climate change scientists to exchange ideas and experiences on climate change impacts and adaptation in relation to food security in Africa. Besides senior researchers young scientists holding a PhD degree are also invited to take part. For more information about the conference, and the guidelines, please visit the NASAC website: www.nasaconline.org or email: climatechangeconf@aasciences.org
Source: African Academy of Sciences (AAS), P.O. Box 14798 Nairobi. Kenya

Useful measures to sustainably manage Ethiopian Forests: Participatory Forest Management can be a solution. The FAO subregional Office for Eastern Africa, has released a publication on Practices and Experiences of Participatory Forest Management in Ethiopia. To order, contact: FAO Subregional Office for Eastern Africa & FAO Representation in Ethiopia P.O. Box 5536 Addis Ababa Ethiopia. Telephone: + 251 11 551 72 – 30; +251 11 551 30 – 49 or email: Rihana.mmohammed@fao.org

Participatory Forest Management in Ethiopia,
Practices and Experiences
By
Ellen Winberg

Food and Agriculture Organization
Sub Regional Office for Eastern Africa (SFE),
Addis Ababa, June 2010

News

The presidents of Tanzania, Kenya, Uganda, Rwanda and Burundi held an informal summit to discuss African food security and climate change. On 2 December 2010, the presidents of Tanzania, Kenya, Uganda, Rwanda and Burundi held an informal summit in Tanzania to discuss African food security and climate change. One of the highlights of the summit was the launching of a new book which claims Africa could feed itself within a generation, and become a major agricultural exporter. The book, *The New Harvest*, by Harvard University professor Calestous Juma, calls on African leaders to make agricultural expansion central to all decision-making. Improvements in infrastructure, mechanization and Genetically Modified crops could vastly increase production, he claims. It was stressed that climate change makes the quest for increased productivity more crucial.

Author's email: calestous_juma@harvard.edu

News item by Neil Bowdler, Science reporter, BBC News. Culled from: BBC News Science Environment column website: http://www.bbc.co.uk/news/science-environment-11890702

Cancun Climate Deal Puts UN Process Back on Track

The United Nations climate change conference in Cancun wrapped up two weeks of negotiations on 11 December 2010 with agreement on a package of decisions that UN officials are hailing as a victory. The Cancun Agreements recognize the goal of reducing greenhouse gas emissions from rich countries by 25 to 40 percent from 1990 levels within the next 10 years. Current pledges amount to about 16 percent. Developed countries committed to a goal of mobilizing jointly US$100 billion per year by 2020 to address the needs of poorer countries. Delegates at the conference also agreed to establish a Green Climate Fund of US$30 billion of new contributions for the period 2010-2012 to help the most vulnerable developing countries adapt to the unavoidable impacts of climate change and reduce their carbon footprints.

Delegates decided that carbon dioxide capture and storage in geological formations will be included as an eligible project activity under the Kyoto Protocol's Clean Development Mechanism. This flexible mechanism allows 37 developed countries to fulfil their greenhouse gas emission obligations by investing in projects that reduce emissions in developing countries. The Cancun Agreements include action to protect the world's forests, important because deforestation accounts for nearly one-fifth of all global carbon dioxide emissions. Delegates decided to establish a three-phase process for tropical countries to reduce deforestation and receive compensation from developed countries in an agreement that includes protections for forest peoples and biodiversity. They also created a mechanism to share clean technologies to help developing countries move away from fossil fuels.

"The real bright spot was moving forward with REDD+, the program to eliminate tropical deforestation," said Doug Boucher, director of climate research and analysis with the Union of Concerned Scientists, based in Washington, DC.

News item culled from: Environment News Service, 620 Vineyard Lane, Suite #B303, Seattle, WA 98110. Questions or Comments: news@ens-news.com

Website: http://www.ens-newswire.com/ens/dec2010/2010-12-11-01.html

Special Feature

Food security and natural resources management: Overview on climate change implications for Africa

Christopher Gordon[1], Alhaji M. Jallow[2], Elaine T. Lawson[3], Jesse S. Ayivor[4] and Adelina M. Mensah[5]

Summary

In Africa, agriculture is one of the most vulnerable sectors to climate change because of its seasonality, the lack of resilience to disaster of the peasant farmers, the presence of major non-climatic stressors that influence sensitivity to changes in climatic conditions, and endemic poverty. This paper examines the implications of climate change for food security and natural resource management in Africa. It presents information on the current state of knowledge on the vulnerability, impact and adaptation of African agriculture and natural resources to climate change. Though the impacts of climate change on smallholder and subsistence farmers will be locally specific and hard to predict, research has shown clear crop physiological and agronomic evidence that climate change will significantly reduce productivity in some cases while increasing productivity in others. An increase in the frequency and severity of flooding will result in the loss of agricultural land and yield. Changes in habitat type caused by increase in number of dry days and higher temperatures are predicted to cause loss of species due their limits of tolerance being reached. The main conclusion of the paper is that climate change must be seen as an opportunity for African governments to strengthen measures to develop agriculture and natural resources management to ensure food security for their people. Climate change will impact disproportionately on poorer African countries, especially Small Island States and those in the Sahel. Governments that follow the "business as usual" approach to climate change will lose out on the opportunities that climate change offers to development.

Introduction

The primary objective of this paper is to examine the implications of climate change for food security and natural resource management in Africa. It aims at shedding more light on the current state of knowledge on the vulnerability, impact and adaptation of African agriculture and natural resources to climate change. More importantly, it also draws attention to what national governments can do to help populations adapt to and

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mitigate the effects of climate change, not forgetting the vast amount of traditional knowledge which assists some of the most vulnerable groups to pre-adapt to climate change. The impacts of climate change on smallholder and subsistence farmers will be locally specific and hard to predict due to climate change itself, the complexity in household crop and livestock productions and non market relations among others. Family labour, existing patterns of diversification and indigenous knowledge are, however, important resilience factors to help communities cope with crises (Morton, 2007). These provide internal insurance and support mechanisms as well as coping strategies to spread risk. There is a need to minimise the "doom and gloom" approach and emphasise the various opportunities that exist for climate change issues to be a positive force for development in Africa.

Food Security in Africa

FAO (1994) defines food security as access by all people at all times to the food needed for a healthy and active life. FAO (2008) gives the four main components of food security as food availability, food accessibility, food utilization, and food system stability – which implies affordability. The major thrust of the drive towards food security is to bring about a significant increase in agricultural production in a sustainable way and to achieve a substantial improvement in people's entitlement to nutritionally sound and adequate food as well as culturally appropriate food supplies.

Africa is the only region in the world in which the average per capita food production has been consistently falling for the last 40 years, with as a consequence, a high level of poverty particularly in rural areas. In the coming decades Africa will have to feed a population that is expected to increase from 832 million people in 2002 to over 1.8 billion in 2050 (FAO, 2006).

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) (IPCC, 2007), notes that in the low latitudes of the tropics, many wet areas will get wetter and dry areas, drier, aggravating drought and flood tendencies. In addition, the frequency and magnitude of extreme weather events will increase, creating more variability in water supplies that drive agricultural and hydrological systems (Boko *et al.*, 2007). The World Fish Centre (2007) reports that in the oceans, rising water temperatures may reduce the upwelling of food supplies that fish in upper water layers depend on, and increased carbon dioxide in the atmosphere will increase the acidity of water bodies, adversely affecting shellfish and coral reefs. The coasts of the world, which include some of the most densely populated and biologically productive areas, will be especially hard-hit by rising sea levels and more intensive oceanic storms such as typhoons or hurricanes.

Climate change jeopardizes the progress achieved by Africa to date due to the substantial diversion of resources required to fund adaptation initiatives. Estimates predict economic losses as a result of climate change will be up to 14% GDP if adaptation measures fail to be implemented. If this was to occur significant levels of investment would need to be diverted away from key rural development projects to responses to short term emergencies, in particular undermining the achievement of Millennium Development Goals (MDGs) and core Comprehensive Africa Agriculture Development Programmes (CAADP). Africa will need food supplies for the chronically

undernourished 94 million (about 27 percent) of its population, and an additional 18 million each year if it is to meet the MDGs by 2015.

Climate Change and Africa

Climate change will impact disproportionately on poorer African countries. The poorest people in those countries will suffer the greatest consequences. Those least able to cope will be hit the hardest. Economic activity in these countries is principally rural-based, relying on agriculture, fisheries and forestry, which are vulnerable to the effects of climate change. It is they who will see the possibilities of escape from poverty become increasingly more difficult to achieve due to climate change brought about almost entirely by other, richer, people living elsewhere.

The impacts of climate change on Africa's agricultural systems will most likely result from increased intra-annual (seasonal) and inter-annual climate variability and from an increased frequency of extreme events than from changes in mean climatic conditions (Padgham, 2009). Africa contributes the least to climate change but is likely to suffer the most, as increasing climate variability is already affecting water sources, land, forest, biodiversity. Agricultural yields will continue to decline with rising temperature, while in developed countries production of some crops will rather increase. There are comprehensive assessments that identify the direct and indirect/secondary impacts of climate change in agriculture (e.g., Kurukulasuriya & Rosenthat, 2003) including livestock and livestock systems (e.g., Thornton *et al*., 2009). It is estimated that after 2040, with a mean average global temperature of 1.5°C, the economic costs of climate change will be equivalent to 1.7 percent of Africa's GDP; at 2.2°C by 2060 will cost 3.4 per cent; and with a temperature rise of 4.1°C by the end of the century, will cost just under 10 per cent of the continent's GDP (Clements, 2009).

The African subsistence farmer is among the most vulnerable. This is because the current low levels of agricultural productivity in Sub-Saharan Africa prevent much of the population from escaping poverty, hunger and malnutrition. Adaptation will not be possible for those already living on the edge without significant and concerted assistance. Climate change is accelerating the rapid depletion of Sub-Saharan Africa's natural resources and the genetic erosion of indigenous germplasm which further threatens the sustainability of the peasant farmer. The lack of comprehensive and accessible early warning systems for farmers compounds the problems. Adaptation thus should be well integrated with livelihood priorities and development goals if it is to succeed. Bringing a climate-aware perspective to agricultural development is particularly important for investments with a long life span including infrastructure and national strategies – which should be adapted to the long term issues of climate change

African Governments and international agencies have been aware of the risks to the African farmer since the production of the first IPCC report and despite several initiatives, no real progress toward a comprehensive solution of the problem based on the actual options available on the ground for the subsistence farmer has been made. Some of these initiatives include the NEPAD 2006 Abuja Summit on Food Security in Africa; the 2007 Chennai Declaration on making Hunger History; the 2009 World Summit on Food Security, etc. In West Africa however, ECOWAS is leading a process that has delivered a Sub-regional Adaptation Plan to Climate Change in the sub-region which constitutes an excellent start. The 2009 EU-US Summit Declaration Annex 1: Statement

on Development Dialogue and Cooperation states "… *we will accelerate implementation of our commitments under the Paris Declaration and Accra Agenda for Action, with a strong focus on in-country implementation. We will focus our initial cooperative efforts on three common priorities: food security and agricultural development, climate change and the Millennium Development Goals*."

Development policies that target vulnerable groups are needed (i.e., that include gender in adaptation policies as the burden on women's labour will increase with impacts of climate change on water and land resources). Policy is also needed to govern data access and knowledge dissemination, strengthen processes that support collective action as well functioning social networks enable communities to manage and recover better, include climate risk considerations in decentralization and property rights policies to avoid increasing the vulnerability of marginal groups (Padgham, 2009).

The promotion and protection of traditional and local food and agricultural knowledge can help in dealing with food security in the face of climate change. This will require international, intercultural and interdisciplinary approaches, communication and cooperation. Coordination of indigenous and local communities' sustainable use, conservation and management of food and agriculture within and across ecosystems, landscapes and seascapes will also require synergies that link food security, livelihood sustainability, poverty alleviation and food and agricultural productivity to rural development processes based on in and ex-situ conservation of food and agricultural genetic resources.

One-third of the African population already lives in drought-prone areas. Six of the ten largest cities in Africa are located on the coast (Garcia, 2008). These are both areas susceptible to climate change. With climate change, food and water supplies will become unreliable, livelihoods and access to food insecure, and available arable land reduced, causing population movements by making certain parts of the world much less viable places to live (Brown, 2008). This in turn may force large numbers of people to leave their homes and communities. The so called 'environmental migrants' not only leave behind degraded farm lands and destroyed trees but also may increase conflicts in transit and destination areas.

Climate change adaptation could become an important development agenda for African countries when based on ecosystems approach (e.g., the FAO Ecosystem Approach to Fisheries). Protection of natural ecosystems like wetlands, floodplain forests, mangroves and other coastal vegetation could provide storm protection, coastal defences, and water recharge, and act as safety barriers against natural hazards such as floods. This could complement or serve as a substitute for very expensive infrastructure investment to protect coastal and riverine settlements in times of extreme weather events. Wetlands protection in Africa as a climate change adaptation response could help to filter pollutants and serve as water recharge areas and nurseries for local fisheries (World Bank, 2009).

Information on the nature, extent and location of the impacts of climate change on households in Africa that are particularly dependent on natural resources for their livelihoods is lacking but crucial if appropriate adaptation options are to be designed and implemented to deal with changing crop and livestock production potential. These

impacts may be highly variable across space and through time, as a result of the interactions between temperature increases and shifts in rainfall patterns and amounts.

Africans have historically used several coping strategies especially in the water-stressed Sahelian zone to avert the effects of climate variability. Some of these include the building of anti-erosion small dykes to allow for sedimentation and particle deposits upstream of the dykes to reduce run-off and increase water percolation; the "*zai*" technique, which is also applied in Sahelian zone, involves planting of crops in small, circular pits perpendicular to the slope to capture rainwater and retain soil moisture (Brown and Crawford, 2007), and improved land clearing technique which involves leaving of tree stumps and trimmed shrubs and small trees to facilitate fast re-growth.

Opportunities and the way forward for Africa

The main conclusion from the literature synthesis and the main message of this paper is that climate change must be seen as an opportunity for African governments to implement measures to develop agriculture and natural resources management to ensure food security for their people.

Climate change adaptation for most African countries is fundamentally about sound resilient development. The key areas of adaptation, which when sustained could bring development, are disaster risk reduction; sustainable land, water, and forest management; coastal and urban development; watershed management, increased agricultural productivity; health and social issues (World Bank, 2009). Adaptation responses, however, have to be tailored to local conditions and needs, since the nature of risks and the affected livelihood groups vary from one ecosystem to another (MA, 2005). There is an urgent need to promote and build capacity for the FAO initiative for Sustainable Land Management (SLM) in Africa. This knowledge based procedure helps integrate land, water, biodiversity, and environmental management including input and output externalities to meet rising food and fibre demands while sustaining ecosystem services and livelihoods (World Bank, 2006). SLM, if promoted by national governments, could reduce the region's dependence on natural factors like rain-fed agriculture and natural soil fertility which cannot withstand the pressures of climate change.

Measures to assist deal with climate change impacts must be seen as additional to ongoing international development assistance, not as a substitute. There needs to be a harmonized approach in international joint efforts on actions that will help insulate the African farmer from the worst impacts of climate change. This would need policy coherence for aid effectiveness and accelerated implementation of commitments under the Paris Declaration, the Accra Agenda for Action, as well as use of the 2009 L'Aquila principles, with a strong focus on in-country implementation.

There is increasing potential for African countries and small-scale farmers to be involved in voluntary markets for carbon and international market mechanisms such as the CDM (Clean Development Mechanism). Knowledge and strategies to reduce carbon emissions through community based afforestation and reforestation projects, agroforestry and reduced deforestation and degradation (REDD and REDD+) are being generated, but need to be tested and adopted. These strategies have the potential to

create synergies for increasing productivity and achieving the multiple functions of agriculture if well implemented.

As more people congregate in the urban areas in Africa, there is the urgent need to promote peri-urban agriculture, where appropriate, using all available land resources to off-set anticipated short falls in relation to climate change. Farm units close to towns and cities have potential to operate intensive semi-or fully commercial farms to grow vegetables and other horticulture, raise chicken and other livestock, produce milk and eggs, and develop aquaculture fisheries. When carried out properly under safe conditions, this system of farming can contribute to food security by increasing quantity of food available especially during times of crisis, enhance the freshness of perishable foods on the urban market and offer opportunities for productive employment to the unemployed.

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References

Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R. and Yanda, P. 2007. Africa: Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P. J. and Hanson, C.E., (Eds.), Cambridge University Press, Cambridge UK, 433-467.

Brown, O. 2008. Migration and Climate Change. IOM Migration Research Series, Geneva. International Organization for Migration.

Brown, O. and Crawford, A. 2007. Climate change: A new threat to stability in West Africa? Evidence from Ghana and Burkina Faso. International Institute for Sustainable Development (IISD). *African Security Review* **17** (3): 39–57.

Clements, R. 2009. The economic cost of climate change in Africa. http://www.christianaid.org.uk/images/economic-cost-of-climate-change-in-africa.pdf. Cited 11 Dec 2009.

FAO 1994. Special Programme for Food Security. Food and Agricultural Organization of the United Nations, Rome.

FAO 2006. Report of the Twenty-Fourth FAO Regional Conference for Africa. Bamako, Mali, 30 January – 3 February 2006. ftp://ftp.fao.org/docrep/fao/meeting/011/j8238e.pdf. Cited 11 December 2009.

FAO 2008. Challenges for Sustainable Land Management (SLM) for Food Security in Africa. 25th Regional Conference for Africa, Nairobi Kenya, Information Paper 5. 15 pp.

Garcia, D. 2008. The climate security divide: Bridging human and national security in Africa. *The African Security Review* **17** (3): 2-17.

IPCC 2007. Summary for Policy Makers. Climate Change 2007: Impacts, Adaptations and Vulnerability. Intergovernmental Panel on Climate Change (IPCC), Contribution of Working Group II to the Forth Assessment Report of the IPCC: 7-22.

Kurukulasuriya, P., and Rosenthat, S. 2003. Climate change and agriculture: a review of impacts and adaptations. Washington, DC: Climate Change Series Paper No. 91, World Bank.

MA 2005. Ecosystems and Human Well-being: Synthesis. Millennium Ecosystems Assessment (MA) Report. Washington D.C., Island Press for WRI.

Morton, J. 2007. The impact of climate change on smallholder and subsistence agriculture. www.pnas.org/cgi/doi.10.1073/pnas.0701855104. Cited 28 Nov 2009.

Padgham, J. 2009. Agricultural development under a changing climate: Opportunities and Challenges for Adaptation. The World Bank, Agriculture and Rural Development & Environment Departments: http://siteresources.worldbank.org/INTARD/ Resources/climate_change_combined.pdf. Cited 01 Dec 2009.

Thornton, P., van de Steeg, J., Notenbaert, A., and Herrero, M. 2009. The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. *Agricultural Systems* **101**: 113-127.

World Bank 2006. Reengaging in agricultural water management: Challenges and options. Washington DC. World Bank.

World Bank 2009. Convenient solutions to an inconvenient truth: Ecosystem-based approaches to climate change. Environment Department. The World Bank. Washington DC.

World Fish Center 2007. Fisheries and aquaculture can provide solutions to cope with climate change. Issues brief 1701, Penang, Malaysia.

Opinion Piece

Agriculture, climate change and nature in Africa

Jeffrey Sayer[1]

When I began working in Africa in the late 1960s the continent had a population of about 250 million. Since then the population has quadrupled and there are now over a billion Africans. During the intervening years agricultural yields per capita and per hectare stagnated and in many cases declined although the past ten years have seen promising signs of progress and the economies of the continent are now growing at around 3% per annum. Nonetheless the continent has the highest proportion of food insecure people of any region of the world (FAO 2010); the population is set to double again within a couple of decades and hundreds of millions of people still live from subsistence agriculture on farms that average two hectares but which are often much smaller. The challenge of feeding this growing population has to be met in a context of great uncertainty about future climates and without destroying the environment upon which all agriculture ultimately depends.

Challenges and opportunities for Africa

Much of Africa is arid and in general the soils are poor - yet many areas of Africa clearly do have enormous agricultural potential. In South America, Brazil is emerging as one of the world's agricultural powerhouses and much of its agriculture occurs in conditions that are not so different to those found in Africa. The Cerrado with its vast soybean plantations making Brazil the world's second largest producer of this important crop is remarkably similar to the vast Miombo woodland belt that runs across the width of Southern Africa. The floodplains of Africa's mighty rivers – the Nile, the Niger, the Senegal, the Zambezi etc – all have enormous untapped potential for irrigated agriculture. The forest zones of central and western Africa have great potential for tree crops ranging from the mixed tree crop systems of West Africa to the potential for very large plantations of oil palm in Congo Basin countries. There is untapped potential for industrial plantation forestry along the coasts of Angola and Mozambique. In theory Africa could be transformed from a food deficit continent to one of the world's major exporters of agricultural crops. The issue for environmentalists is that there are a number of different pathways for agricultural expansion in Africa and they each present different challenges and opportunities for the environment. These challenges have to be met in a context of increased climatic variability, higher temperatures and in general dryer climates in dry areas and wetter climates in those areas that are already wet. This context of climate change has major implications for whatever agricultural strategy is adopted.

Over the last three decades of the 20th Century the increase in world food production – even though it failed to keep pace with population growth – came from the Green Revolution in Asia and through the expansion of the area farmed elsewhere. In Africa

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large areas of forest and savannas were cleared for mostly low productivity agriculture. This was clearly the least good solution for the environment. Today there are still people who see area expansion as the solution to Africa's food problems. However, most environmentalists would see this as a major threat to Africa's remarkable biodiversity. Environmentalists would like to see increased production coming from better use of existing farmland. This means that people concerned with the conservation of nature in Africa have to give careful thought to the positions that they adopt in relation to different agricultural development pathways.

Biodiverse, organic agriculture for Africa

UNEP is leading a number of environmental organisations with calls for organic approaches to agriculture in developing countries. The logic is that in the absence of reliable supplies of fertilizers, pesticides and fuel it will be safer for African farmers to invest their labour in locally self sufficient farming systems (UNEP-UNCTAD 2008; Action Aid and Food first 2009). These systems also have less harmful global environmental impacts. The Convention on Biological Diversity and CGIAR research centres like BIOVERSITY, ICRAF and CIAT argue that small scale biodiverse farming systems will be more sustainable and resilient – notably in confronting the challenges of climate change – than specialised high input agriculture. However the danger is that organic locally self-sufficient approaches may keep farmers living at a precarious subsistence level. Locally self-sufficient agriculture may not be effective at bringing about the transformational changes in the lives of poor farmers that most would agree are essential (Walker et al 2010). The Millennium Development Goals will not be met through the continued reliance of 70% of Africa's population on subsistence agriculture. The excellent report of the International Assessment of Agricultural Science and Technology for Development – the IAASTD – assesses the options and implications of different agricultural strategies but comes down on the side of multiple locally adapted solutions but also acknowledges the need for higher inputs and greater market access (IAASTD 2008, 2009). Low technology approaches to agricultural expansion will emit less greenhouse gases, may be more resilient to climate change, may be less impacted by the increasing scarcity of fertilizers and pesticides and less vulnerable to economic shocks but environmentalists should not forget that they will also consume more land than more intensive high technology agriculture.

Africa in the global market economy

A more pragmatic approach is taken by the World Bank's 2008 World Development Report on agriculture (World Bank 2007). This notes that progress driven by economic forces. Improved policies, better infrastructure and greater access to markets would unleash the entrepreneurial potential of African farmers who would respond by intensifying their methods and using more agricultural inputs. Better farmers would expand their land holdings and economies of scale would be achieved. Under this scenario Africa could produce far more food without excessive further expansion into forests and wetlands and agriculture would become one of the motors of economic growth for the continent. The Association for a Green Revolution in Africa –AGRA - is investing heavily in activities which are consistent with this scenario, notably by helping to ensure availability, through the private sector, of improved seeds and fertilizers.. The World Development Report and AGRA approaches are attractive in the context where more and more African's move to cities and work in manufacturing and services. The economic surpluses that they produce would increase their purchasing power and drive

the intensification of small to medium farms. This scenario mimics what has happened in the developed world over the past century with fewer and fewer people involved in agriculture and a concentration of people in cities and more favourable agricultural areas. The emigration of people from rural areas might provide more favourable outcomes for the environment than the organic agriculture scenario that many environmentalists find ideologically attractive. This market driven scenario would require major policy changes implemented by African governments.

Another potential driver of major change in Africa is foreign investment in industrial scale agriculture in high potential areas. In principle such industrial schemes could produce enough food for Africa on a fraction of the land now under farms. The detractors of these schemes label them as "land grabbing" and fear that the investors would act like colonists and exploit Africa's land and labour purely to meet the domestic objectives of the investing country. Some fear that such schemes might not even use African labour but might bring in large numbers of economic migrants thus creating foreign enclaves disconnected from local economies and exacerbating local food supply problems. In principle foreign direct investment in agriculture need be little different to foreign investment in manufacturing or services which are generally thought to be good for economies and - by alleviating poverty - good for the environment. The critical issue is the governance regime under which these mega-agriculture projects operate. If they create jobs, drive local economies and supply local markets then these schemes could concentrate agriculture in smaller areas and reduce pressures on the environment. A recent paper in this journal by Chipeta (2010) discusses these issues in more detail.

Dealing with Climate change

So how might these different scenarios play out under climate change? Advocates of different strategies see advantages in their chosen pathway. Locally adapted, biodiverse, small scale agriculture might be expected to be resilient to change through reduced dependence on external inputs and through "not having all of its eggs in one basket". The UNEP – IAASTD scenario would have farmers producing a wider range of crops, including more trees in their farming systems thus having more options in times of climate stress. However the danger is that farmers would remain poor and the poor are always the most vulnerable to the sorts of outside shocks that climate change will bring. Advocates of the higher input, larger production units and more efficient farming systems see farmers' resilience to change coming from their ability to accumulate assets, store produce, purchase insurance and chemical inputs to deal with emerging threats.

Which scenario is best for the environment?

The best recipe to enable African farmers to adapt to climate change may be to give them good education, technical skills, health care, infrastructure and access to markets. They will then be in a position to make their own choices about the agricultural strategies that best meet their needs. They will also be able to build up the capital that they need to deal with the climatic problems that will certainly afflict them. Farmers may be dependent on a single crop or on multiple crops but if they have the ability to accumulate capital in good times they will be better able to deal with the bad times when these occur (Walker et al 2010).

One reality that environmentalists have to face is that even if we favour one scenario over another we have little capacity to influence agricultural development pathways. We should welcome the attempts by UNEP and the IAASTD to make the links between agriculture and environment clear. The sorts of agriculture that these organizations recommend will be systems that sequester more carbon from the atmosphere, that emit less greenhouse gases and are in general more energy efficient – they are advocating low carbon, ecologically efficient agricultural development pathways. This must be set against the greater land needs for these sorts of agriculture than those for higher input intermediate scale or industrial agriculture.

The reality is that different agricultural development pathways will have a role to play in Africa's future in different parts of the continent and even the foreign mega-investments – the "land grabs" – seem certain to happen. Overall the situation is far from hopeless. Africa has enormous land resources, entrepreneurial and hard working farmers and if economic growth continues to accelerate then infrastructure and markets will provide the incentives for farmers to produce more and accumulate the assets that will enable them to weather the storms of climate change and economic shocks. Environmentalists should be cautious in resisting agricultural innovations that may have short term or local negative impacts on nature but which might provide better long-term options by jump starting the economic growth that people of the African continent so desperately need. Leaving a high proportion of the continent's rural people in poverty is the one outcome that will for certain destroy the environment. Africa needs economic growth, agriculture has the potential to be a motor for that growth and more efficient agriculture will in general be better for the environment than the continuation of the *status quo*. Prosperous farmers will be better able to adapt to climate change and variability than those that are locked into precarious subsistence systems. African governments have to consider all of the options open to them and put the rural farmers at the centre of their development agendas – in the past they have been far too preoccupied with subsidising urban populations. Ultimately African civil society needs to be empowered to pressure its governments to make and enforce the best decisions for the continent but the ability of civil society to assert itself will be much greater when people are prosperous and well fed.

References

ActionAid & FoodFirst. 2009. Smalholder Solutions to Hunger, Poverty and Climate Change (http://www.foodfirst.org/files/pdf/Solutions5.pdf)

Chipeta, E. M. 2010. The new wave of large-scale land intensive foreign investment in African agriculture. *Nature & Faune* magazine, Volume 24, Issue 2.

FAO 2010. The state of Food Insecurity in the World. FAO, Rome Italy.

IAASTD - International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). 2008. Global Report. (www.agassessment.org and www.iaastd.net)

IAASTD - International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). 2008. Global Summary for Decision Makers. (www.agassessment.org and www.iaastd.net)

UNEP - UNCTAD. 2008. Organic Agriculture and Food Security in Africa. UNEP-UNCTAD Capacity-building Task Force on Trade, Environment and Development. (www.unep-unctad.org/cbtf/publications/UNCTAD_DITC_TED_2007_15.pdf)

Walker, B., J.A. Sayer, N. L. Andrew, and B. Campbell. 2010. Should Enhanced Resilience Be an Objective of Natural Resource Management Research for Developing Countries?

Published online 5 March 2010; doi:10.2135/cropsci2009.10.0565.Crop Sci. 2010 50: S-10-S-19.

World Bank, 2007. World Development Report; Agriculture for Development. World Bank, Washington DC.

The Impact of Climate Change on Water and Wetlands and the Consequences For Agriculture and Other Natural Resources

Anada Tiega[1]

Introduction

This paper looks at the influence of global and regional climate change on the interdependent relationships among wetlands, water management, and agriculture. Although the major focus is on such direct influences, the paper also considers how climate change could affect human wellbeing, especially human health; and its effects on agriculture. Wetlands are natural and human-made ecosystems that receive, transport, clean, store, and deliver water to a wide range of users, from the mountains to the seas, for domestic needs, agriculture, biodiversity, industry and other economic production, as well as helping to maintain social and cultural values. The Ramsar Convention on Wetlands recognizes 42 types of wetlands, including rivers and their tributaries and floodplains, lakes, estuaries, marshes, deltas, peatlands, oases, coastal areas, mangroves and coral reefs, and many others.

Interdependence between wetland, water, other natural resources and agriculture

The text of the Ramsar Convention recognizes the "interdependence of Man and his environment [and] the fundamental ecological functions of wetlands as regulators of water regimes", and that "wetlands constitute a resource of great economic, cultural, scientific and recreational value". Wetland ecosystems, in their many shapes, sizes and characters, are integral components of the hydrological cycle and are critically important in regulating the quantity, quality and reliability of water as it moves in its various forms (liquid, ice or snow, vapour) through the cycle.

As a result, water resource protection strategies and utilisation strategies (including agriculture) need to be considered as interdependent, and they need to be effective and efficient in order to optimise and sustain the ecosystem services, as well as agricultural production, industrial production and energy production that we depend upon.

Impacts of climate change on water and wetlands

There is no doubt that easily accessible water and wetlands are dependent upon where and when rain and snow fall. Although scientists have recognized that they can never be certain exactly how extreme expected global warming might become, they have also warned that that is no excuse for delaying action. The findings of the IPCC Fourth Assessment Report (Pachauri, R.K. and Reisinger, A. (Eds.), 2007)) indicate that:

- Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk.

- With regard to changes in snow, ice and frozen ground, there is high confidence that natural systems are affected through enlargement and increased numbers of

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glacial lakes; increasing ground instability in permafrost regions and rock avalanches in mountain regions, and changes in some Arctic and Antarctic ecosystems.

- The effects on hydrological systems are occurring through increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers [and] warming of lakes and rivers in many regions, with effects on thermal structure and water quality.

Consequences of climate change on plant and animal life

The Fourth IPCC Report (Pachauri, R.K. and Reisinger, A. (Eds.), 2007) (*op.cit)* states that there is very high confidence, based on evidence from a wide range of species, that recent warming is strongly affecting terrestrial biological systems, including earlier timing of spring events, such as leaf-unfolding, bird migration and egg-laying. There has been a trend in many regions towards earlier 'greening' of vegetation in the spring, linked to longer thermal growing seasons.

Conventional wisdom based on previous research held that land plant productivity was on the rise. A 2003 paper in *Science* by R. Nemani *et al* showed that global terrestrial plant productivity increased as much as 6% between 1982 and 1999, because for nearly two decades, temperature, solar radiation and water availability, influenced by climate change, were favourable for growth (R. Nemani *et al, 2003)*

However, in another study in *Science*, in 2010, Zhao and Running found that "the impact of regional drought overwhelmed the positive influence of a longer growing season, driving down global plant productivity between 2000 and 2009". Their analysis showed that, since 2000, high-latitude northern hemisphere ecosystems had continued to benefit from warmer temperatures and a longer growing season, but that effect was offset by warming-associated drought that limited growth in the southern hemisphere, resulting in a net global loss of land productivity (Zhao and Running, 2010)

The effects of climate change on wetland ecosystems can also have consequences for human health, both directly and indirectly. Possibly most concern has centred on the likely changes in the range and seasonality of outbreaks of mosquito-borne infections, which will affect most regions of the world in some way. in some parts of the world hydrological regimes will change: for instance, the Komadugu-Yobe River which marks the border for a part between Nigeria and Niger has been changing its course over the 20th century. As a result, one country can gain territory for the first part of the river, but can lose territory the second part. The water quantity in the river has also diminished and the river is getting shallower because of sand being deposited on the riverbed. At small scale, the changes have an impact on the local inhabitants. The erosion on the riverbanks is the most problematic among them. Houses and farmlands along the river have been destroyed or are threatened by the river (Martinsson, 2010) ...., and rainfall may decrease; fresh-water shortages for some communities will result, with consequences for hygiene and sanitation. It is likely that increased injury, dislocation, and even death will occur from increases in extreme weather events, when people live in or near wetlands susceptible to floods, storms, cyclones, and increasingly severe bushfires. There are also increased risks of infectious food-poisoning from salmonella, *Campylobacter*, and other temperature-sensitive bacteria (Confalonieri, et al, 2007)).

All of these problems to human health may occur together at particular times and in particular places, making planning for human health consequences very challenging.

Short-, medium-, and long-term consequences for agriculture

Much of the impacts of an increasingly extreme climate on our future world will be felt through water: in some cases too much in the wrong time and place, elsewhere too little or none where we need it. Floods and droughts will be increasingly affecting land use systems, especially agriculture.

The clear messages from the Millennium Ecosystem Assessment (MA) on water, agriculture and ecosystems (Robert T. Watson et al (2005) have been reinforced by the UNEP GEO-4 report (UNEP ,2010)). GEO-4 stressed that around 70% of available water from rivers and other wetlands is already used for agricultural irrigation, but that fully meeting the Millennium Development Goal (MDG) on hunger reduction will mean doubling food production by 2050, which implies that demand for irrigation water will increase significantly. Yet at the same time that the availability of freshwater is declining, water use is predicted to rise further by 2025, by 50% in developing countries and by 18% in the developed world. So the gap between supply and demand seems still to be widening, while largely sectoral-based global and national governance is taking insufficient action to tackle this most fundamental of all challenges.

The consequences of both present climate variability and long-term climate change are most strongly felt in developing countries, and they particularly affect the poorest in these regions, especially poor farmers. The recent floods in Pakistan illustrate the significance of unexpected floods and the extent of damage that such floods can cause to agriculture. The immediate water damage has caused disaster, as the floods have inundated crop-producing areas, destroying the agricultural-based economy and threatening a food crisis. Officials in the region have estimated that 100,000 acres of soil along the Swat River had been washed out, and that it will take up to 10 years to restore the fertility of this critical area that presently feeds 50,000 people.

Droughts in the Sahel region of Africa and their effects have been studied intensively since the 1970s, as climate variability in the region is leading to food insecurity in many Sahelian countries. Farming in this region is almost entirely reliant on three months of summer rainfall, except along the banks of the major rivers, lakes, and other seasonal water courses.

It is worth noting the case of the Lake Chad Basin, where I supervised a Transboundary Diagnostic Analysis (TDA) and the preparation of a Strategic Action Programme (SAP) from 2003 to 2007 to identify and analyze the causes of land and water degradation and to propose a SAP to reverse the trends of degradation. A team of 30 experts worked closely with a range of stakeholders to prepare the TDA that brought to light the following results (Lake Chad Basin GEF Project, 2007):

Lake Chad, with a maximum surface area of 25,000km2, is made up of distinct morphological pools that become fully visible at a water surface elevation of about 279 meters. Although it is a closed basin within an arid zone, it has relatively low salinity. A major water resources concern of the lake is its shrinkage, with the present expanse being less than 3,000 km2. The shrinkage has impacted negatively on large scale

irrigation schemes in Nigeria, on recession agriculture in Niger, Cameroon and Chad, among other things. The major problem is the variability of hydrological regime and fresh water availability: this pertains to the dramatic decrease in fresh water availability in the Lake Chad Basin, the best illustration of which is the decrease in the lake's volume by 95% from 1963 to 2007. It also pertains to a marked variability in the hydrological regimes of the rivers that feed it, as well as rainfall regimes in the region, worsened by population pressure, low environmental awareness levels and the absence of sustainable development in the political programs of the riparian countries. This has led to continuing decline in local access to water, crop failures, livestock deaths, collapsed fisheries and other wetlands services. The socio-economic consequences of the impacts include food insecurity and declining health status of the populace. Water shortage is rated as the most significant problem not only due to the above impacts and consequences, but also because it drives or contributes towards other problems, including a spiraling effect, as the shortages cause more unsustainable resources harvesting and thus more degradation. The net socio-economic consequence is deepening poverty due to resources shortages.

The lake is strategic for global biodiversity, being the home to 120 species of fish, as well supporting 372 bird species. However, water shortage contributes to biodiversity loss and increasing loss and modification of ecosystems: the lake, for example, has changed from an open water to a marshy environment, and about 50% of wetlands have been destroyed. The impact of this phenomenon is most felt in the collapse of some fisheries and recessional rice cultivation, as well as sedimentation in rivers and other water bodies, which led to the colonization of the silted sites by invasive species: Typha grass is a major problem in the Komadugu Yobe Basin, and quelea birds are major invasive pests prevalent all over the basin. The invasive plant and birds, to a large extent, are the consequences of poor water resources management, poor enforcement of environmental regulations and standards, and the absence of resources use planning. The typha grass blocks river channels and diverts flows, while the quelea destroys crops, both contributing to poverty through the loss of livelihoods.

It is urgent to recognize the crucial role wetlands play in the global water cycle, through holding and processing water, and to appreciate the fact that almost all the water we use comes directly or indirectly from wetlands.

Role of wetland management in response to environmental and social emergencies

Agriculture needs sustainable biological systems such as fertile soils and healthy wetlands and forests to ensure its sustainability, i.e., the capacity of biological systems to remain diverse and productive over time.Wetland management is one way to increase the resilience of water-related ecosystems to support and encourage soil and water conservation, sustainable irrigation schemes, agroforestry, aquaculture, and provision of feedstock and fodder for livestock etc.. The implementation of innovative techniques in soil and water conservation and agroforestry is underway in the Sahel region of Africa, including the Lake Chad Basin. For example, many villages have developed their own erosion control schemes to increase the wetlands' capacity to

support agriculture. It is encouraging that Sahelian farmers are fully aware that rainfall is unreliable, and that they are putting all their efforts into making the best use of available water. In addition, there are now thousands of farmer organizations, and small-scale NGO projects and internationally-funded large-scale development projects and programmes which are involved in environmental rehabilitation, soil and water conservation, and other forms of support to rural people.

Conclusions

For adaptation to climate change, we need to reinforce the link between wetlands and their ecosystem services, especially the provision of fresh water supply and food from wetlands. Effective management, including wetland restoration, under expected climate change scenarios, should also support basic human needs for food and water, whilst keeping in mind that increasing demand for food and water could also undermine wetland management.

To that end, partnership among many players is needed, and in this regard, joint work underway between the Ramsar Convention and various partners, including the UN system, NGOs, and the business sector, is contributing to:

- Better hydro-meteorological monitoring for adaptive management of wetlands;
- Better recognition of the role of wetlands as vital natural ecosystem, which deserves careful attention because effective management of wetlands provides the most robust and resilient mechanism for managing water under conditions of climatic uncertainty;
- Better understanding of the role of wetlands in relation both to climate change adaptation and mitigation;
- More attention to measures that can be implemented in the short term to increase wetland ecosystem resilience and robustness;
- Increased collective action to address management and conservation issues in critical areas such transboundary systems, including rivers and lakes, groundwater systems, mangroves, coral reefs, and peatlands; and
- Better understanding, planning and management of integrated human-made and natural systems (e.g., wetlands) to account for buffer against negative impacts of-climate uncertainties.

The Ramsar Convention is continuing its work on the conservation and wise use of 42 types of wetlands as important assets for various sectors such as agriculture and food security, forestry, energy, water supply, health, urban and rural settlements, infrastructure, tourism, wildlife, trade and transport that contribute to sustainable socio-economic development. The urgency of the situation demands no less.

References

Charles D. Keeling, Hirofumi Hashimoto, William M. Jolly, Stephen C. Piper, Compton J. Tucker, Ranga B. Myneni, & Steven W. Running; Climate-Driven Increases in Global Terrestrial Net Primary Production from 1982 to 1999
Ramakrishna R. Nemani,Science 6 June 2003: Vol. 300. no. 5625, pp. 1560 - 1563
DOI: 10.1126/science.1082750

Confalonieri, U., B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revich and A. Woodward, 2007: *Human health. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 391-431.

Guojing Yang, 2006, "*Potential impact of climate change and water resources development on the epidemiology of schistosomiasis in China*". Inaugural dissertation zur Erlangung der Würde eines Doktors der Philosophie vorgelegt der Philosophisch-Naturwissenschaftlichen Fakultät der Universität Basel, 2006. http://edoc.unibas.ch/478/1/DissB_7523.pdf

IPCC (2007) Climate Change: *Impact, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK.

Jenny Martinsson (2010)- *Changes in the Course of the River Komadugu Yobe during the 20th*
Century at the Border between Niger and Nigeria Master's Thesis
Division of Water Resources Engineering Department of Building and Environmental Technology Lund University (M.Sc.)

Lake Chad Basin GEF Project on Reversal of Land and Water Resources Degradation Trends (2007), *Transboundary Diagnostic Analysis (TDA)*; Lake Chad Basin Commission (LCBC), N'djamena, Chad

Pachauri, R.K. and Reisinger, 2007 A. (Eds.), *Climate Change 2007: Synthesis Report Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.). IPCC, Geneva, Switzerland. pp 104

Ramakrishna R. Nemani, Charles D. Keeling, Hirofumi Hashimoto, William M. Jolly, Stephen C. Piper, Compton J. Tucker, Ranga B. Myneni, & Steven W. Running (2003); Climate-Driven Increases in Global Terrestrial Net Primary Production from 1982 to 1999
Science 6 June 2003 Vol. 300. no. 5625, pp. 1560 - 1563
DOI: 10.1126/science.1082750

Robert T. Watson et al, 2005; *Living Beyond Our Means: Natural Assets and Human Well-Being.* Millennium Ecosystem Assessment (MA)
http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,print:Y~isCURL:Y~contentMDK:20419328~menuPK:34463~pagePK:34370~piPK:34424~theSitePK:4607,00.html

UNEP, 2010; *Global Environment Outlook (GEO*) Section
Division of Early Warning and Assessment (DEWA)
United Nations Environment Programme (UNEP)
P.O. Box 30552 Nairobi, 00100, Kenya

EarthPrint Limited, P.O. Box 119, Stevenage, Hertfordshire SG1 TP, U.K.

UN-Water. "Climate change adaptation, the pivotal role of water". http://www.unwater.org/downloads/unw_ccpol_web.pdf
Zhao and W. Running, 2010; Drought-Induced Reduction in Global Terrestrial Net Primary Production from 2000 Through 2009; Science 20 August 2010:Vol. 329. no. 5994, pp. 940 - 943
DOI: 10.1126/science.1192666

Articles

Climate change impacts on agriculture in Africa: Current assessments and the way forward

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Summary
Information at local scale on impacts of climate variability and climate change are crucial for planning of adaptation strategies and practices in agriculture. There is a diversity of approaches and methods available for understanding the impacts of climate change on agriculture. In general, climate change impact assessments primarily build on the data availability of crop production/yield records, observed climate data, climate change scenarios, hydrological, soil and socio-economic data. In addition, these assessments must be based on an understanding of what future climate will look like and how its variability will affect the biophysical and socio-economic systems associated with agriculture. This paper briefly presents the results of previous assessments for Africa and seeks to identify future priorities with respect to data, methods and tools for climate change impact assessment in agriculture.

Introduction

The expected future changes in climate will alter agricultural systems with negative consequences for food production in Africa and elsewhere. In order to ensure a sustainable agricultural development, a comprehensive understanding and assessment of the likely impact of climate change on crop production systems at regional, country and local scale is necessary. The impacts of climate change on crop yields are either direct effects due to changes in temperature, precipitation and CO_2 concentrations or indirect effects through changes in soil moisture content and the incidence of pests and diseases.

Many climate change impact assessment methods have been developed based on the fundamental understanding that agriculture activities are closely related with past, current and future climatic conditions. But, these interactions are extremely complex and the models developed thus tend to exclude the complexity especially due to non-availability of proper tools and data. The climate change impact assessments in agriculture use climate change scenarios of Global Climate Models (GCMs) linked with crop models to assess likely impacts. The Regional Climate Models (RCMs) provide climate change scenarios for relatively smaller areas and can be used for local

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assessments. Detailed local assessments are gaining increased importance due to their applicability for adaptation planning.

With this brief background, the objectives of this paper are: (i) to present a summary of observed and predicted changes in climate of Africa and selected results of impact assessments and (ii) to present the priorities for in-depth impact assessments in the future and the way forward.

Observed and predicted climate change in Africa

The observed climate variability in Sub-Saharan Africa, has shown a marked decline in rainfall leading to an observed average decrease in discharge of some watercourses (Niasse et al., 2004). In the second half of the last century, mean annual temperatures in Africa rose approximately half a centigrade with some areas warming faster than others (Eriksen et al., 2008). This gradual heating meant more warm spells (days) and fewer cold days across the continent.

With regard to predictions for the future, the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (IPCC, 2007) summarized that the warming in Africa may be higher than the global average and that it may persist throughout all seasons. Further, it was reported that annual mean surface air temperatures are expected to increase between 3°C and 4°C by 2099 for a medium warming scenario, roughly 1.5 times the average global temperature rises.

On regional variations, Eriksen et al. (2008) concluded that warming is likely to be greatest over the interior of the semi-arid margins of the Sahara and central Southern Africa. IPCC (2007) projections for East Africa suggest that increasing temperatures due to climate change will increase rainfall by 5-20% from December to February, and decrease rainfall by 5-10% from June to August by 2050. Recently, Battisti and Naylor (2009) used observation data and outputs from 23 global climate models to show a high probability that, by the end of this century, and even earlier for some parts of the Sahel region, the average temperatures during the growing season are expected to exceed the hottest seasons recorded during the past century.

Climate change impact on agriculture in Africa

Africa is considered the most vulnerable region in the world in terms of climate change, due to its physical and socio-economic characteristics. In the Sahel region of Africa, warmer and drier conditions have already led to a reduced length of the growing season with detrimental effects on crops. The areas suitable for agriculture, and the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid-areas, are expected to decrease.

The past and current assessments of climate change impact on African agriculture clearly showed uniformly negative impacts on crop yields. Even the Second Assessment Report of the IPCC (IPCC 1995) concluded that low income populations depending on isolated agricultural systems, particularly dryland systems in semi-arid and arid regions, are particularly vulnerable to climate change and many of these at risk populations are found in sub-Saharan Africa. The Fourth Assessment Report of IPCC (IPCC, 2007) reiterated that projected climate change impacts and declining agriculture productivity may compound the risk of food insecurity in Africa. The report further

noted that the agricultural production and food security in many African countries and regions are likely to be severely compromised by climate change and increasing climate variability.

Fischer et al (2002) developed an agro ecological zoning model that identified suitability of land for agricultural production and simulated the changes in the availability of suitable agricultural land that can be expected from climate change. The results of the assessment, which covered several African countries, showed that for rainfed cereal production based on one crop per year, land currently under cultivation would experience a decrease in production potential by 3.5 percent.

Cline (2007) used temperature and precipitation projections (2070 – 2099) from six climate models to obtain change in crop yields. The results of the analysis stated that, with a 2°C warming, there would be sharp declines in crop yields in tropical regions and for Africa these decreases would range from 5 to 10 percent. At 4°C warming, agricultural yields would decline by 15 to 35 percent. It was predicted that higher temperatures will lead to a substantial decline in cereal production, particularly if the expected carbon fertilization effect is smaller.

Lobel et al. (2008) used data sets on historical crop harvests, monthly temperatures and precipitation to develop statistical crop models and then applied data from 20 general circulation models (GCMs) for the assessment of climate change impacts in 2030. The results of the impact analysis indicated that Southern Africa will likely suffer negative impacts on several crops that are important to large food-insecure populations and stressed the need for sufficient adaptation measures. However, on the methodology part, the results highlighted poor climate-yield relationships due to inadequate data sets at local level and reiterated the need to improve the data quality to be able to prioritize suitable adaptation measures.

Africa's economy is highly exposed to climate variability and extremes. Several approaches have been employed to assess the impact of climate change on economic progress in Africa. Darwin et al (1995) arrived at the conclusion that the effect of benchmark warming would be positive with a gain of 0.47 percent of agricultural Gross Domestic Product (GDP) in Africa. However, later studies by Tol (2002) showed significant negative impact for a 2.5°C warming for Africa, with an average of 1.2 percent of agricultural GDP. More recent estimates predict economic losses as a result of climate change as high as 14 percent of the GDP if adaptation measures fail to be implemented (Nelson et al., 2009). A very recent study by Nhemachena (2010) based on a cross-sectoral survey of over 8 000 farming households from 11 countries of Africa showed that the net farm revenues are, in general, negatively affected by warmer and drier climates.

The generic approach of climate change impact assessment

Several methodologies have already been developed that combine observed meteorological variables, historical agriculture yields and climate change scenarios to simulate future yields, incorporating the CO_2 fertilization effect, technological trends and potential adaptation options (UNFCCC 2008). The FAO's climate change impact assessment methodology, which considers all the above components, is shown in Fig.1. Crop growth models are frequently used for climate change impact assessment which

requires information on observed weather, future weather from climate change projections, soil parameters, along with crop specific parameters, such as crop phenology, water use efficiency etc. The reliability of impact assessment method depends on how well the crop model explains the physiological processes of a crop in relation to climate and other external factors.

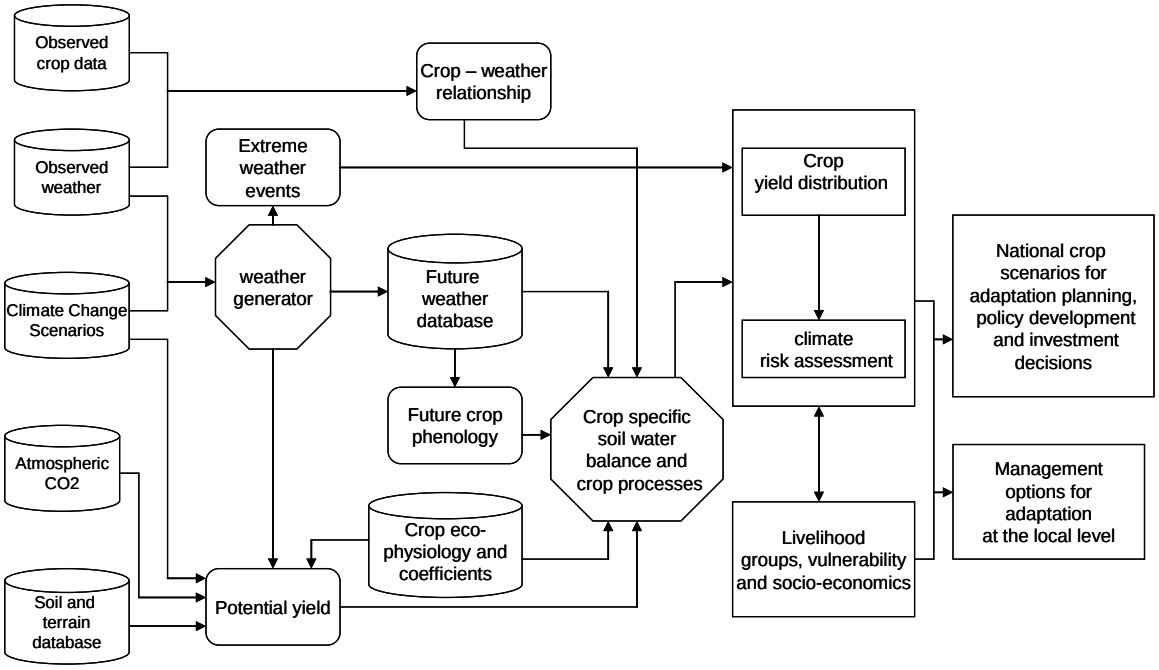

Fig.1.Data and information flow of a generic climate change impact assessment framework (Source: based on FAO, 2009)

The primary inputs for climate change impact assessments are downscaled future climate change data at station level from GCMs. The study area can be determined by the administrative borders, extent of the hydrological basins and/or crop specific ecological zones. The methodology includes a step to calibrate the downscaled data for the baseline period against past observed weather records of each station.

The climate data sets together with elevation, land cover and soil maps will form the input to the hydrological model, which can provide an estimate of surface and ground water resources in water catchments. The model is calibrated against observed water discharges at the basin scale. Water availability for irrigation is derived from the water resources estimates from hydrological model.

The crop model provides an estimate of the yield on the basis of climate scenarios, soil data and water availability during a given season. The yield projections are obtained considering the technological trend scenarios (mechanization, plant breeding, agricultural practices, inputs, management etc.) and CO_2 fertilization effects. The projected crop yields can be incorporated into economic models in order to analyse the possible effects of yield change on the agricultural economic sector.

The FAO methodology (FAO 2010) is designed for country-wide studies, but it could be applied at sub-national or regional levels. The methodology combines four major components: a downscaling method for processing GCM's output data, a hydrological model for irrigation water resource estimation, a crop model to estimate crop yields and

a Computable General Equilibrium (CGE) model to simulate the effect of changing agricultural yields on different economic sectors.

Conclusions and way forward

The climate change impact assessment studies employed systematic methodology including many countries, regions, and regional sub-zones, but these approaches mainly focused on overall economy and are not adequate for planning of adaptation practices at sub national and local levels. Experiences show that there is a need for detailed impact assessments for agriculture taking into consideration the physical, biophysical and socio-economic complexities of African countries, with special reference to the most vulnerable populations. However, a sufficient database of climatological, meteorological, phenological, soil and agronomic information is crucial for undertaking such an analysis.

In addition to agrometeorological and crop information, data on climate change scenarios are pre-requisite. Crop growth models are useful to better quantify climate change impacts, as well as developing crop and soil management practices that reduce the impacts. However, these models need to be chosen based on data availability and should be calibrated and validated based on observed climate and crop data. The data from climate model and crop models can be coupled with geographic information system (GIS) to analyze crop suitability, yield variability, water productivity at river basin and regional scales under current and future climates. Advancement of impact assessment studies require close cooperation between agencies and organizations dealing with climate and agriculture at international and national level to establish a climate and crop data sharing platform for impact assessment and decision making to improve food security.

References

Battisti, D.S., Naylor, R.L. 2009. Historical warning of future food insecurity with unprecedented seasonal heat. Science, 323: 240-244

Clements, R. 2009. The economic cost of climate change in Africa. http://www.christianaid.org.uk/ images/ economic-cost-of-climate-change-in-africa.pdf. Cited 11 Dec 2009.

Cline, W.R. 2007. Global Warming and Agriculture: Impact estimates by country. Washington DC: Center for Global Development, 250 pp.

Darwin, Roy, Marinos Tsigas, Jan Lewandrowski, and Anton Raneses. 1995. World Agriculture and Climate Change. Agricultural Economic Report no. 703 (June). Washington: US Department of Agriculture, Economic Research Service.

Eriksen, S., O'Brien, K. and Losentrater, L. 2008. Climate Change in Eastern and Southern Africa:Impacts, Vulnerability and Adaptation. Global Environmental Change and Human Security, Report 2008:2.

FAO, 2009. Impact of climate change on agricultural yields in Morocco, Food and Agriculture Organization of the United Nations, Rome. Available at: http://www.fao.org/nr/climpag/pub/FAO_WorldBank_Study_CC_Morocco_2008.pdf

Fischer, Günther, Harrij vanVelthuizen, Mahendra Shah, and Freedy Nachteergaele. 2002. Global Agro-Ecological Assessment for Agriculture in the 21st Century: Methodology and Results. Laxenburg, Austria: International Institute for Applied Systems Analysis.

IPCC, 1995. Climate Change 1995: A report of the Intergovernmental Panel on Climate Change, 63p Available at: http://www.ipcc.ch/pdf/climate-changes-1995/ipcc-2nd-assessment/2nd-assessment-en.pdf

IPCC, 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

Lobell, D.B., Burke, M.B., Tebaldi,C, Mastrandrea, M.D., Falcon, W.P., Naylor, R.L. 2008. Prioritizing climate change adaptation needs for food security in 2030. Science, 319: 607-610

Nelson, G. C., Rosegrant, M. W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, M. and Lee, D., 2009.Climate change impact on agriculture and costs of adaptation. International Food Policy Research Institute. Washington, D.C.

Nhemachena, C. 2010. Measuring the conomic impact of climate change on African agricultural systems. Climate change economics, 1 (1): 33-55

Niasse, M., Afoud, A., and Amani, A. (Eds.) 2004. Reducing West Africa's Vulnerability to Climate Impacts on Water Resources, Wetlands and Desertification: Elements of Regional Preparedness and Adaptation. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 66pp.

Tol, R.S.J. 2002. Estimates of Damage Costs of Climate Change. Environmental and Resource Economics 21: 47–73

UNFCCC (2008) Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change. The United Nations Framework Convention on Climate Change. Available at: http://unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/2674.php

Planning agricultural water storage for climate change in sub-Saharan Africa

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Summary
Rainfall variability is a key constraint to agricultural production, livelihoods and economic growth in many developing countries. This is likely to be exacerbated in many places as rainfall variability increases (even where the total amount of rain increases) as a result of climate change. Changes in rainfall will also increase variability in groundwater recharge and river flow, thus affecting all water sources. Water storage, in its various forms, provides a mechanism for dealing with variability which, if planned and managed correctly, increases water security, agricultural productivity and adaptive capacity. As such, water storage can make an important contribution to safeguarding livelihoods and reducing rural poverty. However, ill-conceived_water storage is a waste of financial resources and, rather than mitigate, may aggravate negative climate change impacts. Systems that combine complementary storage options are likely to be more adaptable and sustainable than those based on a single storage type. More systematic planning and management is required to avoid the mistakes of the past and to ensure more effective and suitable storage systems for the future.

Introduction

For many of Africa's poorest people, water scarcity *per se* is not the most pressing concern. Rather it is the inability to manage rainfall variability that is a key contributing factor to food insecurity and poverty. Frequent periods with too much water are followed by periods with too little, and intermittent water scarcity is often a direct consequence of rainfall variability. Lack of predictability both in the amount and timing of rainfall makes rainfed farming extremely difficult. Farmers have to make difficult choices about when to plant. Plant too early and, if the rain falters, the seeds may not germinate; plant too late and rain may cease before the crops have reached maturity. Pastoralists have to make similarly difficult choices about when and where to move their livestock for grazing and water. Where rainfall is less variable farmers do not face these dilemmas.

As a consequence of climate change, rainfall variability is likely to increase in many places (Boko et al., 2007). Consequently water management will become much more difficult and, without doubt, many poor farmers will become even more vulnerable than they are currently. Under such circumstances, even small amounts of water storage can, by supporting crops and/or livestock during dry periods, significantly increase agricultural and economic productivity and enhance people's well-being. For millions of smallholder farmers, reliable access to water is the difference between sufficient food and hunger. Consequently, it has an important role to play in poverty reduction, sustainable development and adaptation to climate change. However, throughout Africa the climate and socio-economic conditions vary significantly and will be affected by climate change in a myriad of diverse ways. Hence, storage options need to be carefully tailored to suit exact needs.

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The water storage continuum

When it comes to storage, water resource planning focuses today primarily on large dams. Indeed, many of the world's 50,000 large dams were built for irrigation (ICOLD, 2003). However, for agriculture, dams are just one of a range of possible water storage options. In fact agricultural water storage can be considered a *continuum* of surface and subsurface options which include natural wetlands, enhanced soil moisture, groundwater aquifers, ponds and small tanks, as well as large and small reservoirs. The effectiveness of these options varies, but each of them provides a buffer during dry periods. Broadly, the deeper and/or the larger the storage, the more reliable the water supply it can help ensure; and the more 'natural' it is, the less complex and less costly it is to develop, manage and access (Figure 1). However, none of these options is a *panacea*. All have strengths and weaknesses which depend, in part, on their inherent characteristics (Annex 1) but they are also affected by site-specific conditions and the way the storage is planned and managed. Consequently, the impact of different types of storage on poverty can vary significantly, with some types being much more effective in certain situations than others (Hagos, 2010).

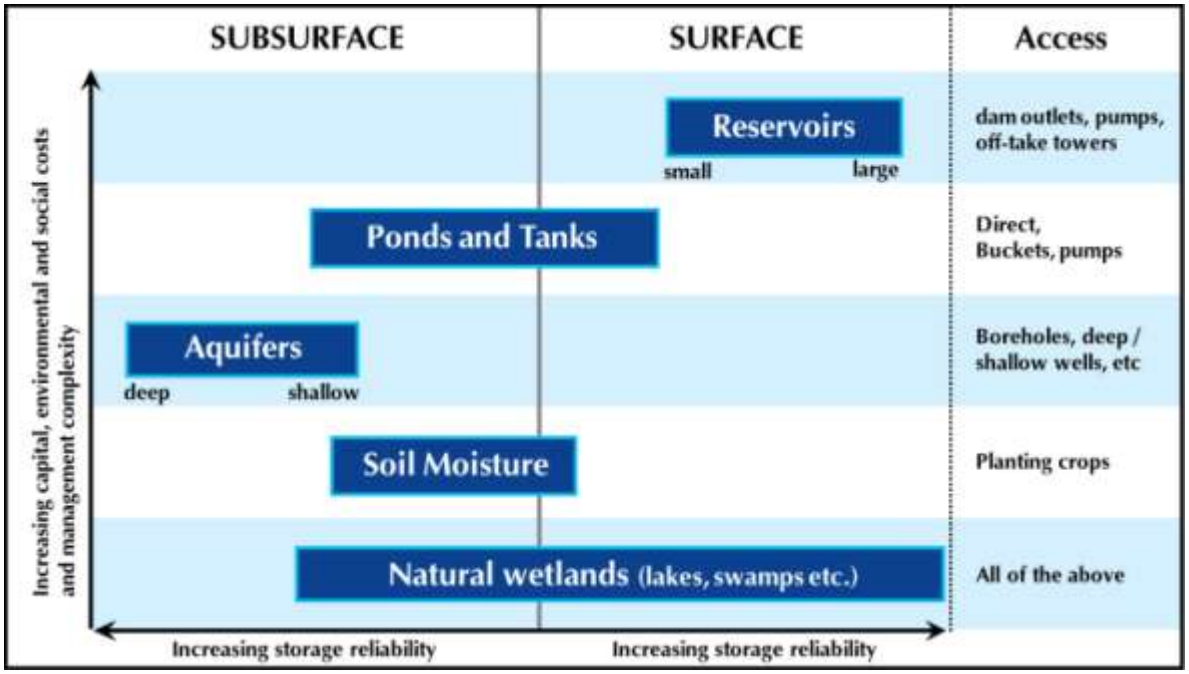

Figure 1. Conceptualization of the physical water storage continuum.

With the exception of large dams, in most places past storage development has occurred in a piece-meal fashion, largely through local initiatives and with minimal planning. It is generally characterized by the absence of data or poor data management, insufficient communication with local stakeholders and water resource authorities, and lack of any integrated planning (Johnston and McCartney, 2010). In some cases (e.g. where reservoirs are silted, boreholes are dry and ponds have severe negative health impacts) it is clear that, despite the best of intentions, the lack of information and planning has resulted in less than optimal investments. For example, of around 4,000 rainwater harvesting ponds constructed in the Amhara region of Ethiopia between 2003 and 2008, the majority were non-functional by 2009 (AMU, 2009). Failures have been attributed to a range of factors, including: poor site selection, poor design, technical problems (e.g. failure of lining materials leading to seepage) and lack of commitment by communities for maintenance.

Water storage and climate change

Climate change, in conjunction with population growth, will increase the importance of water storage in many developing countries. Appropriate storage will reduce peoples' climate vulnerability by increasing water and food security as well as adaptive capacity (Figure 2). However, all water storage options are also potentially vulnerable to the impacts of climate change (Annex 1) and, as water resources are increasingly utilized and climate variability increases, planning and management will become ever more difficult. In all situations maximizing the benefits and minimizing the costs of water storage options will, as in the past (but rarely implemented), require consideration of a wide range of complex and inter-related hydrological, social, economic and environmental factors. However, in a departure from the past, future planning needs to be much more integrated across a range of levels and scales, with much greater consideration of the full range of possible options. To date, although there have been many studies of the effects of climate change on hydrological regimes, there has been very little systematic research into the potential impacts of climate change on different water storage options, or how to plan and manage water storage under a changed climate. Despite the high levels of uncertainty it is important that climate change projections and scenarios are used to improve planning of all types of water storage.

A key to planning water storage is the determination of current and future needs, making appropriate choices from the suite of storage options available. In any given situation this requires understanding both biophysical and socio-economic issues that influence the *need*, *effectiveness* and *suitability* of the different water storage options. In the past there has generally been little explicit consideration of these issues, even in large dam construction projects. For storage options other than large dams, where planning is generally less formalized, needs are usually regarded as self-evident and alternative options are rarely considered.

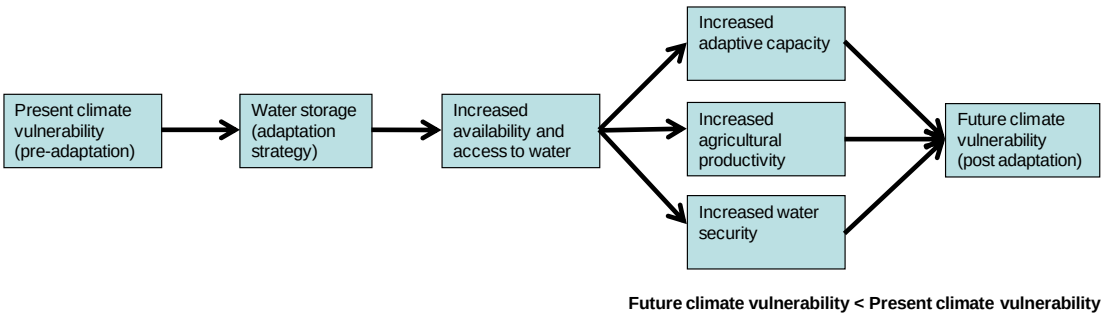

Figure 2: Water storage as an adaptation strategy to reduce climate vulnerability

The details of climate change are unknown so planning must allow for great uncertainty. Future water storage must be more reliable and resilient and less vulnerable than in the past. All water storage options have strong comparative advantages under specific conditions of time and place. Hence, storage "systems" that combine and build on complementarities of different storage types are likely to be more effective and sustainable than those based on a single option. For example, combinations of surface and groundwater storage or large and small reservoirs, can dampen mismatches between supply and demand, and are already used successfully in some places.

The optimal combination of storage options will vary depending on local biophysical and socio-economic circumstances. However, there will rarely be an ideal combination and in most instances trade-offs will need to be considered. Without a greater understanding of which types of storage are best suited for specific agro-ecological and social conditions, and

in the absence of much more systematic planning, it is probable that many water storage investments will fail to deliver intended benefits. In some cases they may even worsen the negative impacts of climate change. To avoid inappropriate storage options, future planning needs to be much more evidence-based. To this end, studies are needed to better understand: the social and environmental impacts of different storage options; the implications of scaling up small-scale interventions; and, very importantly, the reasons for the successes and failures of past interventions. Systematic methods for evaluating the suitability and effectiveness of different options, both individually and within larger systems, need to be developed.

Conclusions

In sub-Saharan Africa rainfall variability is an important factor in development and translates directly into a need for water storage. For agriculture the storage can take a variety of forms all of which have an important role to play in climate change adaptation. However, more integrated and evidenced–based planning is required to ensure that, in any specific situation, the full range of storage options are properly considered and the likely implications of climate change evaluated.

References

Arba Minch University (AMU) 2009. Inventory of water storage types, their distribuiton and characteristics in the Abbay River Basin. Unpublished report prepared for IWMI. Addis Ababa, Ethiopia.

Johnston, R.; McCartney, M.P. 2010. Inventory of water storage types in the Blue Nile and Volta River Basins. Colombo, Sri Lanka: International Water Management Institute 48pp (IWMI Working Paper 140).

Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo R. and Yanda, P. 2007: Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press,Cambridge UK, 433-467.

Hagos, F.; Gayathri, J.; Awulachew, S.B.; Loulseged, M.; Yilma, A.D. 2010. Poverty impacts of agricultural water management technologies in Ethiopia. Water Policy (forthcoming)

International Commission on Large Dams (ICOLD) 2003. World Register of Dams, 2003. International Commission on Large Dams, Paris, France. 340 pp.

ANNEX 1: Comparison of different agricultural water storage options and the possible implications of climate change

	Inherent Benefits (Pros)	Inherent Risks (Cons)	Possible risks from climate change	Possible social and economic implications
Natural wetlands	• Water storage is provided as an ecosystem service without the need for costly infrastructure	• Excessive utilization of water in, or upstream of, natural wetlands may undermine other ecosystem services	• Reduced rainfall and runoff inputs resulting in desiccation • Higher flood peaks resulting in wetland expansion and flooding of fields/homes • Improved habitat for disease vectors	• Increased failure to provide community/household needs • Loss of water dependent ecosystem services • Increased risk of water borne diseases
Soil moisture	• Generally low cost options that can be implemented by individual farmers and communities	• Where land holdings are extremely small, farmers may be unwilling to use precious land for these interventions. • Limited storage - will not provide water for more than a few days without rain	• Reduced infiltration or water logging/erosion resulting from modified rainfall intensities and durations • Depleted soil moisture arising from higher evaporative demand • Reduced soil quality (including water holding capacity) resulting from modified rainfall and temperature	• Decreased productivity – more frequent crop failures and reduction in yields
Groundwater	• Evaporation losses are low or non-existent. • Multi-year storage that is largely decoupled from seasonal variability	• Detailed geological information is required to locate wells and estimate yields • Depending on geology, may contain high concentrations of toxic chemicals (e.g. arsenic)	• Reduced recharge resulting from modified rainfall intensities • Reduced recharge resulting from land-cover modification and increased soil moisture deficits • Saline intrusion in near-coast aquifers	• Falling water levels make it increasingly costly to access groundwater • Poor water quality make groundwater unsuitable for use
Ponds and Tanks	• Generally relatively low cost options, implementable by communities and NGOs.	• High evaporation losses • Water contamination (e.g. from water flowing in and livestock entering the water) • Risk of siltation • May provide breeding habitat for disease vectors	• Reduced inflow, resulting in longer periods between filling • Higher evaporation, increasing rates of pond/tank depletion • Infrastructure damage caused by larger floods • Improved habitat for disease vectors • Increased risk of eutrophication, salinization and siltation	• Increased failure to provide community/household needs • Increased labor requirements and costs to repair structures • Increased risk of water borne diseases
Reservoirs	• Large volumes of water stored, which can be used for multiple purposes. • The only option that	• Significant capital investment • Often displacement of large numbers of people • Significant environmental and	• Reduced inflow, resulting in longer periods between filling • Higher evaporation, increasing the rate of reservoir depletion • Infrastructure damage caused	• Increased failure to meet design specifications (irrigation and hydropower etc.) • Increased costs due to the need to redesign infrastructure (e.g.

	enables production of electricity and can offer protection from floods	social impacts arising from changes to river flows • May provide breeding habitat for disease vectors	by larger floods • Improved habitat for disease vectors • Increased risk of eutrophication, salinization and siltation	spillways) • Increased risk of water borne diseases

Opportunities and Capacity for Community-based Forest Carbon Sequestration and Monitoring in Ghana

John Schelhas[1], Sparkler Samar[2], Cassandra Johnson[3], Kwaku Asumadu[4], Francis Tease[5], John Stanturf[6], Dominic Blay[7]

International efforts to address global climate change will certainly include Africa's forests, for example through efforts to reduce emissions from deforestation and forest degradation (REDD)(Sandker et al. 2010). Whether these efforts harm or provide new opportunities for rural people will depend on how programs are designed. In Ghana, as in many developing countries, there are few reliable data for estimating current forest carbon stocks. Newly established forest plantations constitute one of the largest and most immediate sources for changes in carbon stock in the country. The government and other organizations are presently establishing forest plantations at a rate of 20,000 hectares annually. Monitoring carbon in forest plantations will be an important component of REDD efforts in Ghana. While methods based on remote sensing can support country-level assessments (Patenaude et al. 2005), ground-based measurements and ground truthing are needed to validate remote sensing results and to provide more reliable_estimates of change. While ground-based forest inventories are expensive, approaches that involve local people directly in data collection and interpretation have been shown to overcome resource limitations while at the same time improving conservation project success by linking monitoring to the decisions of local people and building cooperation between local people and the authorities (Blay et al., 2008; Appiah, 2009).

Over the past ten years the Forest Research Institute of Ghana (FORIG) has been working in a benefit-sharing scheme with ten forest fringe communities to restore degraded forest reserve land (Blay et al., 2008). Forest plantations using mostly native tree species have been established through a modified taungya agroforestry system.

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While plantations are established through agroforestry, the use of tree native species and subsequent growth of native understory vegetation and vines after cropping ceases are intended to ecologically approximate forest restoration in a way appropriate for forest reserve lands. Under the agroforestry system, community members have been: (1) provided with tree seedlings, training in reforestation and tree care, and tools, and (2) given access to forest reserve land on which they could plant trees, grow crops until the canopy closed, and receive a share of later economic benefits. While economic benefits would typically come from timber harvest, payments for carbon sequestered in the plantations may offer another line of benefits. We know of no published papers on community-based carbon sequestration and monitoring efforts in rural communities like these. Sandker et al. (2010) used a participatory modeling approach to analyze possible tradeoffs and landowner decision-making in a cacao growing region of southwestern Ghana. Our cases differed from the one modeled in being public—private collaboration, with payments to community members being made for carbon sequestered in forest plantations established on government lands inside of forest reserves.

Methods for Community Assessment

In conjunction with work to develop measurement techniques for community-based carbon-monitoring (Stanturf et al., 2010), we developed and tested a rapid appraisal approach for assessing opportunities and capacity for community-based forest carbon sequestration and monitoring in forest restoration projects in Ghana. Our work focused on two critical areas: (1) an assessment of how forest restoration fits into community land use and household economic strategies, and (2) and assessment of community technical and institutional capacity for forest carbon monitoring. A team of two US Forest Service and three FORIG scientists worked in three villages bordering two forest reserves to assess the capacity of local communities to monitor forest carbon stocks and assess the role that payments carbon sequestration can play in land use decisions and local economies. The communities had all been involved in FORIG's projects on restoring degraded forest reserve land through local benefit-sharing, although only some members of each community participated.

In each community we convened a group of diverse and representative community members, with due consideration to age, gender, and income diversity, and including both participants and non-participants in FORIG projects. We began with a series of activities drawn from Participatory Rural Appraisal toolkits (WRI, 1991) to clarify community and household livelihood strategies, land use, forest uses and values, and social institutions. We then conducted individual and focus group interviews to address specific questions about forest use, agroforestry, forest values, climate change, and carbon monitoring. All work took place in local languages, with on-site translation.

Results and Discussion

All communities were immediately adjacent to Forest Reserves. Reserve vegetation in all cases was very degraded and presently dominated by grass and/or ferns and subject to endemic bush fires. Hunting and gathering of forest products took place on both Reserve and adjacent private lands. Each of the communities involved grew a different cash crop—shade grown cocoa, palm products, and cassava. These cash

crops led to differences in the spatial arrangements of trees into cropping systems on private lands, and also in the use of trees. Trees were often better cared for on private lands than in reserves, suggesting that forest care is associated with receipt of direct benefits from trees. Because communities had insufficient land of their own, agroforests on forest reserve lands provided critical access to land for crops and forest products. Communities differed in access to crop land, and those with less community land had more interest in collaborative projects that provided access to additional land. Communities also had very different levels of economic status, education, community organization, and social cohesion and trust. The latter, in particular, was an important determinate of desired institutional arrangements for future projects. Members within the community varied in their knowledge of climate change and carbon sequestration, but all expressed interest in hypothetical projects in these areas.

A carefully followed and evaluated pilot project of carbon sequestration payments may be the best way to learn exactly how people will respond to opportunities to participate in carbon sequestration and monitoring activities. Our work suggests several factors that should be borne in mind when designing such projects.

First, a steady stream of benefits is important to maintain community involvement and care of forest plantations over time. The greatest benefits of the modified taungya system are in the initial 2 or 3 year cropping phase. Limited access to crop land correlated with high interest in agroforestry suggested that access to crop land was one of the prime motivations for communities to participate in agroforestry projects. People were able to list many mid- and long-term benefits of reforested areas, such as the provision of non-timber forest products and environmental services, but discussions suggested that these forest uses made only small contributions to local livelihoods. We suggest that maintaining interest in and protection of forests is more likely to be sustained if: (1) projects continue to provide opportunities for local people to establish new agroforestry plots, thereby maintaining critically important short-term food cropping opportunities; (2) long-term economic benefits from trees, including both timber harvesting and carbon sequestration, are formalized and agreed upon at the beginning of the project; (3) direct mid-term benefits are provided through collection of non-timber forest products and game, enhanced where possible by projects to enrich agroforests with these products.

Second, there was clear and strong interest among local people for receiving payments for carbon stored in agroforestry plantations as a potential source of income to supplement other sources of scarce cash income. We currently have no estimates of what these payments might amount to and could not provide any estimates to interviewees in the communities, but at least in the short run the amount will probably be modest and may be below expectations. Payments in the longer term may be higher, particularly with further development of the REDD process, implementation of a climate agreement, and/or further development of carbon markets. Sandker et al. (2010)'s modeling suggests that the opportunity costs of conserving forests instead of growing crops, may lead people to drop of carbon payment programs over time. It is important that payments for carbon storage be integrated into a comprehensive package of short-, mid-, and long-term benefits from forests that includes continual expansion of agroforestry to restore forest reserves. The carbon payments are likely to start accruing in the mid-term, a time where there

are at present few cash benefits from the forest plantations. While carbon payments may be low they will be more likely to influence behavior if they fill the gap between short- and long-term benefits derived from agroforestry.

Third, processes for benefit payments need to be developed with input from local communities. Community members felt that benefits should go to the individuals who planted and cared for the trees, not to the community at large. They stressed the need for written agreements that clearly specify the rights which actively engaged participants have to payments related to trees they have planted and protected. In the planning stage it will also be important to clarify the permitted uses of the forest and to know how various uses affect carbon stocks. In particular, knowledge and rules are needed about the relationship between economic benefits from timber harvesting and carbon payments and the relationship or impact of harvest of firewood and other subsistence products to carbon storage and related payments. We found great variation among local institutions and, particularly, in trust in these institutions and in the individuals who played major roles in running them. Because trust may be low, a fair and transparent disbursement process that is agreed to by participants, is crucial for success.

Fourth, although there were varying overall levels of education in the communities we visited, all communities had some literate individuals capable of carrying out the forest measurement work and record keeping. Community-based monitoring must use simple and streamlined measurement processes and record keeping, and training, technical assistance, and auditing will be required before and during the process, suggesting an important collaborative role for NGOs and research institutes such as FORIG.

Finally, appropriate institution building to control wildfires in and adjacent to reserves will be required. All communities involved reported the occurrence of frequent wildfires originating in part from fires set by hunters and shifting cultivators. Community members had low levels of participation in existing Forestry Commission fire protection efforts and community forest committees. Enhancing the benefits that people receive from forests adds an incentive for participation in such activities, but specific institution building programs oriented around forest care and restoration will also be necessary.

Literature Cited

Appiah, M., Blay, D., Damnyag, L., Dwomoh, F., Pappinen, A, Luukkanen, O. 2009. Dependence on forest resources and tropical deforestation in Ghana. *Environment Development and Sustainability* 11: 471-487.

Blay, D., Appiah, M., Damnyag, L., Dwomoh, F.K., Luukkanen, O., Pappinen, A. 2008. Involving local farmers in rehabilitation of degraded tropical forests: some lessons from Ghana. *Environment Development and Sustainability* 10: 503-518.

Patenaude, G., Milne, R., Dawson, T.P. 2005. Synthesis of remote sensing approaches for forest carbon estimation: reporting to the Kyoto Protocol. *Environmental Science and Policy* 8: 1261-178.

Sandker, M., Nyame, S.K., Föster, J., Collier, N., Shepherd, G., Yeboah, D., Blass, D.E., Machwitz, M., Vaatainen, S., Garedew, E., Etoga, G., Ehringhaus, C., Anati, J., Quarm, O.D.K., Campbell, B.M. 2010. REDD payments as incentive for reducing forest loss. *Conservation Letters.* 3: 114-121.

Stanturf, J., D. Blay, J. Schelhas, C. Johnson, and J. O'Brien. 2010. Community-Based Carbon Monitoring: a Pilot Project in Ghana. International Forestry Review 12 (5): 476-477. [Poster presented at the, XXIII IUFRO World Congress, Seoul, Republic of Korea, Aug 23-28, 2010]

WRI (World Resources Institute). 1991. Participatory Rural Appraisal Handbook. Washington, DC: World Resources Institute

FAO REGIONAL OFFICE FOR AFRICA

Climate change mitigation and REDD+ in Africa: Issues, options and challenges for REDD+ implementation

Edward Kilawe[1]

Climate change mitigation and adaptation strategies are being discussed at the global level, however, there are big gaps in terms of information between negotiators and those who will be highly impacted with the effects of climate change, notably, indigenous peoples, forest-dependent communities and other vulnerable groups, who are currently not very much present at the negotiating table. Most of the agreed issues are not necessarily conveying positions and interest of these affected groups. And some of the proposed strategies may not therefore be relevant to these groups, and may even harm them more than help them cope with the climate change.

However, a clear frame of understanding on climate change adaptation and mitigation activities have become a key priority for people in Africa region, as the world prepares to enter a new climate regime which is envisaged to come into place as the post- Kyoto protocol in 2012.

Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD) is a proposed environmental financial mechanism to simultaneously address forest conservation and climate change mitigation within the framework of sustainable development. Its concept is a key constituent of the UN climate change negotiations and is under rapid development as a new financial instrument to be part of the post-Kyoto climate agreement. The need to support efforts to reduce emissions from deforestation and forest degradation has been expressed at the highest political levels, such as the UN and the G8, and has been included in the United Nations Framework Conference on Climate Change's Bali Action Plan (2007). This Plan launched a process to negotiate a post-2012 regime, including possible financial incentives for forest-based climate change mitigation actions. In particular, efforts towards REDD+ have strongly emerged as a new approach that links two key environmental domains – the forest sector and climate change – within the development agenda. It refers to policy approaches and positive incentives to reducing emissions from deforestation and forest degradation in developing countries. More recently, REDD+ is the acronym used to also recognise conservation efforts, sustainable management of forests and enhancement of forest carbon stocks.

The UN-REDD Programme

A mechanism to catalyse REDD+ will involve complex institutional, financial, technical and development efforts, all in synergetic way. A UN collaborative programme towards REDD+, namely the UN-REDD Programme, was launched in 2008 as a partnership between FAO, UNDP and UNEP to support countries in their national REDD+ process and to enhance a global approach towards REDD+. The three agencies are to bring in together strong sense of collaboration, their convening power and expertise to the countries.

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The aim of the UN-REDD Programme is to support countries getting ready for an eventual REDD+ mechanism, generating the requisite transfer flow of resources to significantly reduce global emissions from deforestation and forest degradation. It intends to enhance in-country capacities, including policies and structured Carbon payment mechanisms, to create incentives that ensure actual, accurate, consistent, reliable and measurable emission reductions, while maintaining and improving the other ecosystem services that forests provide. In supporting national readiness, the UN-REDD Programme has three objective: (i) to assist developing countries to "get ready" to participate in a future REDD+ mechanism; (ii) to apply the Paris and Accra principles of country ownership and leadership in order to build confidence in the establishment of a REDD+ mechanism; and (iii) to be at the forefront of UN agency joint programming, in terms of delivering coordinated and harmonized support.

REDD+ readiness process

A REDD+ readiness process entails not just forestry issues, but equally requires a wide range of considerations and reforms in sectors such as governance, human rights, fiscal administration, productive sectors and the overall development framework of the country.

REDD+ readiness has six core components which are to be implemented in phases, including: Management of REDD+ readiness, Stakeholder participation, REDD+ implementation framework, National REDD Strategy development, Reference Scenario, and the National Carbon Monitoring Reporting and Verification (MRV) system (see Figure 1. below).

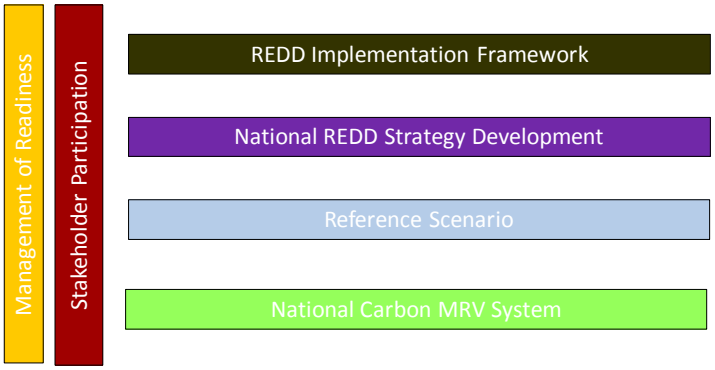
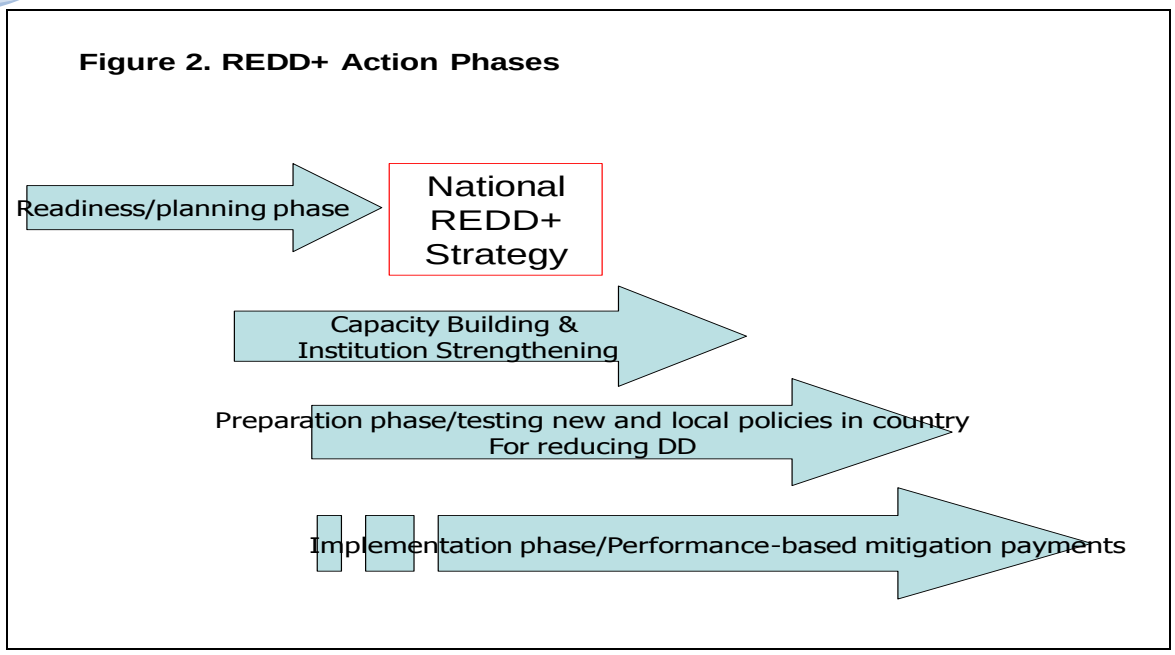


Figure 1. Internationally-agreed REDD readiness components

REDD+ implementation is envisaged through a phased approach (see Figure 2. below)in which a country first undertakes 'REDD+ readiness' preparatory activities. REDD+ readiness relates to the efforts a country undertakes, with the support of multilateral or bilateral initiatives, to build capacity to be ready for participation in a REDD+ mechanism. The second phase involves the implementation of national REDD+ strategies and measures, and the third phase involves payments (either funds, credits, or both) if and when a country can demonstrate actual emissions reductions (referred to as 'results or performance-based payments').Management of readiness and stakeholders participation will be implemented throughout the process.



Key principles to make implementation of REDD+ programmes effective

- There will be a need for strong awareness creation to mobilize opinions that will enable various groups to know their rights and benefits from REDD+ schemes;
- Strong capacity building is required at all levels, to activists, politicians, foresters up to the communities to be able to engage effectively in the development and implementation of various REDD+ strategies;
- Consultation and outreach programmes have to be established and functioning, they should the core elements in the design and implementation of national REDD+ strategies;
- There is a need to ensure inclusiveness and representative institutional mechanisms, which should be developed only after adequate consultations with the concerned parties, including Indigenous Peoples, community forest groups and other civil society organizations;
- There will be also a need to ensure documents relating to the REDD+ processes are made accessible, avoid difficult jargons and are translated into community languages in order to make them community friendly.

Towards a REDD+ readiness process in Africa

Platforms for support:

- UN-REDD Programme

The UN-REDD Programme pilot countries are clearly committed to REDD+ and hence a potential for reduction of emission from deforestation and forest degradation. Although, countries are in different stage of formulation and implementation of their REDD+ programmes. The UN REDD programme has three pilot countries in the Africa region (Democratic Republic of Congo (DRC), Tanzania and Zambia) and six partner

countries (Congo, Central Africa Republic, Gabon, Kenya, Sudan and Nigeria). The pilot countries have received a funding between USD 4-6 millions for their readiness programmes. DRC and Tanzania have made some significant progress with their programme implementation and Zambia has just launched their programme. Nigeria, Central African Republic and Congo have initiated their process with their own funding and from other funding sources but they also benefit from information and experience generated from pilot countries as well as technical assistance from the UN REDD programme.

- Forest Carbon Partnership Facility

Hosted at the World Bank, the Forest Carbon Partnership Facility (FCPF) aims to provide a framework for piloting activities to reduce emissions from deforestation and forest degradation. It supports developing countries in their initiatives on REDD+ implementation. The FCPF has the dual objectives of building capacity for REDDplus in developing countries in tropical and subtropical regions, and testing a program of performance-based incentive payments in some pilot countries, on a relatively small scale, in order to set the stage for a much larger system of positive incentives and financing flows in the future.

FCPF has so far 37 participating countries, with 14 countries (November 2010) from Africa participating to the readiness. These include Cameroon, Central Africa Republic, Democratic Republic of Congo, Congo Republic, Equatorial Guinea, Ethiopia, Gabon, Ghana, Kenya, Liberia, Madagascar, Mozambique, Tanzania and Uganda. Some countries have received direct support for readiness fund for REDD+ preparation and some received support from the investment fund, and a few participating countries are there only for sharing experience among REDD+ countries.

FCPF consists of two funds, namely, 1) the Readiness Fund, which provides assistance to build countries' capacities and structures for REDD+ implementation; and 2) the Carbon Fund, which finances emission reduction activities once the readiness phase is finished.

World Bank also hosts a Forest Investment Programme which currently is piloted in eight countries around the globe, with two countries from Africa (Burkina Faso and Ghana). It aims in supporting developing countries in ongoing forest initiatives and strengthen efforts already identified at the national level.

- Other processes for supporting REDD+ Readiness

There are moreover programmes in the Africa region implemented through bilateral support and private financing, which also support REDD+ readiness effort in countries, provide training, advocating solutions to key policy and financing challenges for REDD+ and build broad stakeholders support for REDD+ policies. These include initiatives led by Norway's Forest and Climate Initiative, International Forest Carbon, Congo Basin Forest Fund, Clinton Foundation, Conservation International, The Nature Conservancy, World Wildlife Fund, Wildlife Conservation Society and other actions from international and national non- governmental organizations.

REDD+ has received widespread support from the international community and was recognised in the Copenhagen Accord as having a crucial role to play in climate change mitigation. To date ten countries have pledged over US $ 5 billion to 'fast track' REDD+, although the mechanism for delivering this funding has yet to be agreed. In absence of official Fund mechniasm for REDD under convection some developed countries had championed REDD+ Partnership which so far has more than 60 countries subscribed to it. Its aim is to mobilize and fast tracking financial resources so as to scale up REDD+ activities in developing countries.

Challenges ahead

There are many challenges for possible REDD+ implementation:

- There is a need to demonstrate that REDD+ funds will not flow to the most egregious deforesters, which may create an incentive for others to take up their chainsaws and chop down forests.
- It is also debated whether the REDD+ mechanism will create the right incentives and attracts the necessary resources to address ongoing obstacles to equitable and sustainable forest management.
- Low awareness and understanding about REDD+ among local communities and other sub-national stakeholders (e.g. local government) could provide challenges for implementation.
- Unclear and disputed land tenure rights in many countries could likely result in conflict and mistrust among government and other actors; this could be more exacerbated by a lack of clarity over rights to trees and carbon.
- Corruption – there is much fear that local-level benefit capture by secondary stakeholders (e.g. local government, forestry officials, and local elites).
- Institutionalizing and governance. It is going to be a great challenge in reforming weak institutions in many developing countries. For example, land-use planning for oil palm or jatropha cultivation might involve not only the ministry of forestry but also those of agriculture, finance, energy and infrastructure as well as the army and the police. All have their own priorities, and saving trees is not among them.

In order to allay some of these fears there is need to develop REDD+ programme with early actions through:

- Building awareness and raise understanding among communities and in some cases local governments, in order to participate effectively in REDD+ planning and decision-making.
- Working with communities to develop the skills that will enable them to benefit from REDD+ (e.g. SFM, MRV/carbon accounting, benefit sharing, etc).
- Advocating to stakeholders to encourage their engagement in both planning and decision making.

Conclusion

While there is now substantial support for REDD+ from donor countries, many issues remain unsettled, partly due to inconclusiveness of ongoing discussions and

negotiations for Post-Kyoto mechanism and broadly implementation and testing of REDD+ have not much occurred on the ground. Scale, location, and timing of REDD+ emission reductions will vary by country conditions. However, for REDD+ to be sustainable mechanism, it will have to be more than life support for the rainforest. It should provide ways for tropical countries to develop growth strategies that do not involve deforestation. Its success will also rely on rigorous carbon accounting and monitoring to ensure forests remain intact, are rehabilitated and lock away CO2. Hence a strong national REDD MRV system is required to be put in place. Such accounting steps will underpin the value of the carbon offsets that will be the currency of REDD+ projects, with governments and companies from developed world buying the credits to the benefit of local communities in poorer nations.

Therefore, REDD+ needs to encourage both national and local conservation efforts. That might mean letting local governments choose from a range of nationally approved conservation measures. The details have yet to be worked out, but some promising experiments have already been launched in countries where pilot activities are currently underway.

There is a need to equitably provide adequate ‘‘readiness’’ funding to the range of countries interested in participating in REDD+. Prior to large-scale REDD+ development, there is also the need to ensure that there will be reliable and adequate resources to compensate countries for their future emissions reductions. Just as participating forested countries must deliver emissions reductions, Annex I nations should be able to deliver promised payments.

There is thus a need for coordination among the various REDD+ funding mechanisms to ensure that a common approach is taken and double-counting does not occur. It should be noted that the two main multilateral platforms for REDD+, i.e. the FCPF and the UN-REDD Programme, have developed good coordination backed by a high level of commitment.

It should be noted that a future REDD+ mechanism ‘‘may not be everything to everyone,’’ though there is a great potential for many developing countries to participate including those with low forest cover but in principle they will stand to benefit more from ‘hidden’ non-carbon benefits and protection of their remaining forest resources than it would have been without any action.

References

Angelsen, A. (2009): Realizing REDD+ National Strategy and Policy Options, CIFOR, Bogor Indonesia.

FAO Global Forest Resources Assessment (FRA). Main report. 2010. http://www.fao.org/forestry/fra/fra2010/en/

IPCC 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme. Ed. Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T. and Tanabe, K. (Japan: Institute For Global Environmental Strategies)

UNFCCC, 2009c. Draft decision -/CP.15: Proposal by the President. Copenhagen Accord. (FCCC/CP/2009/L.7), United Nations Framework Convention on Climate Change (UNFCCC), Geneva, Switzerland.

UN REDD Programme web site, http://www.un-redd.org/

FCPF web site, http://www.forestcarbonpartnership.org/

September 2010 (The Economist). Better REDD than dead: Tropical forests' best hope, http://www.economist.com/node/17062737

May 2010, Oslo Climate and Forest Conference: REDD financing and activities survey report
http://www.oslocfc2010.no/pop.cfm?FuseAction=Doc&pAction=View&pDocumentId=24922
November 2010, A Preliminary Assessment report of the Context for REDD+ in Nigeria, prepared by Macarthy Oyebo, Francis Bisong and Tunde Morakinyo
http://www.unredd.net/index.php?option=com_docman&task=doc_download&gid=4129&Itemid=53

FAO REGIONAL OFFICE FOR AFRICA

The role of agriculture and natural resources in the Post 2012 climate change regime: Enhanced call for adaptation in Africa

Alemneh Dejene[1] and Meshack Malo[2]

Summary

The impact of climate change threatens the progress made over recent years in reaching the Millennium Development Goals in many parts of Africa. The Intergovernmental Panel on Climate Change (IPCC) reiterated that Africa will be hard hit by climate change with serious effects on the agricultural and natural resources sector where the majority of the population derive their livelihood. Without immediate steps to adapt to climate change, there will be grave implications for agriculture and food security. African governments are placing top priority on adaptation while at the same time recognizing the need for mitigation to lessen the extent of long-term adaptation. This paper focused on the role of agriculture and natural resources in the post- 2012 climate change regime outlining that the desired increase in food productivity and strengthening of the resilience of the food production system would entail two simultaneous steps. First, improved input and service systems, and secondly, protection of the natural resource base. Therefore, any increase in investment in both adaptation and mitigation in Africa must be accompanied by an increase in agricultural development and natural resources management to strengthen the capacity of the most vulnerable people and communities who live in highly degraded environments. This win-win option in agriculture and natural resources management could be one of the preferred outcomes for African countries at the COP 16 meeting in Cancun, Mexico as well as the post-2012 climate regimes.

The impact of climate change is manifested in extreme weather and variability causing disruption of food production systems, water supplies, reduced incomes, home and ,property damage and even loss of life. The recently published Intergovernmental Panel on Climate Change Report (IPCC, 2007) unequivocally concludes that there is "very high confidence" that increased emissions of Greenhouse Gases (GHG) are of human origin.[3] Least Developed Countries (LDC), of which a significant number are in Africa, are most vulnerable to these impacts and bear the highest risks to their socio-economic development.

Climate change and related variability now stand to jeopardize some of the progress made over recent years in overcoming hunger, poverty reduction and attainment of the broad Millennium Development Goals (MDG's) in many parts of Africa. The Intergovernmental Panel on Climate Change (IPCC) Reports focuses on Africa as one of the regions that will be hardest hit by the impact of climate change. It points out that agricultural production, food security (including access to food) and development plans in many African countries could be severely affected by climate change and

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[3] IPCC (2007). "Climate Change 2007, the Fourth Assessment Report. Volume 1.

variability. . As an example of what we should expect, studies by McKinsey & Co. and Project Catalyst have shown that by 2030, 85 percent of the world's population (including all of Africa) is expected to suffer from water scarcity. [1]

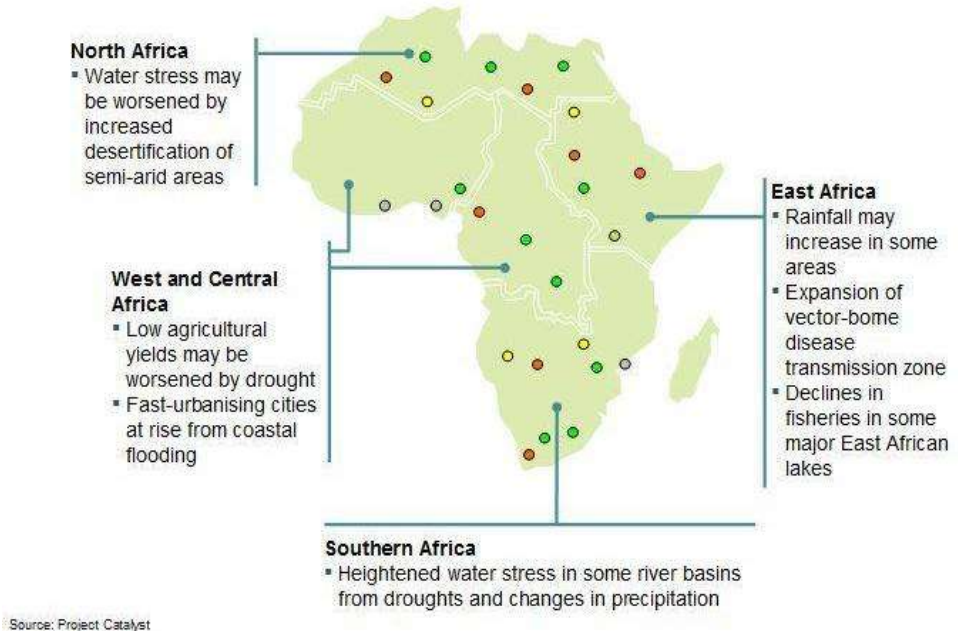

Figure 1: Highlights some of predicted impacts of climate change in various regions of Africa.[2]

It is estimated that about 65 percent of Africa's population and an area of about 16.1 million km^2 are currently affected by land degradation. The rate of agricultural production is reduced by 3 percent per annum. In addition, at least 4 million tons of nutrients are removed in harvested produce compared to the 1 million tons returned to the soil in the form of manure and fertilizers, thereby affecting soil fertility.[3]

The degradation of land and natural resources is a serious impediment to attaining food security and sustainable agriculture in many parts of Africa. The recent FAO regional conference for Africa (Luanda Angola, 3-7 May 2010) that focused on the impact of climate change on poverty reduction and food security warned that business as usual was no longer an option and urged African governments to prioritize and implement measures to develop agriculture and promote the sustainable use and management of natural resources. It noted that climate change will exacerbate existing vulnerabilities to land degradation, floods and drought and will challenge farmers and communities to make changes to production systems and protect natural assets.

The desired increase in food productivity and strengthening the resilience of the food production system would entail two simultaneous steps: improved input systems

[1] Studies by McKinsey and Co. and Project Catalyst, 2009: Presented by Edward S. Ayensu at the UNESCO International Conference on Broadcast media and Climate Change. Paris, France
[2] Ibidem (Footnote 2).
[3] Challenges for Sustainable Land Management (SLM) for Food Security in Africa. 25th Regional Conference for Africa, Nairobi Kenya, Information Paper 5.

(seeds, fertilizers etc) and protection of the natural resource base. Sustainable land, water and forest management strategies and practices stand to enable farmers and communities to become more resilient to climate change by increasing food production, conserving soil and water, enhancing food security and restoring productive natural resources. Integrated land and water management can prevent land degradation, restore degraded lands, and reduce the need for further conversion of natural forests and grasslands. Land users can reduce GHG emissions and maintain carbon stocks in soil and vegetation at relatively low cost, while also improving food production and securing livelihoods.

Enhanced call on adaptation and financing agriculture and natural resources management

The Copenhagen Accord (COP-15, 2009), though not binding on any country, stressed the need to establish a comprehensive adaptation programme (including international support) and agreed that developed countries shall provide adequate, predictable and sustainable financial resources, technology and capacity building to support adaptation action (aimed at reducing vulnerability and building resilience) in developing countries, especially LDCs, Small Island Developing States (SIDS) and Africa. Developed countries pledged to provide new and additional resources, including for forestry and investments through international institutions, approaching US$30 billion for the period 2010-2012 (fast track), with balanced allocation for adaptation and mitigation.

Following the meeting (COP-15), there is also now greater recognition that post-Kyoto regimes (2012) should provide increased resources and commitment to climate change adaptation. Delaying adaptation would be costly as indicated in the Stern Report. [1] This also means that post-2012 climate financing regimes should recognize the eligibility of carbon sinks beyond forest, to include all land-use systems (i.e. cropland, rangeland, forest land, agricultural soils, good agricultural practices, improved land and water management practices, watershed management, restoration of degraded land and agroforestry practices). Adaptation will enable agricultural systems to be more resilient to the consequences of climate change. Mitigation addresses its root causes, and, over time, limits the extent and cost of adaptation, as well as the onset of catastrophic changes. It is <u>not</u> a debate of "either/or" mitigation or adaptation, but priority focus-based on regions.

Therefore, in the African and Least Developed Country context, an integral part of addressing overall development includes climate change adaptation considerations. Integrating adaptation with development planning and actions can exploit the synergies to advance both adaptation and development goals. For example, a number of agricultural management practices capture carbon from the atmosphere and store it in agricultural soils. These practices increase soil organic matter, which in turn increases fertility, water retention and the structure of soils, leading to better yields and greater resilience.

[1] Stern, N. (2007) *The Economics of Climate Change: the Stern Review*. Cambridge University Press, Cambridge, UK.

Without adaptation, the impact of climate change on agriculture and food security will be high. This issues is at the core of the current African climate negotiation, and African governments are placing top priority to adaptation while at the same time recognizing the need for mitigation to lessen the extent of long-term adaptation. Adaptation efforts encouragingly can also be crafted serve mitigation objectives. The combination of technologies that prove best at combining benefits which are also economically affordable and accessible can be described as "Climate- smart agricultural practices/ technologies".

FAO supports the development and dissemination of such innovative technologies with synergies to both adaptation and mitigation. Some of the FAO activities include:

- promoting breeding of trees, crops and livestock and fish adapted to changed climate conditions;
- improving the adaptive capacity of production and management system, including alternative cropping, conservation agriculture, precision agriculture, organic agriculture, sustainable forest management, and post-harvesting methods;
- identifying technologies for efficient use of inputs (energy, fertilizer, seed and integrated pest management) and waste;
- identifying and promoting improved soil and water management and irrigation systems;
- strengthening capacity for climate information and early warning systems;
- developing strategies for disseminating new technologies and innovation, such as through NGOs networks, farmer field schools and extension services.

With appropriate research, planning and financial support, agriculture, forestry and natural resources sectors can offer cost-effective adaptation mitigation options with essential benefits for improving food security, livelihood and sustainable development (win-win options). Years of experience in African fields have generated *a sound knowledge base on practices, techniques and technologies for improving farming systems* in a way that supports food security and development. Incentives, policy approaches and institutional mechanisms, including adequate financing, technology and capacity-building support to enable the adoption of climate-smart agricultural practices and techniques, could make agriculture a significant part of the solution to the interdependent challenges of climate change and food security in the context of continuing economic development.

Under the UNFCC negotiating process for post-2012 regime, adaptation was identified as one of the five key building blocks (shared vision, mitigation, adaptation, finance and technology) of a future climate change deal. Although countries have made progress in defining a comprehensive framework for strengthened action on adaptation that is capable of addressing the needs of developing countries for scaled-up, financial, technology and capacity-building[1] support has been lacking and major breakthrough is needed at COP-16.

[1] text from UNFCCC website - http://unfccc.int/press/fact_sheets/items/4985.php

Thus, any increase in investment in both adaptation and mitigation in Africa must be accompanied by an increase in agricultural development and natural resources management that will strengthen the capacity of the most vulnerable people and communities who live in highly degraded environments. Africa must look into actions that will catalyze and embark on nationally-appropriate synergetic innovation and practices in adaptation and mitigation (as highlighted above) that will contribute to climate resilient growth in agriculture. This win-win options in agriculture and natural resources management could be one of the preferred outcome for African countries at the COP 16 meeting in Cancun, Mexico (December 2010) as well as the post-2012 climate regimes.

References

Challenges for Sustainable Land Management (SLM) for Food Security in Africa. 25th Regional Conference for Africa, Nairobi Kenya, Information Paper 5.

IPCC (2007). "Climate Change 2007, the Fourth Assessment Report. Volume 1.

McKinsey and Co. and Project Catalyst, 2009: Presented by Edward S. Ayensu at the UNESCO International Conference on Broadcast media and Climate Change. Paris, France

Stern, N. (2007) The Economics of Climate Change: the Stern Review. Cambridge University Press, Cambridge, UK.

UNFCCC website - http://unfccc.int/press/fact_sheets/items/4985.php

FAO REGIONAL OFFICE FOR AFRICA

Central Africa is not only carbon stock: Preliminary efforts to promote adaptation to climate change for forest and communities in Congo Basin.

Denis J. Sonwa[1] , Youssoufa M. Bele[2] , Olufunso A. Somorin[3] and Johnson Nkem[4]

Summary:
In Central Africa, REDD+ (Reduced Emissions from Deforestation and Forest Degradation and conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries) is receiving political attention with the support of the international community who have interest in conserving biodiversity and maintaining carbon stocks. However, adaptation which is closely related to development and which seems to be priority for vulnerable societies, is not receiving the same level of attention in the region. By giving political priority to REDD+ projects and other mitigation approaches, national efforts at adaptation may become weakened. In this paper, the authors, (1) present the state of the forests of the Congo Basin and give a very brief summary of efforts to combat climate change; and (2) highlight some preliminary efforts of the Center for International Forestry Research (CIFOR) and partners aimed at improving adaptation to climate change of forest and forest dwelling communities in countries of the Congo Basin.

The international community is looking for solutions to combat climate change, mainly by focusing on reducing the emission of greenhouse gases (GHGs) and also by developing strategies for adaptation. Emphasis is on mitigation, which tackles the source of the problem. Recently, there has been a call to include emission reductions from deforestation and forest degradation in many developing countries through the REDD+ mechanism. This offers opportunities to developing countries to contribute to global mitigation efforts. The other set of strategies, which is centered on adaptation, has not attracted as much political attention as the mitigation option. Adaptation consists of developing strategies to cope with the impacts of climate variability and change. It aims to reduce the vulnerabilities of human populations and ecosystems exposed to climate variability and change. Developing countries are generally the

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most vulnerable to climate change due to their poverty, poor infrastructure, weak governance, amongst others (IPCC, 2007).

Adaptation strategies are closer to development and this present more legitimacy for development than mitigation, especially in many developing countries contexts (Kok et al., 2008). In the Congo Basin region, the perceived risks is that by giving political priority to REDD+ projects and other mitigation approaches, national efforts on adaptation may become weakened. The consequence would be exposure of local poor communities to negative impacts of climate variability and change. The aim of this article is to (1) present the state of the forests of the Congo Basin and give a rapid summary of efforts to combat climate change, and (2) highlight some preliminary efforts of the Center for International Forestry Research (CIFOR) and partners aimed at improving adaptation to climate change of forest and forest dwelling communities in countries in the region.

Congo Basin forests and Climate Change

The Congo Basin forest covers more than 40% of the total land area of the six countries in the basin: Cameroon, Central Africa Republic (CAR), Democratic Republic of Congo (DRC), Equatorial Guinea, Gabon and Republic of Congo. The population of the six countries was estimated at 86.11 millions in 2005 and is projected to reach 100 million inhabitants in 2010. Poverty is common in this part of the world, especially in the rural communities. Agriculture remains the primary activity and pre-occupation of the people, and practices such as slash and burn, shifting cultivations have continued to contribute to forest loss. In Cameroon for example, close to 30% of its GDP comes from agriculture (Molua, 2008).

The Congo basin is known to be rich in biodiversity, and this has stimulated the interest and willingness of the international community to conserve this vast diversity of endemic plant and animal species (Kamdem et al. 2006). Protected areas are established and currently countries like CAR, Cameroon and Equatorial Guinea have more than 20% of their national territory in protected areas (IUCN Category 1-6), while others like Congo and DRC have designated around 10% of their land as protected areas. Some of the protected areas have also been recognized as UNESCO-World Heritage (*Patrimoine Mondial de l'Humanité*) (White and Vande Weghe, 2008). Beside these protected areas, sustainable forest management has continued to be promoted as a means of protecting the forest as well as improving the livelihoods of people that depend directly on these forests (Nasi et al. 2006).

From 1990 to 2000, the annual deforestation rate has been reported to rise from 0.17% (Nasi et al. 2009) to 0.38% (FAO, 2005). With climate change increasingly taking centre stage in the international agenda, it is becoming more apparent now that the Congo Basin forest is receiving a renewed interest in terms of the amount of carbon they have stored in the vegetation (Brown et al., 2010). It is estimated that 46 billions of carbon stock are stored in forest of the Congo Basin (Nasi et al. 2009). As efforts continue to be put in place to protect these current carbon stocks through many management systems, it is fast becoming the norm to reduce present and future deforestation and degradation, and if possible, increase future carbon stocks through afforestation and reforestation.

The forest and community of the Central Africa are exposed to climate change. In Cameroon for example, temperature had increased by 0.7 ^{0}C since 1960 and the number of hot nights per year had increased by 79 (an additional 21.7% of night) between 1960 and 2003 (McSweeney al. 2009). Annual precipitations have decreased by 2.9 mm/month between 1960 and 2003. The projection gives 1.0 to 2.9 degree for temperature and -12 to +20mm per month (-8 to +17%) by the 2090s for rainfall change (McSweeney et al. 2009). Forest and communities are sensitive and vulnerable to climate change and variability. National reports submitted to the UNFCCC by the countries in the region point out vulnerabilities of the countries due to factors varying from poverty, political instability, civil wars and unsustainable forest management practices (Bele et al., 2010). A recent study shows that forests in Africa are sensitive to green house gases increase which has a resultant effect on the carbon stock of these forests (Lewis et al. 2009).. The economy of a country like Cameroon is heavily linked to climate: An increase of 3.5% in temperature and 4.5% precipitation without irrigation facilities will lead to a loss of 46.7% in output value (Molua, 2008).

The countries of Central Africa have different stages of development and implementation of climate change adaptation strategies. Cameroon currently has produced only one report or position statement on climate change, while DRC and CAR have already developed a National Adaptation Program of Actions (NAPA). In the case of Cameroon, 2 main areas, the northern part and the mangrove were seen as highly vulnerable and should be given more attention. Although several countries of the region received funding to support NAPA development, only DRC was able to receive implementation fund (Ecosecurities, 2009). Some countries have received funding to support capacity building of government so that they can include adaptation into national policies. Some countries like DRC and Gabon were able to present some detailed adaptation but this has not been the case with Cameroon and Congo. These Adaptations are not necessarily taking forest in consideration and also fail to consider forest as tools for adaptation despite the importance of forest for livelihood of communities in these countries. Central Africa potentially has the opportunity to use reforestation and aforestation as adaptation and attenuation (Ecosecurities, 2009). Scientific literature is gradually showing the linkage between forest and adaptation. Linkage between forest and adaptation is not yet common in Central Africa Region. The following section describes how CIFOR and partners are making this become a reality in Congo Basin.

Promoting climate change adaptation for forest and communities

With the vulnerability of forest and community of Central Africa, it is thus evident that there is a need to develop strategies for adaptation in this part of the world. Based on the previous experiences in tropical forests including those of West Africa, the Congo Basin Forests and Climate Change Adaptation in Central Africa (CoFCCA) project was developed (Sonwa et al. 2009). The aim was to mainstream climate change in forest policies and forest into climate change policies. Prior to the development of the project, a meeting was organized in 2007 with the aim of brainstorming on the topic. The project is funded by IDRC and implemented in 3 countries: Cameroon, CAR and DRC. The science-policy dialogue is one of the main approaches used in the project. The first dialogue was organized during the kick off meeting of the project in 2008, the

emphasis was on identifying sectors considered to be sensitive to climate change by the stakeholders. Sectors were prioritized for each country. This activity constituted in fact the entry point for future research and development activities on forest and adaptation to climate change in the region.

One of the main challenges is to bring different stakeholders together and develop methodologies for vulnerability assessment and development of adaptation strategies. For the policy dialogue, we used group discussion. For activities at the local level, a workshop with different scientists from different backgrounds and different parts of the world (experience of sub-Saharan Africa and Southern America) was organized. Participatory Action Research (PAR) approach was adapted for the forest context and climate change. The authors through the project are also trying to understand the institutional aspects that can enhance mainstreaming of Adaptation at the regional, national or local level (Brown et al 2010; Nkem et al. 2010; Bele et al. 2010). In conjunction with the Meteorological Office in the United Kingdom and colleagues from West Africa, the authors are using the PRECIS (Providing REgional Climates for Impacts Studies) model (**http://precis.metoffice.com/**) to generate climate change projections for the Congo Basin.

In order to assess vulnerability of communities in each of the sectors that came out of the science policy dialogue, a number of tools including household surveys, GIS, etc were used by students selected within the project. In all, more than 15 students from different relevant disciplines are currently doing their research through fellowships within the project. The project is currently providing internships to communication students to get them used to the terminology of climate change especially forest and climate change adaptation. At the local level, after the vulnerability assessment by communities, they propose some adaptation strategies. Negotiations with different stakeholders helped in initiating some pilot adaptation strategies that will help in the future to explain how adaptation for communities can look like in forest zone. At the moment, these activities are implemented in 6 sites (including 2 biodiversity landscape) of the region. Working in those landscapes help to link adaptation to climate change with other activities of the landscape (such as biodiversity conservation and poverty alleviation). The project is making effort to understand the general contexts of local livelihoods and rural development and the process of mainstreaming adaptation to climate change agenda. From the experience in implementing this project, the CIFOR team has acquired new funding from African Development Bank (AfDB) to work on synergies between mitigation and adaptation. This newly funded project will be useful in generating information that is critical to promoting adaptation and mitigation in the Congo Basin.

Conclusion.

Central Africa countries are vulnerable because of their weak infrastructural and economic development. Although they represent an important carbon stock, especially in the Congo Basin, where the international community is trying to protect and avoid the emission of greenhouse gases through the REDD+ mechanism, significant percentage of the population is still living in poverty. Those conditions could be worse with the advent of climate variability and change. But the international community is putting emphasis on REDD+. This holds the potentials to allow not only

an increase of carbon storage but could also contribute to the conservation of biodiversity. Adaptation which is also one of the important components of the fight against climate change has not received the same level of attention as REDD+ in Central Africa. Adaptation is more closely related to development and thus offers certain legitimate opportunities for populations in alleviating their poverty and vulnerability to climate change/variability. Failing to take into consideration poverty and vulnerability will lead to more pressure on carbon stock and biodiversity. There is thus a need to consider not only protection of carbon pool, but also to take care of the plights of poor populations of these countries. The efforts by CIFOR and partners currently aim at mainstreaming climate change in forest policies and also mainstreaming forest in climate change policies. Other related activities are concerned with science-policy dialogue, institutional studies (at the regional, national and local levels), pilot adaptation strategies, climate change projections, and capacity building, to name a few.... These efforts are still at the early stage but it is hoped that they will help to foster and boost activities on adaptation of forest and communities to climate change.

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References.

Bele MY, Somorin OA, Sonwa DJ, Nkem JN and Locatelli B (2010). Forest and adaptation policies in Cameroon. Mitigation and Adaptation Strategies for Global Change. DOI 10.1007/s11027-010-9264-8

Brown, H. C. P.; Nkem, J. N.; Sonwa, D. J.; and Bele, M.Y. (2010). Institutional adaptive capacity and climate change response in the Congo Basin forests of Cameroon. Mitig Adapt Strateg Glob Change 15:263–282

Ecosecurities (2009). Gestion des terres et options de financement lies aux changements climatiques en Afrique centrale : activités d'atténuation et d'adaptation aux changements climatiques en afrique centrale et options pour améliorer l'accès aux financements liés aux changements climatiques et pertinents pour la ccd. Document de travail Mécanisme Mondial de l'UNCCD, Rome Italie. 89 pp.

FAO, 2005 State of the World's forest 2005. Food and Agriculture Organization of the United Nations, Rome.

Intergovernmental Panel on Climate Change (IPCC) (2007) Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge

Kamdem-Toham, A., D'Amico, J., Olson, D. M., Blom, A., Trowbridge, L., Burgess, N., Thieme, M., Abell, R., et al. (2006). A vision for biodiversity conservation in Central

Africa: biological priorities for conservation in the Guinean-Congolian forest and freshwater region. WWF. Washington, D.C

Kok, M., Metz, B., Verhagen, J., van Rooijen, S. (2008), 'Integrating development and climate policies: national and international benefits', Climate Policy 8(2), 103–118.

Lewis S.L., Lopez-Gonzalez G., Sonke B., Affum-Baffoe K., Baker T.R., Ojo L.O., Phillips O.L., Reitsma J.M., White L., Comiskey J.A., Djuikouo K.M., Ewango C.E., Feldpausch T.R., Hamilton A.C., Gloor M., Hart T., Hladik A., Lloyd J., Lovett J.C., Makana J.R., Malhi Y., Mbago F.M., Ndangalasi H.J., Peacock J., Peh K.S., Sheil D., Sunderland T., Swaine M.D., Taplin J., Taylor D., Thomas S.C., Votere R. & Woll H. (2009). Increasing carbon storage in intact African tropical forests. Nature, 457, 1003-6.

McSweeney, C., M. New, and G. Lizcano (2009). "UNDP Climate Change Country Profiles. Cameroon. 26 pp. School of Geography and Environment, University of Oxford. 26 pp. http://country-profiles.geog.ox.ac.uk/UNDP_reports/Cameroon/Cameroon.lowres.report.pdf

Molua E.L. (2008). Turning up the heat on African agriculture: The impact of climate change on Cameroon' agriculture African Journal of Agricultural and Resource Economics, 2008, 02, (1)

Nasi, R., B. Cassagne, A. Billand (2006). Forest management in Central Africa: where are we? International Forestry Review 8(1); 14-20

Nkem, J. Kalame, F.B. Idinoba, M. Somorin, O; Ndoye, O. & Awono, A. 2010. Shaping forest safety nets with markets: adaptation to climate change under changing roles of tropical forests in Congo Basin. Environmental Science & Policy 1 3: 498 – 508.

Sonwa, D., Bele, Y., Somorin, O. Jum, C. and Nkem, J. (2009). Adaptation for forests and dependent-communities in the Congo Basin: the CoFCCA experience. *ETRFN* News 50, 93-100

White L and Vande weghe J.P. (2008). Patrimoine mondial Naturel d'Afrique centrale Biens existants - Biens potentiels. Rapport de râtelier de Brazzaville du 12-1 4 mars 2008. Unesco –CAWHFI.

FAO REGIONAL OFFICE FOR AFRICA

West Africa : Confronting the challenges of climate change

Stéphane Jost[1] and Christophe Perret[2]

Summary
West Africa is an area prone to high climate variability. Even though it remains difficult to estimate, particularly regarding rainfall patterns, the impact of climate change on agriculture and livestock may increase the vulnerability of the sub-regions' fragile ecosystem. Faced with these challenges, farmers have already developed and should strengthen adaptation strategies and get involved in the debates and consultations on actions to take in order to alleviate or adapt to climate change[3].

Introduction

On the eve of the next meeting of the United Nations Framework Convention on Climate Change in Cancun, in December 2010, member countries are preparing negotiations with the hope of arriving at better results than during the last meeting of the Convention in Copenhagen in December 2009. The challenges facing Africa are tremendous. Indeed, the continent is considered as one of the regions the most vulnerable to the effects of climate change in view of the fragility of African countries economies. However, it is too early to assess the scope and nature of changes related to climate change on this continent.

Regarding temperatures evolution, climate models are relatively satisfactory to project predictable changes in Africa. The International Panel on Climate Change (IPCC) indicates that during the 21st century, climate warming should be more important in Africa than in the rest of the world. The increase in average temperature between 1980/99 and 2080/99 could reach between 3°C and 4°C across the continent, higher by half than at global level. This increase should be less important in coastal and equatorial areas (+3°C) and the highest in the western part of the Sahara (+4°C).

On the other hand, uncertainties remain over the results of projections regarding rainfall patterns, especially in West Africa. As is the case for the countries around the Mediterranean as a whole, North Africa could record a decline in rainfall. At the other end of the continent, Southern Africa could also experience less rainy winters and springs. In the tropical zone, the results of models show an increase of rainfall in East Africa and in the Horn of Africa.

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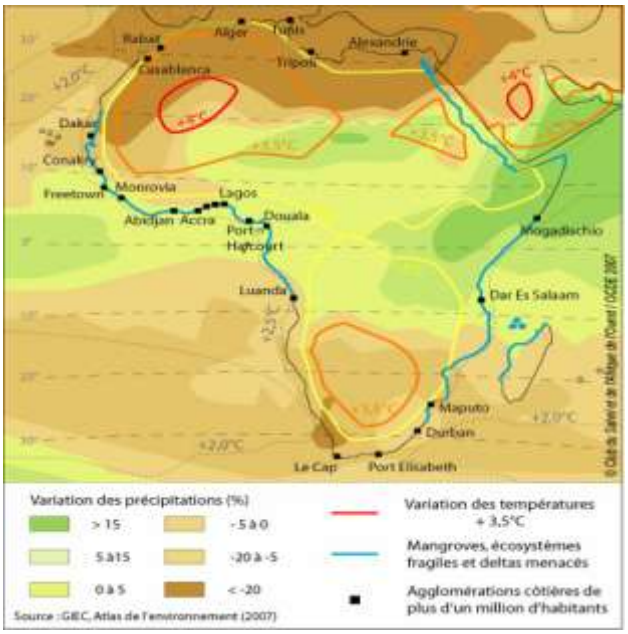
Climate change projections in Africa
2080/99 average compared to 1980/99

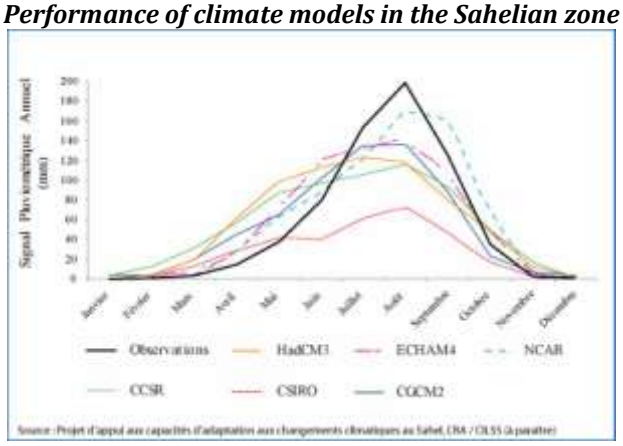


Uncertainties in rainfall projections

On the other hand, no clear conclusion could be arrived at regarding rainfall patterns in West Africa. During the second half of the 20th Century, West Africa experienced a marked decrease in rainfall with a clear break in the Sahel during the years 1968-1972. This phenomenon led to a climate desiccation process characterized by the great droughts of 1970 and 1980. But since the mid-1990's, there has been a return to better rainfall conditions in the Sahel region, notably in the East-Sahel (Niger, Northern Nigeria and Chad), but with a higher interannual rainfall variability.

In the long term, IPCC's projections do not enable drawing clear conclusions regarding rainfall patterns for West Africa. A simple average of the set of scenarios would lead to conclude that a slight humidification occurred in the Sahelian zone (mainly in the East) while the Guinean coast would not undergo any significant changes. Recent tests showed the limitations of General Circulation Models (GCM) in their ability to retranscribe the West African climate. The work of the African Centre of Meteorological Applications for Development (ACMAD) on West Africa, shows that the periods for the start of the rainy season in the models appear one to two months before the dates noted. According to the *Centre Régional Agrhymet* (CRA/CILSS), the comparison of the Sahelian climate observed (normal 1961-1990, black line in the graph) with climates simulated by six General Circulation Models recommended by IPCC (colored curves) also illustrates these weaknesses: projection of an advanced start of the rainy season and a significant underestimation of annual rainfall increments as compared to the data observed.

Performance of climate models in the Sahelian zone



The IPCC also acknowledges the limitations of research on extreme climate events. Climate changes are likely to increase the frequency and severity of floods and droughts in areas already prone to high rainfall variability. Were the great droughts of 1973 and 1984 in the Sahel already manifestations of climate changes? Whatever the case, the Sahel should face this climate challenge which is first and foremost a vulnerability and uncertainty challenge.

Climate, cereal agriculture and adaptation strategies of farmers in the Sahel

The challenges facing the agro-pastoral sector and food security are important for Sahelian countries: the farming population reaches 50 to 80% of the total population depending on the countries: the agro-pastoral sector contributes between 25 to 30% of their GDP; finally the consumption of cereals contributes between 80 and 85% of calorific needs of the population. In the past, Sahelian farmers showed that they could adapt to climate variability and uncertainty.

Cereal agriculture in the Sahel is mainly rainfed, uses little inputs and is closely related to the characteristics of the rainy season: in addition to the amount of rain received, the starting dates and the length of the wintering period have direct impacts on cereal yields or on the breeding grounds and the movement of crop pests such as Desert Locusts. IPCC's scenarios show that Sahelian and Sudano-Sahelian zones could see a more than 20% decrease in the length of the farming season by 2050. They appear among the most vulnerable areas in West Africa.

Faced with the various risks related to climate variability (drought, winds, crop pests, etc), farmers developed adaptation strategies. Among these strategies, there are those related to farming practices such as farming land degradation control, soil fertility management, crop diversification, water management techniques. These techniques have had non negligible impacts on natural resources. Since the beginning of the 1980's in Niger, 250,000 hectares of highly degraded land were reclaimed using simple techniques such as anti-erosive dykes in rock bunds, trenches, zais, halfmoons. In addition, there are other forms of adaptation: animal production and sale, support and cooperation, activity diversification, seasonal migration, etc. Extensive farming is considered a strategy aiming at compensating for the decline in yields in the absence of improved technical crop itineraries. This extension is unfortunately done to the detriment of pastoral areas.

Apart from cereal productions, livestock plays an important role in all the Sahelian countries. Transhumant pastoralism (70 to 90% of bovine livestock) remains a production mode adapted to certain sahelo-sahelian ecosystems. Climate changes, whether favorable or not, will modify the quantity and quality of natural pastures and will undoubtedly constitute an opportunity for new forms of open-range breeding in the region. However, breeders will have to face increasing farming stress and stronger environmental constraints. Some of them will increasingly turn to agro-pastoralism, an association of farming and breeding within the same farm, or towards a sedentary or semi-transhumant breeding.

Conclusion

In the past, farmers developed adaptation strategies to face challenges related toclimate changes. Some of the knowledge and practices have enabled these actors to adapt to climate fluctuations, soil erosion and more generally to natural resources degradation. These practices will probably not, always, be able to face extreme climate events or very different climate conditions that could prevail in the longer term (for example 3°C increase over one century).

In spite of these limitations, the inventory and development of local knowledge and analysis of natural resources use, practices, and environmental risk management strategies in the various agro-ecological zones of West Africa will be necessary to better define and implement adaptation polices at national and regional levels (National Adaptation Action Programmes – Regional Action Plans). These strategies could be accompanied with research on technologies such as climate change-resistant crops. Moreover, farmers and farmers' organizations should be more informed and aware of the new challenges and participate in debates and consultations over actions to take for the alleviation or adaptation to climate change.

Bibliographic References

Club du Sahel et de l'Afrique de l'Ouest, CILSS, FAO (2008), *Climat et changements climatiques en Afrique de l'Ouest*. Atlas de l'Intégration Régionale en Afrique de l'Ouest : www.fao.org/nr/clim/abst/clim_080502_fr.htm

FAO (2009), Profil sur le changement climatique : www.fao.org/docrep/012/i1323f/i1323f00.htm

FAO (2010), Répercussions du changement climatique pour la sécurité alimentaire et la gestion des ressources naturelles en Afrique : www.fao.org/docrep/meeting/018/k7542f01.pdf

IPCC (2007): *Climate Change 2007*. Fourth Assessment Report (AR4) : www.ipcc.ch/ipccreports/ar4-syr.htm

Some Internet sites:

Atlas de l'intégration régionale en Afrique de l'Ouest : www.atlas-ouestafrique.org

FAO - site sur les changements climatiques : www.fao.org/climatechange/fr

FAO – site Climpag sur l'impact du climat sur l'agriculture : www.fao.org/nr/climpag/index_fr.asp

FAO - Conférence de haut niveau sur la sécurité alimentaire mondiale : les défis des bioénergies et du changement climatique, (Rome 3-5 juin 2008) : www.fao.org/foodclimate/fr

Centre Régional Agrhymet (CRA) : www.agrhymet.ne

The future is now: How scenarios can help Senegalese and Mauritanian fisheries adapt to climate change

Marie-Caroline Badjeck[1] and Ndiaga Diop[2]

Abstract:
Localized changes in the productivity of marine and inland waters induced by climate change will pose new challenges to the fishery and the aquaculture sectors in West Africa. However, climate change does not occur in isolation of other drivers of change: processes of environmental, economic and social change can affect the fishery sector, potentially creating additional vulnerability to climate change. Scenarios are a useful tool to explore uncertainties and understand non-climatic drivers of change. Despite their prevalence in global environmental change research, few have focused on the fisheries sector. This article presents the construction of fisheries sector scenarios for Senegal and Mauritania required for the analysis of climate change adaptation policies.

Introduction:

In Senegal, 47% of animal protein intake comes from fisheries (FAO 2005) and the sector generates 600 000 direct and indirect employment[3]. In Mauritania, the sector is export oriented, contributing to foreign exchange earnings and the budget envelope: 20% of the government budget came from the sector between 1993 and 2000 (MAED 2002). In these countries uncertainties exist on how future biophysical changes due to climate change will interact with other stressors and impact the fisheries sector. Scenario building can be a creative method that provides a robust framework for strategic decision-making and understanding of uncertainty. Scenarios are not forecasts or projections; they are plausible stories about how the future might unfold. They can help strengthen the policy development process in confronting uncertainty and change, and the development of alternative adaptation strategies. The WorldFish Center and the Leibniz-Centre for Tropical Marine Ecology invited experts from Ghana, Mauritania and Senegal to a workshop held on the 14-16 April 2010 in Dakar, Senegal, to debate critical issues facing their fisheries in the next 40 years and construct plausible scenarios for 2050. The scenarios developed during the workshop are based on assumptions related to various drivers identified by the experts in an electronic survey where they were asked: "*Given your area of interest or expertise, list 10 drivers you think would have the most significant impact (positive and negative) on fisheries and aquaculture production systems over the next 40 years*". These were ranked according to their importance in terms of impact, and their level of uncertainty in terms of rate and direction of change. In this article we focus on the preliminary results from Senegal and Mauritania.

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Photo 1. A space for creative thinking at the regional level: some of the participants of the workshop "Envisioning 2050 Climate Change, Aquaculture and Fisheries in West Africa"

Senegal 2050: Is a blue revolution possible through aquaculture development?

For Senegal, participants felt that the most uncertain and important drivers were market forces, from a regional/localized market to a globalized one, and the different paths aquaculture could take, from extensive to intensive high input aquaculture. This resulted in four possible scenarios (Figure 1). In the "Accelerated" scenario high technology, global market orientation and intensive production combine for a strong push in technology and growth. The policy implications are that substantial input in education and training as well as a clear legislative framework to curb potential environmental problems is needed. In addition considerable pressures exist with regard to product standardization and certification leading to new forms of competition in international markets.

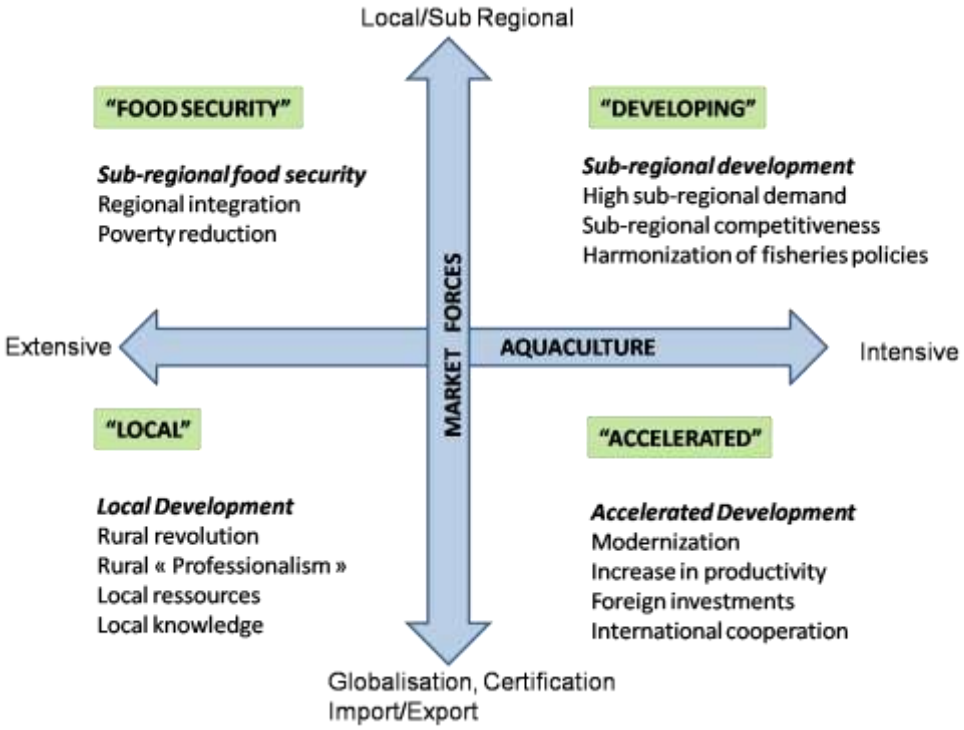

Figure 1: Senegal Scenarios

In the "Developing" scenario high-tech, intensive aquaculture is combined with economic development oriented toward the sub-region as opposed to global markets. Some members argued that this approach would go well with the rising demand in fisheries products at the regional level. However, in terms of policy this would entail substantial capacity building and awareness with regard to the potentially detrimental environmental effects of intensive aquaculture. It would also need a strong effort at the regional level to create a framework for harmonized regulations and regional market access.

The "Food security" scenario moved from a solely economic perspective present in the first two scenarios towards a food security one. Local and regional markets are favoured by an extensive aquaculture and small holders are at the centre of the "blue revolution". The feasibility of such an approach was doubted by several members of the group, and even more so the desirability of such a combination. However, discussions highlighted that this might be interesting in terms of rural poverty reduction. Finally, the last scenario "Local" focused on local self-determination and rural 'grassroots' development but turned toward global seafood markets. Policies would push for a "rural revolution", including the mobilization of local knowledge and rural education (and extension) to cope with the challenges of a 'village-based' production for a globalized world.

These four scenarios identified several issues for the future of the Senegalese fisheries sector including: can aquaculture address both national food security and macroeconomic growth? Should regional trade be promoted or access to global markets? Can intensive high input aquaculture benefit small holders in rural areas? The participants realized that while discussion currently existed in Senegal on aquaculture development, the different development pathways as well as the impact of climate change on each of them had been so far seldom addressed.

Through a "backcasting" exercise, where participants identified what policies are needed to be in place to reach successful outcomes in a scenario (Food security) and avoid negative ones, adaptive water resource management was perceived as essential to adapt to future climate change. Additionally, climate change should be mainstreamed within fisheries policy and in order to achieve this sub-regional institutions and actor's network should be strengthen. In terms of research and development (R&D), climate-to-fish modelling and identifying species that could adapt to new environmental conditions were seen as priorities. In the long term environmental and adaptation policies' objective should include ecosystem restoration to increase the resilience of inland fisheries and aquaculture.

Mauritania 2050: Raising alarm bells!

For Mauritania, participants labelled the most uncertain and important drivers as "overexploitation", from fully exploited fisheries, where management actions can still reverse trends, to overexploited ones where management actions have failed, and "climate change", ranging from slow onset resulting in small incremental changes that can be palliated by adaptation strategies to severe climate change and extreme events. The ability to predict climate change was also mentioned as an important element of this driver (from good to inexistent). The four possible scenarios based on these two axes are presented in Figure 2.

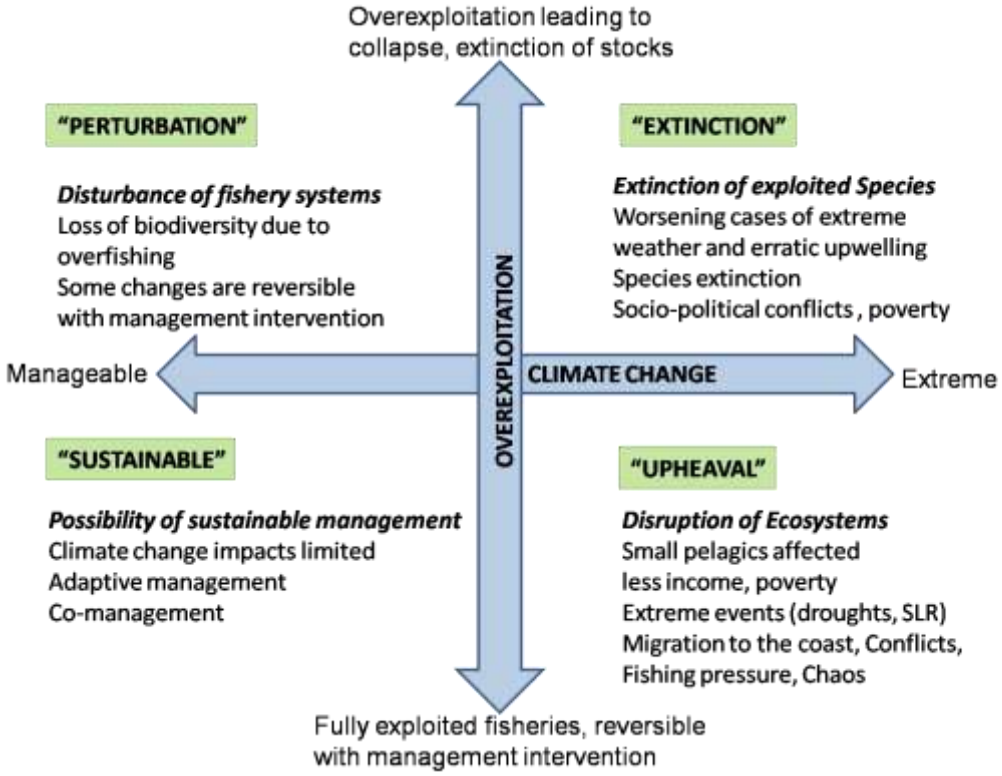

Figure 2: Mauritania scenarios

As opposed to Senegal, the Mauritanian scenarios were pessimistic: climate change is ineluctable and its magnitude and rate of change is creating a heighten level of uncertainty. Overexploitation is inevitable albeit in the "perturbation", "sustainable" and "upheaval" scenarios management interventions could still reduce impacts through for instance increased capacity building and research, and aquaculture development. Overall the scenarios are an "alarm bell" for the Mauritanian fisheries sector and are described in more details below.

In the "Perturbation" scenarios, disturbances in the fisheries sector are mainly driven by anthropogenic factors. Even though climate change impacts will not be as severe as in other scenarios, overexploitation and collapse of main aquatic resources are compounded by increased pollution, leading to a decrease in water quality, modification of habitats and loss of biodiversity. These have a widespread socio-economic impact on the country. In the "Extinction" scenario climate extremes are worsening are causing the total collapse and extinction of commercial stocks, loss of biodiversity and a high level of poverty. Failure to adapt to environmental changes is due to inadequate management and policy responses, resulting in poverty reduction efforts and economic growth being drastically curbed since fisheries play a critical role in the national economy. Policy makers are overwhelmed and have to deal with social and political conflicts. By adopting policies that enabled overexploitation and ignored climate change, the sector has entered a "road of no return".

The "Sustainable" scenario is characterized by limited climate change effects due to the ability to successfully adapt. Adaptive management is adopted: scarce resources are managed while maintaining fishing equity, efficiency, and protection of the

environment. The perceptions and uncertainties of sectoral actors are taken into account and a portfolio of participatory management approaches, including co-management, are implemented. Despite adverse conditions, the sector can still remain sustainable, "ride out the storm". Finally, in the "Upheaval" scenario droughts, floods, increases in temperature and sea level rise are worsening. Inland areas are receiving less rain, resulting in a massive population exodus to coastal zones: the coast is considered a zone of ultimate "resort" and there is exponential pressure on aquatic resources. In the ocean the lowest trophic species with no commercial value dominate the fishery. Small pelagic fisheries are greatly affected as they are extremely sensitive to environmental fluctuations. Despite this turmoil, society still tries to respond to these extreme environmental changes through adaptive management, which might include exiting capture fisheries.

Like the Senegalese group, participants identified what policies needed to be in place to reach successful outcomes in a scenario ("Upheaval") and avoid negative ones. In the short term the Sub-Regional Fisheries Commission was considered to play a crucial role in increasing cooperation and technological transfer related to climate change, including the promotion of energy efficiency. Strengthened regional cooperation will result into a stronger presence and "united front" in international fora related to climate change. For R&D, the integration of climate change issues in education curricula was seen as a priority and by 2030 academic centres of excellence on fisheries and climate change should exist throughout the region. However capacity building is not limited to the scientific community, in order for decision makers to design evidence-based adaptation policy at the national and regional level that are implement by 2020-2030, their awareness on climate change issues needs to increase in the short term.

Looking ahead to adapt now: what we have learned

Scenarios are often used for strategic planning in the private sector, and increasingly so in the public sector in Europe and North America, but with few such initiatives in Africa, especially regarding fisheries. Experts at the workshop expressed the desire to see this type of planning process and creative thinking more widely applied to fisheries, with special emphasis on the rigorous methods used in the workshop. The opportunity for creative thinking was recognized as an important part of adaptation planning to climate change. Indeed more careful attention to "processes" of learning and sharing knowledge could have more lasting impact on decision-making, and challenge assumptions about potential solutions to environmental changes (Allison 2002). Mamadou Ngom, a Senegalese aquaculture expert, reported to the organizers how the exercise made him realize that developing aquaculture to supply globalized export markets had quite different implications than if regional trade and food security were the primary focus. Clearly, he added, these differences should be taken into account by experts developing national aquaculture strategies, especially in a context of water scarcity fuelled by changes in demand and climate changes.

The scenarios exercise presented here is the first step of an iterative process and the following recommendations will be acted upon:

- Participants identified the development of a methodological brief on scenarios as a high priority. The WorldFish Centre is in the process of developing such a brief
- Quantify the scenarios and combine with climate-to-fish models developed within the QUEST_fish project (see http://web.pml.ac.uk/quest-fish/default.htm)

The final message of the workshop is that, in the face of high uncertainty, where coupled climate and fisheries models have difficulty predicting fishery productivity in upwelling regions such as West Africa, opportunities are needed to map plausible pathways and futures in a collaborative manner. While fishery policymakers cannot foresee the future in a crystal ball, by imagining plausible scenarios, taking into account the likely impacts of climate change and other drivers, they stand a better chance of preparing the region to face the challenges ahead.

Acknowledgements
We thank the 24 participants of the regional expert workshop "Envisioning 2050: Climate change, aquaculture and fisheries in West Africa" that took place in Senegal in April 2010 for their input and ideas as well as our colleagues from the the Leibniz Center for Marine Tropical Ecology (Germany). This article is based on research financed by Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) on behalf of the Government of the Federal Republic of Germany, the Climate Change Adaptation in Africa (CCAA) programme from Canada's International Development Research Centre (IDRC), and partially supported financially the UK Natural Environment Research Council Quest thematic programme (QUEST-Fish).

References

Allison, E. H. (2002). "Sustainable management of the African Great Lakes: Science for development?" *Aquatic Ecosystem Health & Management*, 5(3), 315 - 327.

FAO. (2005). "Fisheries Issues. Contribution of aquaculture to food security." FAO Fisheries and Aquaculture Department [online]. Rome. Updated 27 May 2005. [Cited 10 October 2010]. http://www.fao.org/fishery/topic/14886/en Rome.

MAED. (2002). "«Etude sur la fiscalité de la pêche en Mauritanie», Rapport provisoire." Ministère des Affaires Economiques et du Développement, Repulique Islamique de Mauritanie.

Biodiversity conservation and climate change in Nigeria

Israel T. Borokini[1]

Introduction

Article 1 of the United Nations Framework Convention on Climate change (UNFCCC, 1992) defined Climate system as the totality of the atmosphere, hydrosphere, biosphere, geosphere and their interaction with human being. The same article defined Climate Change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to the natural variability observed over comparable time periods'. The Convention article also goes further to define 'adverse-effect-of-climate-change' as 'changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare' (UNFCCC, 1992).

Biological diversity is used to describe the number, variety and variability of living organisms within each variety or species in a given ecosystems (Heywood & Baste, 1995). Convention on Biological Diversity (CBD) and United Nations Environment Programme (UNEP) (1992) have defined this as the variability among living organisms from all sources including *inter alia* terrestrial, marine and aquatic ecosystems, as well as the ecological complexes of which they are a part. Another widely used definition of biodiversity is "the variety and variability among living organisms and the ecological complexes in which they occur" (OTA, 1987).

Conservation is defined as the management of human use of the biosphere so that it may yield the greatest sustainable benefit to the present generations, while maintaining its potentials to meet the needs and aspirations of future generations. Thus, conservation embraces preservation, maintenance, sustainable utilization and restoration and enhancement of the natural environment (IUCN, UNEP & WWF, 1991). This paper considers the effect of Climate change in Nigeria and the effects of this on the sustainability of the Nation's rich biological diversity. It concludes with suggested solutions towards effective biodiversity conservation in the wake of climate change.

Climate change and Nigeria

Nigeria is particularly vulnerable to the impact of climate change in many fronts considering its geography, climate, vegetation, soils, economic structure, poor physical infrastructure, population and settlement, energy demands and agricultural activities (Okali, 2008). Nigeria is bounded in the south by over 850km long active coastline and in the north by a similar length of the Sahara Desert. The country is therefore permanently being ravaged by coastline erosion to the south as well as desertification to the north. Global warming is now acting as a catalyst to these two destructive natural forces (Agagu, 2009). The inter-annual variability of rainfall, particularly in

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the northern parts is large; often result in climate hazards, especially floods and droughts with their devastating effects on food production and associated calamities and sufferings. More often than not, certain parts of Nigeria receive less than 75 percent of their usual annual rainfall and this is particularly worrisome in the north (Adejuwon, 2004).

Based on the Intergovernmental Panel on Climate Change (IPCC) projection, the humid tropical zone of southern Nigeria, which is already too hot and too wet, is expected to be characterized by increase in both precipitation (especially at the peak of the rainy season) and temperature. Already, temperature increases of about 0.2°C - 0.3°C per decade have been observed in the various ecological zones of the country, while drought persistence has characterized the Sudan-Sahel regions, particularly since the late 1960s. For the tropically humid zones of Nigeria, precipitation increases of about 2-3% for each degree of global warming may be expected. Thus, it is reasonable to expect that the precipitation would probably increase by approximately 5 - 20% in the very humid areas of the forest regions and southern savanna areas. The increase in temperature in these areas would also possibly increase evaporation, reducing the effectiveness of the increase in precipitation.

According to IPCC projections, rainfall in the very humid regions of southern Nigeria is expected to increase. This may be accompanied by increase in cloudiness and rainfall intensity, particularly during severe storms. It could also result in shifts in geographical patterns of precipitation and changes in the sustainability of the environment and management of resources. However, since the increase in temperature could increase evaporation and potential evapo-transpiration, there would be tendency towards "droughts" in parts of these humid areas of the country. In fact, recent studies have shown that precipitation decrease in the humid regions of West Africa, including southern Nigeria, since the beginning of the century is about 10-25% or about 2-5% per decade. If this trend persists, rainfall in the humid regions of southern Nigeria may be about 50% to 80% of the 1900 values by 2100. With increase in ocean temperatures, however, there could be increase in the frequency of storms in the coastal zone of the country (IPCC, 2001; Adejuwon, 2004).

In contrast to the humid areas of southern Nigeria, the savanna areas of northern Nigeria would probably have less rainfall, which, coupled with the temperature increases, would reduce soil moisture availability. Recent studies have indicated that the Sudan-Sahel zone of Nigeria has suffered decrease in rainfall in the range of about 30-40% or about 3%-4% per decade since the beginning of the nineteenth century. Already, these savanna and semi-arid areas suffer from seasonal and inter annual climatic variabilities, and there have been droughts and effective desertification processes, particularly, since the 1960s. This situation may be worsened by the expected decrease in rainfall with greater drought probabilities and more rainfall variabilities and unreliabilities.

Furthermore, Odjugo (2005) studied the rainfall data from 28 stations for the period of 1970 – 2002, and observed that rainfall decreases from 1350 mm (1941–1970) to 1276 mm (1970–2002), and that the duration has also reduced from 80-360 (1941-1970) to 40-280 (1970-2002) rainy days per year.

In addition, the following graphical illustrations depict the abnormalities in the rainfall, relative humidity and temperature in some cities in Nigeria over a ten year period:

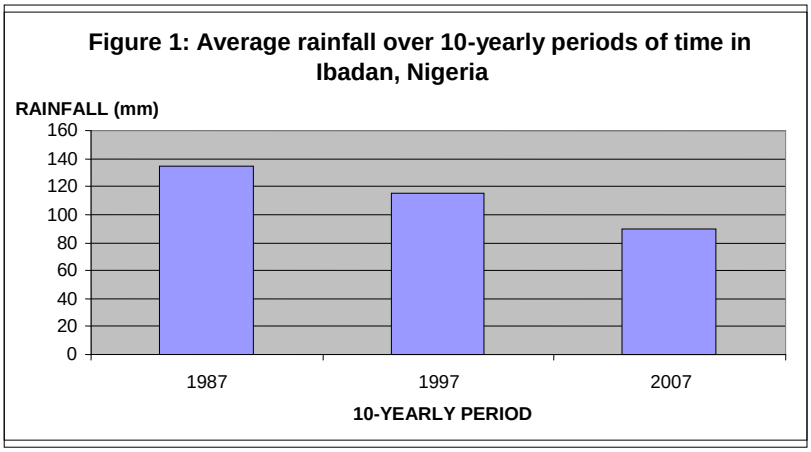


Figure 1: Average rainfall over 10-yearly periods of time in Ibadan, Nigeria

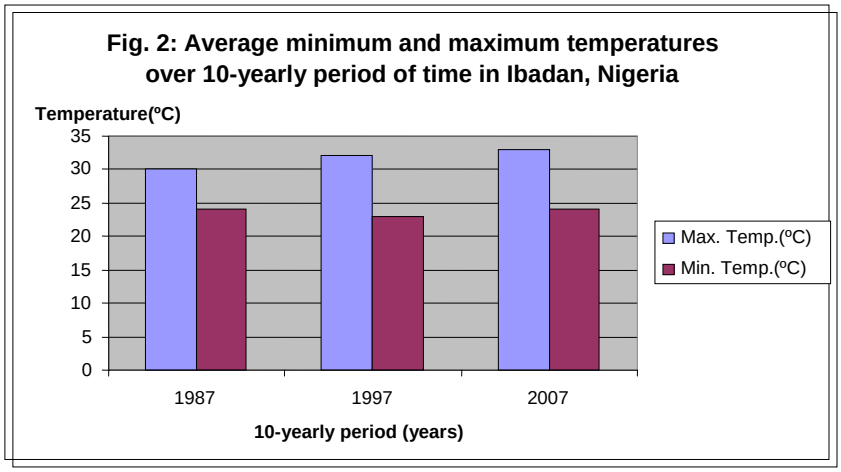


Fig. 2: Average minimum and maximum temperatures over 10-yearly period of time in Ibadan, Nigeria

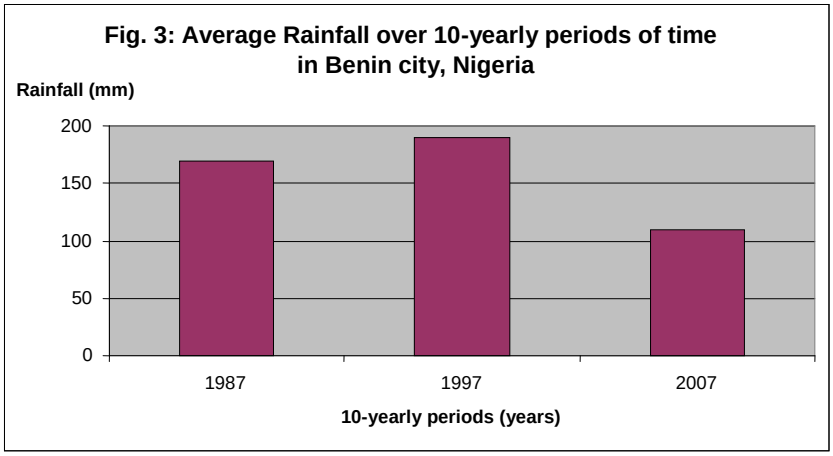
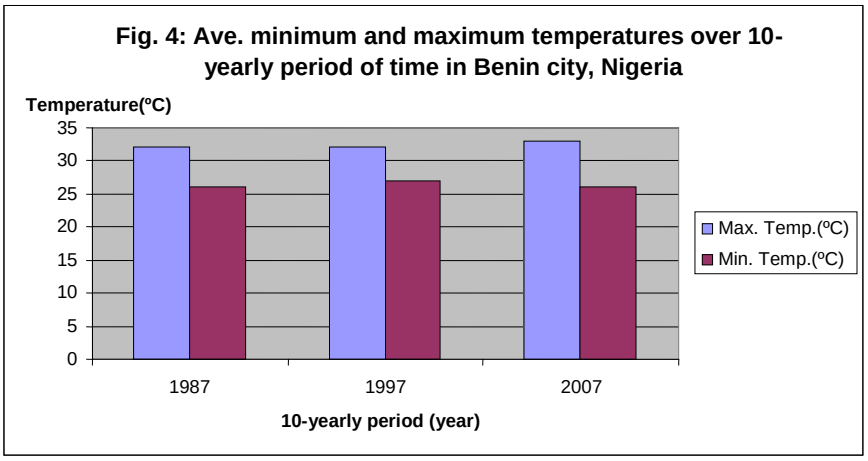
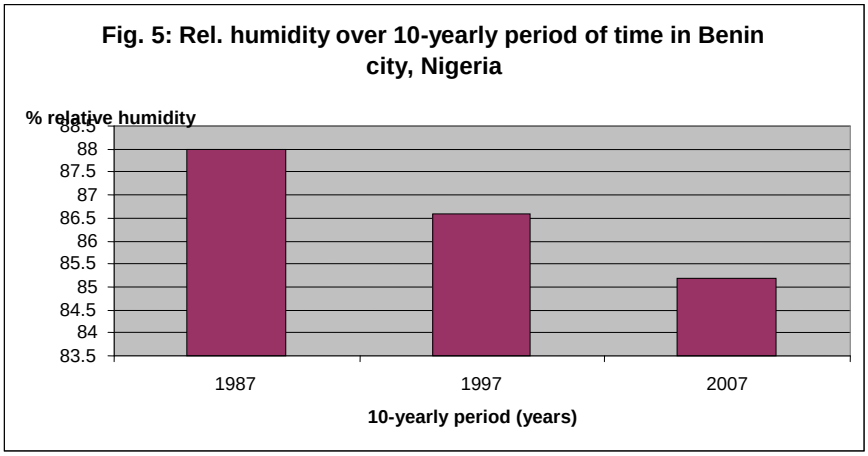


Fig. 3: Average Rainfall over 10-yearly periods of time in Benin city, Nigeria

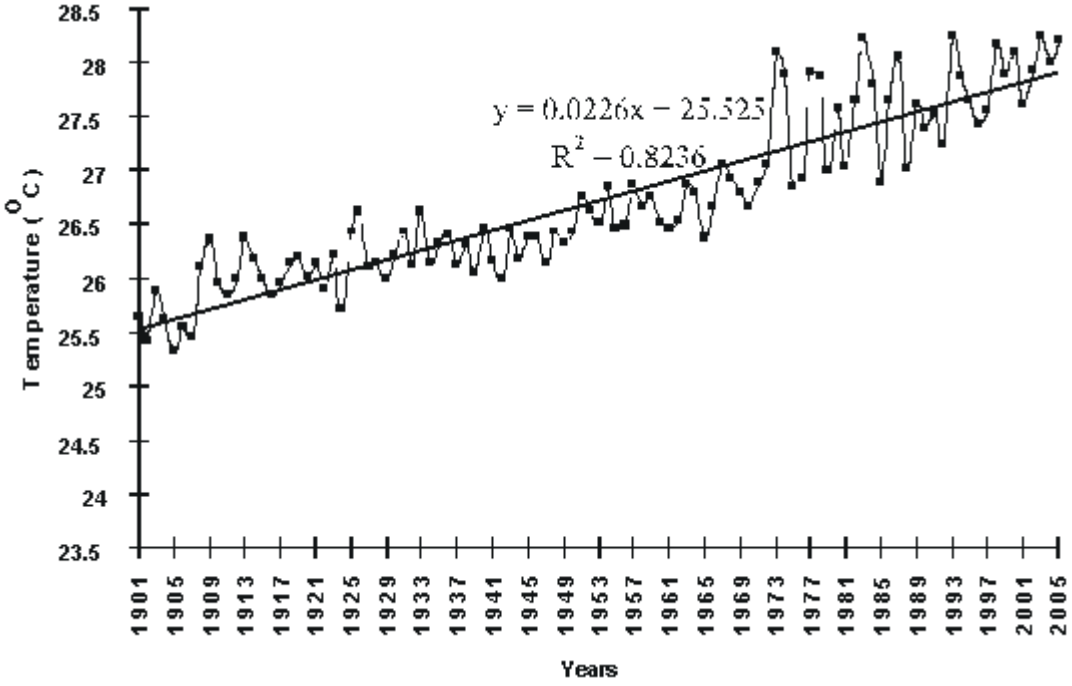




Source: Akpama (2009).

Furthermore, Odjugo (2010) presented the air temperature distribution in Nigeria between 1901 and 2005, according to the data available in the Nigeria Meteorological Agency (NIMET). Figure 6 below explains the findings of the data.

Figure 6: Air temperature distribution in Nigeria between 1901 and 2005



Effect of Climate change on Biodiversity

Odjugo (2005) observed that climate change observed in Nigeria is responsible for the ecological destabilization and an alteration of the pattern of the vegetation belt especially in the northern fringes of the country, and that the rainfall pattern has also enhanced wind erosion/desertification, soil erosion and coastal flooding in the north, east and coastal areas of Nigeria respectively.

Already, desertification has encroached into the northern parts of Nigeria. The following figures depict the situation.

Figure 7: Desert encroachment into Northern Nigeria

Figure 8: Desert landscape in north-eastern Nigeria

Figure 9: Sand dunes in Yunusari Local Govt of Yobe State

The increasing temperature and decreasing rainfall have led to frequent drought and desertification. The Sahara desert is observed to be expanding to all directions trying to engulf the Sahelian region of Africa with annual expansion of 1-10 km (Odjugo and Ikhuoria 2003; Yaqub 2007). Odjugo and Ikhuoria (2003) also observe that Nigeria north of 12°N is under severe threat of desert encroachment and sand dunes are now common features of desertification in states like Yobe, Borno, Sokoto, Jigawa and Katsina. The migrating sand dunes have buried large expanse of arable lands, thus reducing viable agricultural lands and crops' production. This has prompted massive emigration and resettlement of people to areas less threatened by desertification. Such emigration gives rise to social effects like loss of dignity and social values. It often results in increasing spate of communal clashes among herdsmen and farmers and such clashes resulted in the death of 186 people in six northern states of Nigeria between 1998 and 2006 (Yugunda 2002; Yaqub 2007). Akonga (2001) also shows that most of the destitute that emigrated as a result of drought and desertification usually move to nearby urban areas to beg for alms thereby compounding the already tense urbanization problems. In Nigeria, many rivers have been reported to have dried up or are becoming more seasonally navigable while Lake Chad shrunk in area from 22,902 km^2 in 1963 to a mere 1304 km^2 in 2000. This shows that what is left of Lake Chad in the year 2000 is just 5.7% of 1963 (Odjugo 2007). Awake (2009) also confirms the fact that Lake Chad has shrunk by 95% since the 1960s. Lake Chad and so many rivers in Nigeria, especially in Northern Nigeria, are in the danger of disappearing.

Furthermore, the average area of Hadejia Nguru flood plain decreased from 2,350 km^2 in 1969 to less than 1000 km^2 in 1995. Inland Delta of Niger River decreased from 37,000 km^2 in the early 1950s to about 15,000 km^2 in 1990, (Ogunjunmi *et al.*, 2008). Also the surface area of Lake Chad evaluated at 20,000 km^2 during wet years before 1970 has shrunk to less than 7,000 km^2 since early 1990s leading to the splitting up of the lake into two parts, (IUCN, 2004).

In South-west Nigeria, various species of mahogany (*Khaya senegalensis)* are being attacked by shoot borers such as *Hypsiphyla robusta* and *Phytolyma fasca* which normally attack iroko (*Millicia excelsa)*, (Aluko *et al*., 2008). This is as a result of increase in the incidence of pests and diseases attack resulting from climate change. Aluko *et al* (2008) pointed out that potential impacts of climate change would have adverse effects on species as they may have to face new competitors, predators, diseases and alien species for which they have no natural defense. Worse still, coral reefs and mangroves will shrink and eventually disappear leading to land loss for biodiversity conservation.

The conservation of Nigeria's biodiversity, in the face of climate change has proved to be an uphill task as these changes in climatic trends keep militating against the success of conservation efforts. Future viability of existing protected areas subject to climatic changes is a crucial issue for conservation planners. The concern is that areas of suitable climate space occupied by species may move, shrink or even disappear (Meduna *et al* 2008).

Meduna *et al* (2008) pointed out that managers of protected places in Nigeria will need to decide whether they wish to maintain existing suites of species in the area or to allow ecological (and evolutionary) change in the ecosystems represented with them. He further stressed that the problem is acute for endemic or restricted-range species which are largely confined to single reserves comprising only one major climate zone, some species of interest according to Meduna *et al* (2008) includes but not restricted to white-throated guenon (*Cercopithecus erythrogaster)* and sclater's guenon (*Cercopithecus sclateri)* in Okomu National park as well as the mountain gorilla (*Gorilla gorilla)* in Gashaka Gumti National Park, which now face the threat of extinction due to modifications in their local ecosystems under the impact of climate change.

Life cycle of many wild plants and animals are closely linked to seasonal variations. Climate change could therefore result in interdependent species losing synchronization. If such associations involved endangered species being conserved in a game reserve, such species may be forced to migrate from the reserve and by so doing it places itself in danger's way thus defeating the purpose of conservation and the efforts put in by the reserve managers.

Climate change expressed by reduced rainfall and human activities is the main factor associated with the increased rate of desertification. Dry and sub-humid regions will become hotter and drier under the influence of climate change. This could threaten organisms that are already near their heat-tolerance limits such as xerophytes example of which include baobab (*Adansonia digitata).* Increased drought frequency

and intensity, as well as higher temperatures are likely to increase the chances of wild fire occurrence, with severe consequences for biodiversity in the tropics. All-in-all, if not well curbed, climate change might very well frustrate efforts, at all levels, to conserve the rich yet endangered biodiversity of Nigeria (Apkata, 2009).

In January 2008, the author was part of the team from National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, Nigeria, that went on a collection trip for *Khaya grandifoliola* seeds in Cross River State. This trip was successful with lots of germplasms collected for genetic variability studies. However, in January 2009, a similar collection trip to the same locations yielded poor results, as the fruits were not yet matured. The local people attributed it to a 'strange' weather that they were experiencing at that time. This indicates that climate change could affect the physiology of the plants and thereby adversely affect their survival, and worse still could also reduce the population of the frugivorous animals and birds that feed on them. Furthermore, a field survey has just been concluded on the effect of the density of the fruiting trees in Ngel Nyaki Forest Reserve, Mambilla Plateau, Taraba State on the population of the endangered Turaco birds in the Forest Reserve. While the findings of this survey is being compiled as at the time of this write-up, it was generally observed that the population of the Turaco birds greatly reduced when the trees are not fruiting.

Recommendations

Singer and Avery (2007) show that it is impossible for man to stop the natural causes of climate change but much can be achieved in either to stop or drastically reduce the human causes of climate change. Biodiversity is a non-renewable natural resource, which if lost; it may take up to thousands of years to recover this naturally. Therefore, more commitment should be shown to the conservation of natural resources in Nigeria vis-à-vis climate change. The following practical steps are recommended:

- Afforestation, reforestation and nationwide tree planting campaigns should be encouraged, while deforestation should be reduced drastically;
- Industrial productions should convert to machines that emit limited or no greenhouse gases. Automobiles and industrial machines should be improved upon to use only ethanol, solar engines, electric engines or hybrid electric engines. Nigeria should encourage the use of renewable energy sources such as photovoltaic cells in a small scale and the use of low-cost solar energy cookers;
- Education and enlightenment of the public on the hazards of climate change due to human activities example bush burning;
- Integration of climatic issues into economic planning and management at both National and regional levels;
- Oil spillage in the creeks and coastal areas of Nigeria should be guarded against in order to enhance carbon sink in the coastal waters, while gas flaring especially in the Niger Delta region of Nigeria should be reduced to the barest minimum;
- Policy makers should develop a "Clean Development Mechanisms" for the country;
- Agriculture systems in Nigeria need to be improved to integrate irrigation systems and the use of fertilizers rather than depend on rainfed agriculture,

while storage facilities should be established. Bush burning should be discouraged;

- The dependence on timber and timber products in Nigeria should be reduced by changing the building and furniture materials from wood. This way, we reduce deforestation; *and*
- There is the need to establish better-equipped weather stations as against the scanty and ill-equipped ones we currently have in Nigeria. With these, accurate weather forecast and predictions will be possible and this will help to prevent weather-related disasters through early warning and effective response system.

Most of the country's biological resources are found *in-situ* in their natural habitats, especially the forest biomes, found in protected areas such as parks, biosphere reserves, strict nature reserves, forest reserves, game reserves and sanctuaries, Ramsar sites and cultural heritages, among others. It is strongly believed that as Nigeria takes more decisive and pragmatic actions towards checking climate change, our national biological heritage will be conserved for the benefit of posterity.

References

Adeoti, A.I (2009). Women and Climate Change: An Overview of Issues and Challenges. Keynote Address delivered at Conference of Association of Women in Forestry and Environment (AWIFE), 1st – 5th November, Ibadan, Nigeria.

Adefolalu D.O.A (2007). Climate change and economic sustainability in Nigeria. *Paper presented at the International conference on climate change, Nnamdi Azikiwe University,* Awka 12-14 June 2007.

Adejuwon, S.A (2004). Impacts Of Climate Variability And Climate Change On Crop Yield In Nigeria. Paper delivered at the Stakeholders' Workshop on Assessment of Impacts and Adaptation to Climate Change (AIACC), Conference Centre. Obafemi Awolowo University, Ile-Ife, Nigeria.

Agagu, O.K (2009). Threats to the Nigerian Environment: A call for positive action. A Lecture delivered at the 7th Chief S.L Edu Memorial Lecture, Nigerian Conservation Foundation (NCF), Lagos.

Akinyemi, O. D. et al. (2008). *Climate change and biodiversity conservation in Nigeria;* in Climate Change and Sustainable Renewable Natural Resources Management; 32nd Annual Conference of Forestry Association of Nigeria.

Akonga A.Z (2001).The causes and impacts of drought. *ANIS Monograph* No. 3, pp. 1-16

Akpama, J.A (2009). The Challenges of Climate Change on Biodiversity Conservation in Nigeria. A paper presented at the maiden edition of the Annual Nigeria Tropical Biology Association (NTBA) Seminar, University of Ibadan, 26th August 2009.

Aluko, A. P. et al. (2008). *Climate change: a threat to food security and environmental protection;* In Climate Change and Sustainable Renewable Natural Resources Management; Forestry Association of Nigeria.

Awake (2009). Are we running out of water? *Awake!* January 2009, pp. 3-7.

CBD and UNEP (1992). Global Biodiversity Strategy: Guidelines for action to save, study and use earth's biotic wealth sustainably and equitably. CBD, UNEP, Geneva.

Heywood V.H and Baste I (1995). Introduction. *In:* Heywood VH (executive editor). Global Biodiversity Assessment. Cambridge University Press, Cambridge, pp 1 – 19.

IPCC, (2001). Climate Change 2001: The Scientific Basis, Summary for Policy Makers and Technical Summary of the Working Group I Report, Intergovernmental Panel on Climate Change, Geneva, Switzerland, 2001.

Jones, P.D., Parker, D.E., Osborn, T.J. and Briffa, K.R. 2001: Global and hemispheric temperature anomalies--land and marine instrumental records. In: *A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center*, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.

Kennedy, J., Parker, D. and Coleman, H. 2006: Global and regional climate in 2005. *Weather,* 61, 215-224.

Meduna, A. J. *et al.* (2008). *Climate change and implications for biodiversity conservation;* in Climate Change and Sustainable Renewable Natural Resources Management; 32nd Annual Conference of Forestry Association of Nigeria.

Odjugo P.A.O and Ikhuoria A.I (2003). The impact of climate change and anthropogenic factors on desertification in the semi-arid region of Nigeria. *Global Journal of Environmental Science*, 2(2): 118-126.

Odjugo, P.A.O (2005). An analysis of rainfall patterns in Nigeria. *Global Journal of Environmental Sciences* 4(2): 139-145.

Odjugo P.A.O (2007). The impact of climate change on water resources; global and regional analysis.. *The Indonesian Journal of Geography*, 39: 23-41.

Odjugo, P.A.O (2010). General Overview of Climate Change Impacts in Nigeria. *J. Hum. Ecol*. 29 (1): 47-55.

Office of Technology Assessment, OTA (1987). Technologies to maintain Biological Diversity. Washington DC, USA. Government Printing office.

Ogunjinmi, A. A. et al. (2008). *Potential impacts of climate change on biodiversity and cultural values of National Parks*; in Climate Change and Sustainable Renewable Natural Resources Management; 32nd Annual Conference of Forestry Association of Nigeria.

Singer S.F and Avery D.T (2007). *Unstoppable Global Warming: Every 1000 Years.* New York: Rowman and Littlefield Publishers Incm, P. 114.

Sweeney, J., Donnelly, A., McElwain, L. and Jones, M. 2002: *Climate Change: Indicators for Ireland*. Irish Environmental Protection Agency, Johnstown Castle, Wexford, 54pp.

United Nations Framework Convention on Climate Change (UNFCCC) (1992).
United Nations Environment Program Information Unit on Climate Change, Geneva, Switzerland.

Vincent, L.A. and Gullett, D.W. 1999: Canadian historical and homogeneous temperature datasets for climate change analysis. *International Journal of Climatology*, 19, 1375-1388.

Yaqub C.N (2007). Desert encroachment in Africa: Extent, causes and impacts. *Journal of Arid Environment,* 4(1): 14-20.

Yugunda B.S (2002). Socio-economic and cultural impacts of desert encroachment in Nigeria. *Journal of EnvironmentalDynamics,* 5(2): 19-30.

Zhai, P.M. and Ren, F.M. 1999: Changes of China's maximum and minimum temperatures in 1951-1990. *Acta Meteorologica Sinica*, 13, 278-290.

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Possible impact of reform of modalities for obtaining community forests, on forest resources conservation and climate change in Cameroon

Emmanuel D. Kam Yogo[1]

Summary

With the advent of the Forest Law in 1994, community forestry was introduced in Cameroon. Rural communities who were enthused by the idea of obtaining a community forest were constantly faced with the challenge of submitting a simple management plan, the formulation of which was financially beyond their means. Consequently, they turned to business men who 'helped' them financially and in return had control over the community forest thus created. On that account, several community forests were no longer centers of excellence in forest resources management but rather anarchical farming sites. In 2009, the conditions for obtaining community forests in Cameroon was reformed. This seems to put an end to the pillage by allowing rural populations to sign a provisional management convention even if they did not yet have a simple management plan. It is speculated that the reform will have favorable impacts on the sound management of forest resources and ultimately contribute to finding credible answers to climate change challenges.

Introduction

The preamble of the Constitution of Cameroon dated 18 January 1996 stipulates, among others, that the Cameroonian nation has "resolved to use its natural resources in order to ensure the well-being of populations without any discrimination…"[2]. Among the natural resources of Cameroon, forests are predominant. Thus, it can be said that the Constitution of Cameroon acknowledges among, other things, that the development of forests, one of the natural resources of this country, should contribute to the well-being of its people. Therefore, being favorable to forest development to ensure the well-being of populations, the Constitution of 1996 reinforces the pre-emptive right which enables populations in forest areas to manage the forests in order to support the development of their communities. In that same vein, constitutional provisions stipulate that the "State protects the rights of indigenous populations in accordance with the law"[3]. The Forest Law of Cameroon makes provision for a diversity of rights in favor of indigenous populations. Among this diversity of rights, there are for example, use rights[4] and of course the pre-emptive right[1] which is part of the ways to access community forestry.

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[2] *See the 3rd paragraph of the preamble of the Constitution of Cameroon 1996.*

[3] *See the fifth paragraph of the Preamble of the Constitution of Cameroon.*

[4] *The Law No. 94/001 of 20th January 1994 regulating forests, makes several provisions for the use rights of populations; Article 8 §-1 specifies that the riparian populations are entitled to the use right or customary right over all forest, wildlife and fishery products except for protected species intended for personal use; its Article 26 §-1 stipulates: "The reservation* of a forest estate takes into account the social environment of indigenous populations who retain their normal use rights"; Article 30 §-2 concerning communal forests stipulates: "The act of reservation establishes the boundaries and management objectives of the said forest … as well as the exercise of use rights by indigenous populations…"; Article 36 stipulates that "In the national domain forests, surrounding populations are entitled to use rights…". The Decree No 95/531/PM of 23 August 1995 establishing the modalities for the implementation of the Forest law, specifies in its Article

I. The pre-emptive right, a way to access community forest

Viewed as a prerogative available to rural communities, the pre-emptive right thus supports the right to the environment and the right to the development of the populations involved. Considered from that angle, it should be a tool for the implementation of some human rights, notably those of the third generation, because, by exercising the pre-emptive right, a rural community takes the responsibility, on the one hand, to manage in an ecologically sustainable manner, the forest bordering its settlement, a way to ensure its right to a safe environment, and on the other hand, to self-finance its local development through financial resources generated from its community forest[2]. Moreover, as a privilege reserved to the vulnerable groups of rural communities in forest areas, the pre-emptive right is yet another means to protect the livelihoods and culture of indigenous populations[3].

It is only in 1994 that the pre-emptive right of rural communities was introduced in the Forest Law of Cameroon. This means that since the colonial era, indigenous populations in forest areas could benefit from forest development only indirectly, in view of the fact that the law did not give them any particular privilege, except for use rights. Thus, the pre-emptive right in the forestry sector enables rural communities to increase and reinforce their prerogatives over the future of the forest near their settlements. The management of a forest preempted by a rural community passes under the control of that community at the end of an often lengthy administrative procedure. It is in that perspective that the Decree No. 95/531/PM of 23 August 1995 establishing the modalities of implementation of the Forest Law, specifies that each community defines the modalities of attribution of forest logging rights in its community forest[4].

The Decree No. 518/MINEF/CAB of 21 December 2001 establishing the modalities of priority attribution to rural communities surrounding any forest likely to be constituted as a community forest also recalls that "rural communities are entitled to a pre-emptive right in case of alienation of natural products included in their forest, these products being essentially made up of wood and non-wood plant products, as well as forest-derived wildlife and fishery resources"[5]. This confirmation of the pre-emptive right in the Ministerial text completes the process of implementation of this

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26 that use rights consist in the realization by populations, of their traditional activities such as the harvest of secondary forest products (raffia, palm, bamboo, rattan, or food products), in order to meet their local needs. Moreover, use rights are maintained in the national domain forest, except for deferred grazing areas and areas where regulations are adopted by the Minister in charge of forests or the Minister in charge of mines and in accordance with regulations on quarries.

[1] Article 37 of Law No. 94/001 stipulates that "rural communities enjoy a pre-emptive right…"

[2] We can see here a confirmation of the provisions of the third paragraph of the preamble to the Constitution of Cameroon 1996 according to which, the Cameroonian people, « resolved to manage its natural resources in order to ensure the well-being of all by improving the standard of living of populations without discrimination, asserts its right to development…". According to Robert Charvin, "the right to development is both an individual right and a collective right, because the progress and development of the individual are considered as possible only if certain conditions are fulfilled at local community group level" (Robert Charvin, *L'investissement international et le droit au developpement, Paris, l'Harmattan, 2002, p. 113).*

[3] See also, James Mouangue Kobila, *La protection des minorités et des peuples autochtones au Cameroun : entre reconnaissance interne contrastée et consécration universelle réaffirmée*, Paris, Dianoïa, 2009, p.122.

[4] Article 95 §2 of the Decree n°95/531/PM of 23 August 1995.

[5] Article 3 §1 of the said Decree.

prerogative in favor of the forest fringe communities. Operational from a legislative and regulatory stand point, the pre-emptive right in forestry is today an important element among the mechanisms for the protection of forest indigenous people in Cameroon. However, financial constraints have often been an obstacle to the exercise of this right.

Applying the pre-emptive right is done in three phases. First, the State should declare its intention to transfer a forest area[1], then the surrounding rural community should express its intention to manage directly the said forest and fulfill the conditions stipulated by the State[2] and, finally, the State should sign with the rural community involved a provisional convention and a final community forest management[3] convention.

II. The establishment of the provisional management convention, an innovation favoring rural populations and facilitating the sound management of forest resources

The possibility to sign a provisional management convention exists since 2009 following the review of the allocation procedures manual and of the management standards for community forests. Thus, a rural community is no longer obligated to first develop a simple management plan, often very costly[4] for rural populations, before signing a management convention and which constituted a prerequisite before starting activities on the forest requested. This is an improvement[5] in favor of communities, some of whom were hindered in the process due to the lack of financial resources to prepare a complete file including a simple management plan. This lack of means left them at the mercy of large forest companies that subsequently funded the development of simple management plans for the requested forests and managed them as they wished to the detriment of the interests of rural communities. In that context, one of the objectives of community forestry which is to facilitate local development, was completely endangered, since rural communities could not have control over the income generated by their community forests.

In spite of the 2009 reform, forest loggers will still be able to work in community forests. However the importance of their role is no longer the same; it has actually declined. Before 2009, there was a kind of reliance of rural communities towards forest loggers since the approval of a request for community forest depended on their pre-financing. Now, a request for community forest can be approved without a pre-financing from logging companies or business men. Thus, they can no longer unilaterally determine the conditions of exploitation of a community forest as was the case when they used to pre-finance. They are compelled to submit to the modalities established by these rural communities.

[1] See the Decree No. 0518/MINEF/Cab of 21 December 2001 establishing the modalities for priority attribution to rural communities near any forest likely to be constituted as a community forest.
[2] See Article 6 § 3 and 4 of the above mentioned Decree.
[3] Article 37 of Law No. 94/01 of 20 January 1994 regulating forests, wildlife and fishery.
[4] The development of a simple management plan costs an average of five (5) millions CFA Francs.
[5] It is necessary that this positive improvement be integrated in the implementation decree of the Forest Law in order to obtain its full regulatory basis. A review of this decree should therefore be considered to avoid any form of contradiction with the Procedure Manual.

The role of the State remains the same. In accordance with the terms of Article 37 of the Forest Law of Cameroon, the Forest Authority should provide assistance to rural communities requesting for a community forest. Moreover, the development of this forest is performed under the technical control of the State. Beyond this technical oversight, it would be desirable for the State to also make provision for a financial assistance to rural communities in order to promote sustainable management of community forests.

Conclusion

The signing of a provisional management convention thus enables rural populations to start activities in the forest requested and to be able, at the end of those activities, to obtain the necessary financial resources to finance the development of a simple management plan which constitutes the main element conditioning the signing of a final management convention. The 2009 reform will put an end to the control that some forest loggers already had on community forests for which they had funded the development of simple management plan. The end of the control over community forests of unscrupulous business men and logging companies will restore the forests to their transcendent socioeconomic and environmental roles. This will ultimately enable community forestry to contribute to strengthening the regulatory function of forests on the climate.

References

Arrêté n° 0518/MINEF/Cab du 21 décembre 2001 fixant les modalités d'attribution en priorité aux communautés villageoises riveraines de toute forêt susceptible d'être érigée en forêt communautaire.

CHARVIN, Robert, *L'investissement international et le droit au développement*, Paris, l'Harmattan, 2002.

EGBE, Samuel E, « The Concept of Community Forestry Under Cameroonian Law » *Revue Africaine de Droit International et Comparé,* 2000, vol.15, p.277 - 290.

ELONG, Joseph Gabriel, *Organisations paysannes des pouvoirs dans le Cameroun forestier,* Yaoundé, Presses Universitaires de Yaoundé, 2005.

Décret n°95/531/PM du 23 août 1995 fixant les modalités d'application du régime des forêts.

MINFOF, *Manuel des procédures d'attribution et des normes de gestion des forêts communautaires,* Février 2009.

MOUANGUE KOBILA, James, *La protection des minorités et des peuples autochtones au Cameroun : Entre reconnaissance interne contrastée et consécration universelle réaffirmée,* Paris, Dianoïa, 2009.

SINDJOUN, Luc, « Identité nationale et révision constitutionnelle : comment constitutionnalise-t-on le nous au Cameroun post-unitaire ? », *Polis,* 1996, p.10-24.

World Rainforest Movement, *Africa: forest under threat,* Montevideo, WRM, 2002.

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Land-use planning: A tool for ensuring food security in the face of climate change in Senegal

Cheikh Tidiane Touré[1]

Summary
The relevance of land-use planning tools such as the Land Use and Allocation Plan (LUAP)is more than ever a necessity to face challenges of natural resources degradation (water, soil and forest) the effects of which worsen food insecurity and climate changes. This resources degradation is mainly caused by the indiscriminate search for agricultural lands due to extensive farming. Land-use planning enables managers and practitioners to define the use of the areas (agricultural, forest, pastoral, and biodiversity). Compliance with this planning requires an agricultural intensification and respect for biodiversity. This will enhance progress in effectively tackling both climate change and food security issues.

Introduction

The preservation of biodiversity enables farmers, herders and natural resources practitioners to face climate change by boosting sustainable agriculture since conservation strategies embraces all aspects of biological diversity concept: species and races diversity, genetic potential (plant and animal), and ecosystems diversity.

First and foremost, three important elements should be highlighted:

- The management (exploitation) of biological resources was mainly limited to extraction of the biological potential to meet human needs through shifting agriculture, extensive breeding, unsustainable exploitation of wood energy and round wood, fishing and hunting.
- Secondly, in traditional settings, there is an erroneous idea according to which biological resources are inexhaustible (even though this conception of nature is increasingly fading away)
- The third aspect is the great reliance of agricultural production systems on rains with an extensive land exploitation system.

Eastern Senegal is generally characterized by a single rainy season that lasts from June to October, with a highly variable rainfall (intra and inter-annual). Crops occupy 53% of the total surface area of the region. This situation is the same in many countries of West Africa and represents a severe threat for food security since the lack of farmland, a consequence of the rapid population growth in these countries, inevitably leads to deforestation, leading to climate change. This article presents an innovative approach

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to land-use planning which is an efficient tool for ensuring food security in the face of the uncertainties of climate change.

Figure 1a : Cotton farming in Dindéfélo (Eastern region of Senegal)

Figure 1b : Excessive cutting of wood resources

Two traditional practices that contribute to reducing biological diversity and volume of resources (cotton farming and excessive cutting of wood resources)

Biodiversity management approach of the USAID/Wula Nafaa Programme

Faced with deforestation which accentuates the uncertainties of climate change, the USAID/Wula Nafaa Programme developed planning tools to manage natural resources and land-use in general. Among these tools, there is the Land Use Plan (LUP) which includes a programme supporting its development and implementation in rural communities (RC).

In the context of its partnership with some rural communities, the Programme provided them with support in developing the Local Convention for natural resources management. These conventions define the rules of access to the resources. To complete them, the LUPs define land-use rules.

The overall objective is to provide local communities with an institutional and technical tool for the sound management of their land area. The LUP supports an operational planning affordable by all actors and decision makers of the community; it is a tool to assist decision making in the analysis, planning and implementation of development programmes (including infrastructural development) at local level. Actually, the 96-06 Law transferring authorities to local communities, including environmental and natural resources management, grants powers to the three types of local communities for the management of resources.

Land-use Plan (LUP) Development Methodology

The methodology is based on a participatory approach. There are five major steps for its development:

Step 1: Sensitize and inform local communities on the objectives of LUPs
Analytically assess the community setting to establish preliminary contact with local people and authorities and determine programme implementation conditions.

These are ordinary duty tours of technical officers in the field, in order to contact the local managers of the Rural Council concerned and the representatives of the villages. If possible, there should be one session per zone. It should be emphasized that LUPs, which are part of the local conventions, are supported by the zoning of the Rural Community for a better implementation of local conventions.

Step 2: Complete the environmental study of the area of intervention
At this stage, zone meetings are held to perform the participatory diagnosis between the territory of the Rural Council and its natural resources. This will enable better understanding of how populations manage and protect their environment. It is also during these meetings that the local perceptions regarding the natural environment and its evolution are grasped. At the same time, all the bibliographical research on the rural community (maps, monographs, local development plan, …) with all the basic information and participatory diagnosis data are conducted. There is a need to establish the cartography of the physical environment and the administrative boundaries. At this stage, the community forests and biodiversity reserves desired will be identified.

Step 3: Data processing and analysis
Data processing and analysis allow a first cartographical representation by themes (localization, repartition and fragmentation and current land use). This representation will then be restored with the appropriate modalities to the populations concerned. This approach will facilitate a relatively comprehensive inventory regarding the activities and use mode of the space of the whole Rural Community. All this information will be reproduced on a series of three thematic maps, which are:

- Land and vegetation use map with the statistics of surface areas (water points/ponds/valleys, livestock corridors and holding grounds, existing fire walls, fishing and mining areas, mangroves, crops, vegetation typology);
- Zoning map (boundaries of existing reserved forests and leased zones; community forests and biodiversity or protection reserves to be established, boundaries of exploitation zones related to vegetations such as mangroves and *Saba senegalensis* i.e. "*madd"* galleries) superimposed with roads and the main villages;
- Map of inorganic elements (situation in the region and the country, communication ways, infrastructures, all the villages, administrative boundaries, wood and non-wood products collection and sale points, cultural sites).

Step 4: Restitution, validation of the cartographic elements and consensus seeking
The mapped information is subsequently compared with the vision and interpretation of the populations' environment and region during village assemblies in each zone. The definition of an initial situation (Situation 0) will be discussed as a reference to ascertain the progress, level of success, or even, the level of involvement of

populations in the implementation of the LUP. This stage appears essential, since it leads to the general acknowledgement of an initial situation that the community will attempt to improve through a set of actions.

The verification and validation of the units identified are performed in consultation with the populations and technical services (Water and Forests, Local Development Support Centre, etc.) and in presence of the following: the Sub-Prefect or his representative; the Chairperson of the Rural Council or his representative; and the representative of rural organizations. Any proposal for community forests or biodiversity protection zones is entertained. The missing data is integrated in the maps. The initiation of populations to map reading will be done as necessary.

Step 5: LUP Validation

Once the maps are validated by the populations and the summary maps and RC database are finalized, the process is carried forward by the development of the LUP Document submitted for deliberation and approval by the administrative authority.

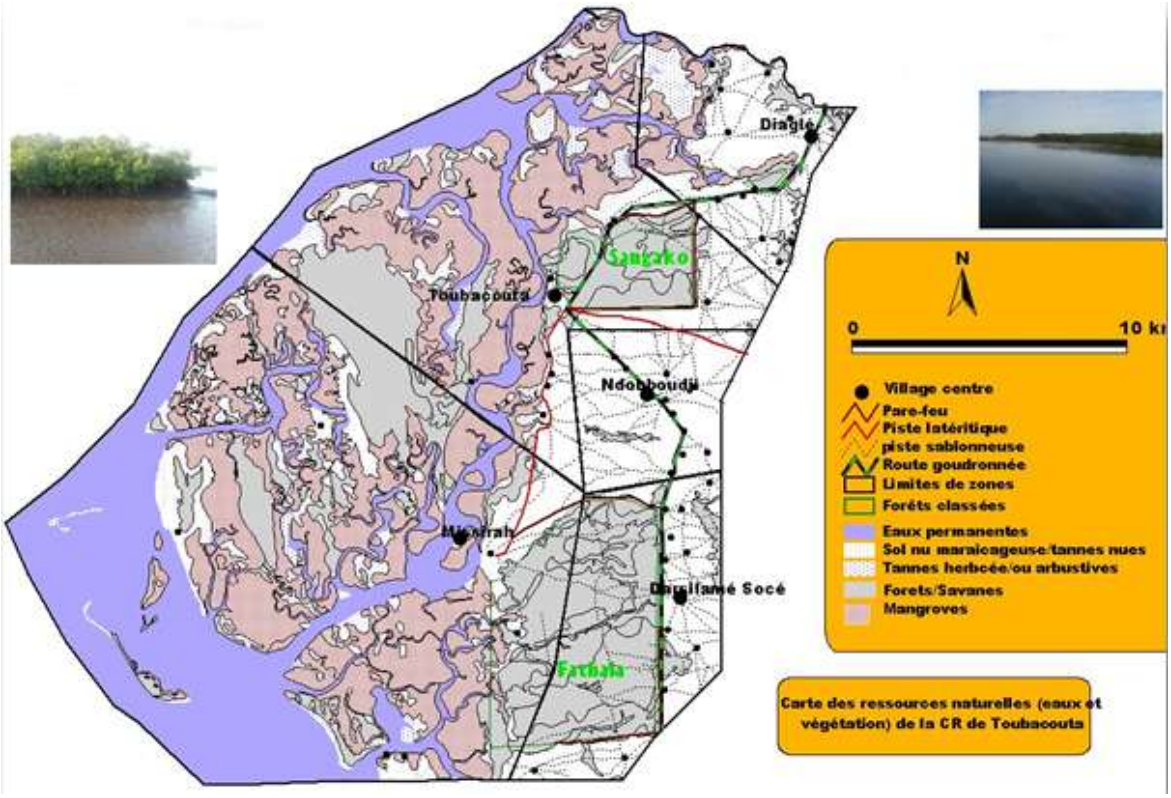

Figure 2: Resources map of the Toubacouta rural community

On the basis of observations and reactions recorded during the restitutions, mapped information presented will be amended and the final versions of the maps will be reprinted.

Land use decision

At the end of this process and with the help of this important decision-making tool, the communities identify the biodiversity protection zones and community forests for which management plans could be prepared (with exploitation and/or protection measures). These protection zones would allow for the preservation of the diversity of the biological resources as they have been deliberated over by the Rural Council and approved by the administrative authority.

Thus, homogenous plant formations with high economic value species such as bamboo parks will be identified and preserved. Their wise management, conservation and sustainable use will contribute to increasing the incomes of local populations. This is all the more important since poverty in rural areas is the main cause of forest resources degradation and, hence the increase of climate change impacts.

Figure 3a : Bamboo stands in Saré Bidii

Figure 3b : Medicinal plant (Icacina senegalensis)

Moreover, there is a regeneration of certain medicinal plants (e.g. *Icacina senegalensis)* which had previously disappeared, but are now flourishing and are being used by local people.

The region's resources and land areas should be managed in an ecologically sustainable manner in order to meet the social, economic, ecologic and cultural needs of the current and future generations, since there is an interaction between conservation actions and the economic activities of local populations. For example, in the areas were chimpanzees are found, the migration corridors have been identified and mapped. To better secure them, deliberations are adopted by the rural councils. Chimpanzees eat the *Saba senegalensis* (madd) and facilitate its regeneration in the gallery forests.

Figure 4a: Stone bunds

Figure 4b : Preservation of rice seeds

Figure 4c : Preservation of maize seeds

Figures 4a,b,c above show pictures of three examples of good practices in Eastern Senegal

This means that a strict enforcement of management rules in the conservation areas, as well as in the practice of environmentally-friendly agriculture contribute to improving community's resources.

Conclusion

Nowadays, climate change constitute a major challenge for the whole world in general and for developing countries in particular. The issue is not only to protect forests since the phenomenon that leads to deforestation is the search for agricultural lands. If we fail to find a palliative to this frantic search, people will continue to clear new lands. Then there would be a need to rethink land management. This ineluctably requires the exploitation of natural resources (Local Convention) and a judicious use of land (LUP) the main requirement of which is the agricultural intensification and protection of biodiversity areas. The implementation of such an approach should be accompanied by a sustained political will of the State through a decentralization policy.

BIBLIOGRAPHY

Guide d'élaboration et de mise en œuvre des conventions locales, Programme USAID Wula Nafaa, 28 pages, décembre 2008

Guide l'élaboration du plan d'Occupation et d'Affectation des Sols (POAS), Programme USAID Wula Nafaa, 12 pages, février 2009

Convention locale pour une gestion durable des ressources naturelles de la communauté rurale de Toubacouta, Programme USAID Wula Nafaa, 30 pages, janvier 2010 ;

Compte rendu de mission dans la zone de Salémata, Programme USAID Wula Nafaa, 15pages, février 2010 produit par Cheikh Tidiane Touré, Expert en Gestion de la Biodiversité et des aires protégées;

Rapport de l'atelier sur la conservation des espèces menacées (chimpanzés, Elan de derby) Programme USAID Wula Nafaa, 38 pages, Avril 2010 produit par Cheikh Tidiane Touré, Expert en Gestion de la Biodiversité et des aires protégées.

Improving traditional land use practices in dryland of Sudan in contribution to adaptation to climate change impacts

Elnour Abdalla Elsiddig[1]

Summary

Sudan is the largest country in Africa, extending over 2.5 million km² between latitude 3⁰ and 23⁰ N and longitude 22⁰ and 37⁰ E and is characterized by a diversity of conditions including deserts, representing 29% of the country's area with rainfall ≤ 100 mm/annum, and sahel zone, equivalent to 19%, with rainfall 100 – 300 mm/annum and the savannas (40% of Sudan), with rainfall 300 – 900 mm/annum. Forests play a significant role in land use practices. However, these are declining at high rates and their contribution to greenhouse gases (GHGs) emission in Sudan cannot be neglected. Continuous deforestation is resulting in major environmental and social impacts for rural communities, leading to increased vulnerability at local levels. Assessments of traditional land use practices and knowledge, and their relation to climate change impacts are essential in framing policies and developing sustainable adaptation strategies. In this respect, the role of participation of the different sectors' in information-sharing and knowledge-dissemination is essential. The objective of this paper is to analyze climate change scenarios in Sudan with respect to land use practices and knowledge, and their effects on adaptation to and mitigations of climate changes.

Methods: A review is made of deforestation and forest cover changes during 1958 – 2005. The carbon dioxide inventory in Sudan has been used to assess carbon dioxide emission trends from 1995 to 2000. Analysis of rainfall for the period (1930-2008) is presented to indicate rainfall variability over time in semi-arid areas and savannas, and its impacts on agriculture. A questionnaire interview was conducted with target groups (farmers and pastoralists) in selected rural areas, and links practices and knowledge to climate issues.

Results

Natural Resources: Sudan is characterized by dry land conditions which constitute areas with most vulnerable conditions to climate variability. The savannas cover the zones most populated and used for agriculture and forests, leading to continuous deforestation. Published studies of the forest cover in Sudan show a continuous decline from 40% (Harrison and Jackson 1958) to 28.6% (FRA 2005). Forests biomass changed from 2.4 billion m^3 within the 1970s (Brown and Wolf 1984) to 0.93 billion m^3 in 2005 (FRA 2005). Rates of annual deforestation of 0.4 – 0.7 million hectares are stated by various authors (World Bank 1985, FRA 2005, Daak 2007, Elsiddig *et al*. 2007). Adverse impacts and crises resulting from unplanned forest resource losses are reflected in declining agricultural productivity, scarcity of forest products and palatable range plants and loss in biodiversity. People in central Sudan are faced with rising prices of wood products that increased by almost 100 % for those who rely on market supply. For the poor people who collect wood from the forests, they at present, walk long distances and collect less than

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they need because of the scarcity of wood in fields. It is only the rich people who are able to use alternative energy like electricity, Liquefied petroleum gas (LPG) and kerosene.

Annual net Green House Gases emissions in Sudan are perceived as insignificant because emissions did not exceed 15.77 GgC between 1995 and 2005 (HCENR 2009). The contribution of the forestry sector in these emissions is high, amounting up to 75% of total emission. Climatic change impacts are clearly reflected in rainfall changes. Figure (1) shows the decreasing trend of rainfall within the savanna region of Sudan. . The Zero Line is used to represent the average annual rainfall for the period (1930 to 2008). Because of uncertainties in rainfall, agricultural yield is continuously declining from 1500 Kg/Ha in 1970s to 600 Kg/Ha in late 1990 to the present (Elsiddig 2006). Famine, hunger and internal displacement are some of the serious impacts on people livelihoods in Darfur, Southern Sudan and East Sudan. Conflicts and wars represent major impacts resulting from grain yield decline and famine. Decreasing productivity per unit area by 30 – 50% compelled farmers to increase cultivated areas in order to produce targeted quantities of grains (Elsiddig 2006).

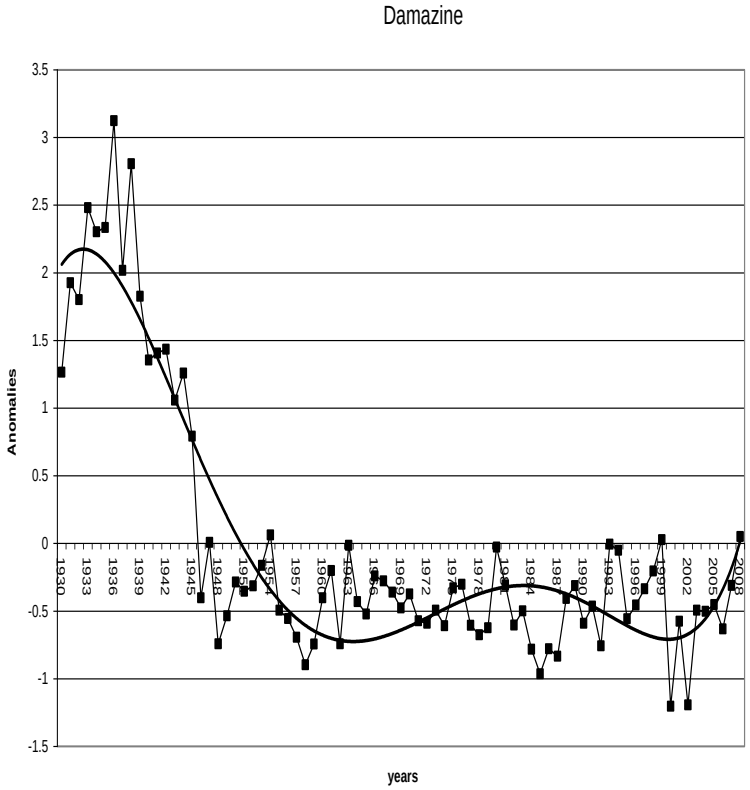

Fig.1. Rainfall variability over the period 1939 – 2008 in the savannas zone, Damazin area. (Source: Khyar 2008)

Agriculture: Changes in precipitation patterns are creating risks that threaten agriculture, food supplies and long-standing production techniques. Ecosystems, which are vulnerable to climate impacts, are becoming stressed due to intensive agricultural practices under uncertain conditions of rainfall. Crop yield in almost all semi-arid and savanna zones are directly correlated with the annual rainfall.

A case study in a locality in Kordofan State in Western Sudan, part of the low rainfall areas of the Savanna belt, shows that the total area cultivated annually by farmers with millet, sorghum and sesame falls in the range of 1.0 – 1.4 million feddans (1.0 feddan = 0.42 hectares), while the actual harvested area follows the pattern of precipitation (Figure 2).

Questionnaires interviews with farmers and key persons in most villages in Kordofan indicated that farmers were aware of rainfall variability in amount and distribution, but had limited knowledge about water harvesting technologies and access to drought resistant varieties. They cultivate their land with hopes that rainfall will enhance growth and yield for the total area they plant. It is very clear that Sudan is faced with big challenges to improve weather forecast systems needed to develop reliable predictions and to develop efficient technologies to produce quality drought resistant seeds in order to improve grain yield under dry land conditions. Increased yield per hectare results in reduced land area used for cultivation and consequently reduce emissions from deforestation.

The development of terraces around smallholdings agricultural land in the gum belt areas of western Sudan where the land accommodates scattered gum Arabic trees (*Acacia senegal*) agroforestry system, is perceived as efficient mean of water harvesting which increased the yield compared with non-terraced areas of mono-cropping system (Daak 2007). The terrace made as an embankment on the boundary of land holdings collects the rain water and results in higher moisture contents than non-terraced fields. In addition to increased grain yield, the gum tree produces more gum per single tree and results in increased income for the farmer.

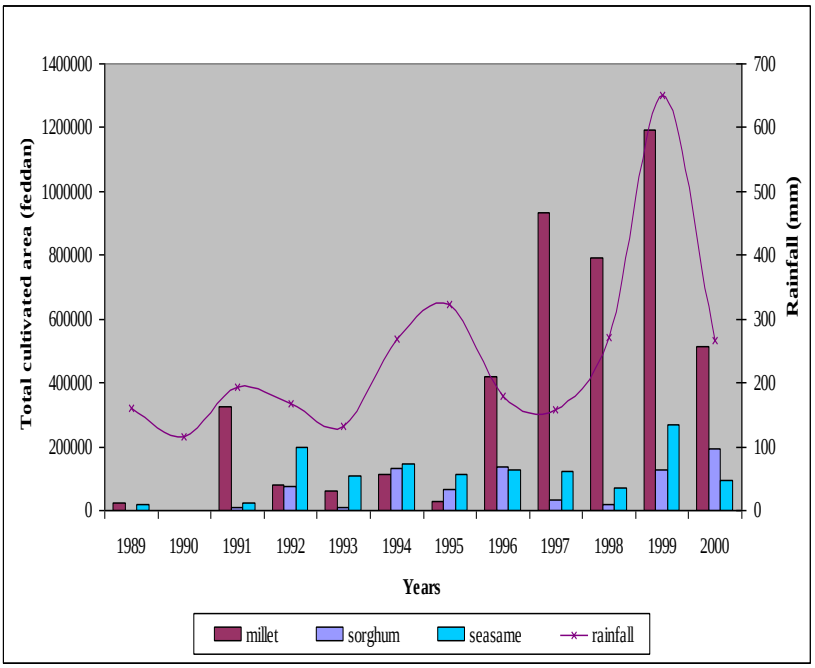

Fig 2: Cultivated area and pattern of harvested area in relation to annual rainfall in Kordofan 1989-2000; Source: Kheiry 2007

Energy saving innovations: The literature for Sudan contains numerous studies on environmentally-friendly intermediate technologies and innovative techniques for energy saving, which support adaptation to vulnerable conditions. Improved cooking stoves, and development of other activities related to food cooking (soaking of beans before cooking, shielding of stoves against wind, covering burning charcoal with ash) are examples. Figure (3) shows three types of household cooking stoves in Sudan (right and middle), efficiencies for the two most used (left).

Figure 3. (right) Cooking stoves: traditional three-stones stove; (middle) traditional metal stove and improved clay stove "Kanoon Elsirur"; (left) bar chart showing levels of energy efficiency of the traditional metal and improved clay stoves. (Source: Practical Action 2008)

Environmental changes are strongly linked to human livelihoods everywhere in the Sudan. Consequently, knowledge about risks and impacts are part of the communications within and between communities disseminated by direct diffusion through social contacts between farmers, nomads and settled public groups or through mass media. Various aspects of climate issues are mentioned in daily newspapers, including water problems, climate change science and impacts. In addition there are some awareness campaigns conducted by development institutions and some donor funded projects that contribute to knowledge dissemination among rural communities (Abdel Magid and Elsiddig 2003). It is through these communication systems that knowledge about good practices can be transferred and , and probably lead to improvements for the communities.

Conclusion

Sudan is a country where innovative land use practices, such as use of wood energy-saving techniques, are useful in reducing deforestation. Water harvesting practices and agro-forestry systems too, are efficient in conserving water and in many cases resulting in improved yield of grains, and increasing peoples' resilience against adverse weather impacts. Sustainable development in land use necessitates integrated approaches and

successful practices founded on comprehensive long term environmental strategies and land use patterns that are based on community participation and knowledge transfer. Sudan has accumulated extensive experiences in forest and other natural resources development based on improved cooking stoves. The clay stove captioned *Kanoon Elsirur* (see Figure 3, the clay stove next to the bar chart) is a successful experience in wood energy saving in central Sudan . These positively effective practices should be supported by legal, institutional and strategic framework. . It is recommended that efficient communication systems be developed so as to facilitate knowledge transfer and enhance good practices to improve peoples' adaptive capacities to climate change impacts.

References

Abdel Magid, T. D. and El Siddig, E. A. 2003. Social Forestry in Sudan, Its Current Status and Future Potential. Paper published in the 12th World Forestry Congress, Canada

Brown, R. L. and Wolf, E. C., 1964. Reversing Africa decline. World Watch Paper 65.

Daak, A.A. 2007., Detection of vegetation cover change using remote sensing and GIS system. MSc. Thesis, Faculty of Forestry, Univ. of Khartoum, Shambat.
Elsiddig, E.A. 2006. Second informal dialogue on the role of LULUCF in CCR Spain 19 – 21 April 2006.

Elsiddig E.A. Mohamed A. G. and Abdel Magid T. D., 2007, Sudan forestry sector review. Forests National Corporation, National Forest Programme Facility.

FRA 2005, Forest Resource Assessment, FAO forestry paper

Harrison, M. H. and Jackson, J. K., 1958, Ecological classification of the vegetation of the Sudan For. dept. (Sudan) Bull. No: 2, 45pp.

Higher Council for Environment and Natural Resources (2009). Sudan National Communication report 2009.

Kheiry N.A. 2007 2010. Monitoring and mapping desertification process in North Kordofan by spectral mixture analysis. PhD thesis, Dresen University.

Khyar A. 2008. Sudan Meteorological Corporation data, 1939 – 2008.

Practical Action 2008. Traditional women innovations on energy efficiency. A workshop 2008.

World Bank 1985, Sudan forestry Sector Review. Report No: 5911 – Sudan.

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Wildlife management in Gonarezhou National Park, Southeast Zimbabwe: Climate change and implications for management

Edson Gandiwa[1] and Patience Zisadza[2]

Created in 1968 in Zimbabwe, the Gonarezhou National Park (GNP) is a protected area dedicated to the conservation of wildlife resources. This paper offers insights in wildlife management and issues related to climate change and the associated implications to wildlife management in the GNP.

Introduction

Climate change is not a new phenomenon; the only constant about climate throughout Earth's history is that it has changed (Marchant, 2010). An earlier study in Africa indicated that some Southern African ecosystems are highly sensitive to climate change (*e.g.*, Magadza, 1994). Climate change in Africa is expected to lead to higher occurrence of severe droughts in semiarid and arid ecosystems (Foley *et al*., 2008). For instance, a severe drought associated with the El Niño-Southern Oscillation phenomenon was recorded in 1991–92 in Southern Africa. In Zimbabwe, the most affected areas in terms of wildlife and ecological systems in the 1991–92 drought were recorded in the southeastern parts of the country (Magadza, 1994).

Climate change directly affects ecosystems through seasonal increases in air temperature and changes in precipitation and indirectly through the effect of climate change on disturbances such as fire and drought (IPCC, 2007). Meteorologically, a drought may be defined as occurring in an area receiving an amount of less than 75% of the mean annual rainfall while an amount greater than 125% is regarded as 'abundant rainfall' (Zambatis & Briggs, 1995). As the climate continues to change, there will be biodiversity shifts and the ranges and distribution of many species will change, with resulting effects on availability, accessibility and quality of resources upon which human and wildlife populations rely on. This will have implications for the protection and management of wildlife, habitats, protected areas and forests (Prowse, 2009). Climate change has rendered wildlife more vulnerable to ecological disasters (Yu, 2010). For ecosystems, the ability to adapt to climate variability and change is influenced by local characteristics such as topography and micro-refugia, existing biodiversity, presence of invasive species, the successional ecosystem state and fragmentation of the landscape among other factors (Joyce *et al*., 2009).

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Therefore, understanding the range of natural variability and ecosystem response to this, has a key role for the future management of ecosystems, including savannas, which are the focus of this paper. A defining feature of savanna ecosystems is the coexistence of trees and grasses in the landscape (Scholes & Archer, 1997). In this paper, we refer to woodland as a savanna ecosystem that has many trees. The paper provides an overview of climate change related influences, their implications on the management of the wildlife resources and provides recommendations to address critical and increasing climate change threats in the Gonarezhou National Park (GNP) in Zimbabwe.

Background to the Gonarezhou National Park

Created in 1968, the GNP is a protected area for wildlife conservation in southeast Zimbabwe (Figure 1). The park covers 5053 km^2 and lies between latitudes 21° 00'–22° 15' S and longitudes 30° 15'–32° 30' E. Altitude varies between 165 and 575m above sea level.

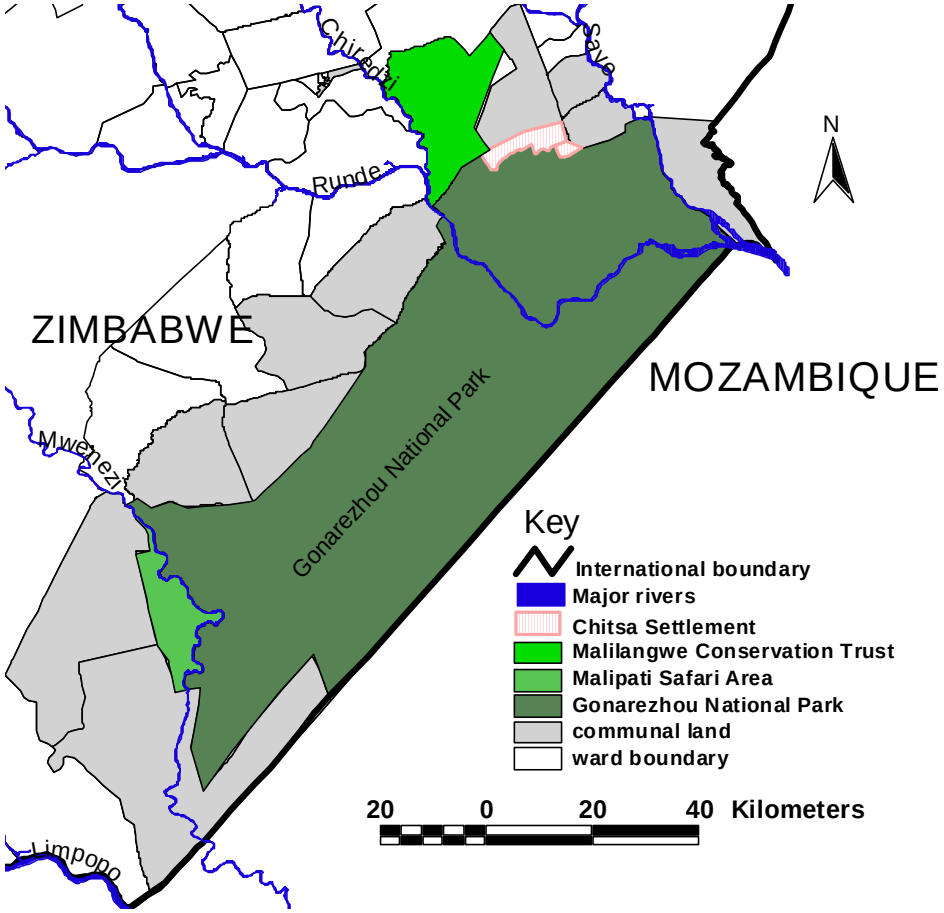

Figure 1: Location of the Gonarezhou National Park and surrounding areas in southeast Zimbabwe

GNP has a hot and semi-arid climate, with a highly seasonal rainfall. A significant feature of the rainfall is its unreliability, both in terms of quantity and duration. Average annual precipitation for the park is 466 mm. The variation from year to year is great and the annual rainfall can range from 20% to 200% of this total (Tafangenyasha, 1998). There are marked seasonal fluctuations in rainfall suggesting that severe droughts might occur at least once in every 15 years (DNPWM, 1998; Figure 2). Three climatic seasons can be recognized: hot and wet (November to April), cool and dry (May to August) and hot and dry (September to October). Average monthly maximum temperatures are 25.9 °C in July and 36 °C in January. Average monthly minimum temperatures range between 9 °C in June and 24 °C in January. Prevailing winds are south-easterly, with wind speeds of between 11 and 17 km per hour.

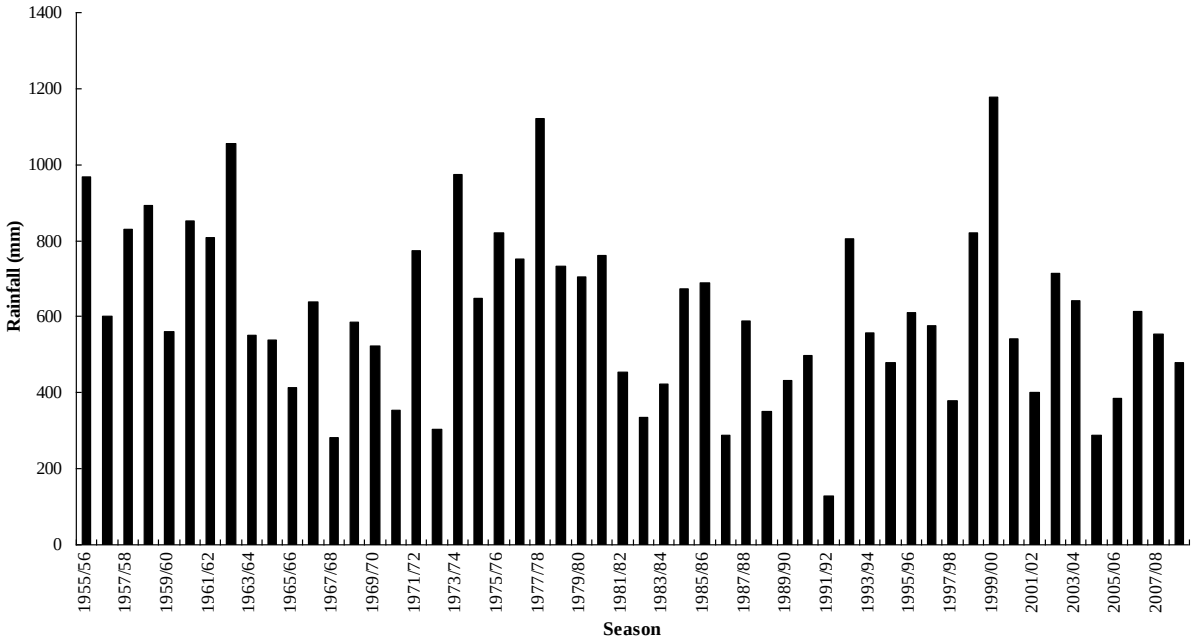

Figure 2: Seasonal rainfall recorded at Buffalo Range Airport adjacent to Gonarezhou National Park, Zimbabwe for the period 1955–2009. Data are from the Meteorological Services Department of Zimbabwe.

The high temperatures and clear skies which prevail for much of the year in GNP lead to high evaporation and prevent the accumulation of moisture in the soil (Tafangenyasha, 2001). Consequently, the vegetation of GNP is typical of semi-arid *Colophospermum mopane* zone (Rattray & Wild, 1955) and is predominantly dry deciduous savanna woodland of varying types (Wild & Barbosa, 1968). The vegetation fluctuates between three phases: woodland, scrub and grassland, due to the influence of browsers, grazers, fire, frost, rainfall and human activities (Farrell, 1968; Tafangenyasha, 1997). Physiognomic vegetation types in GNP are woodland savanna (59%), scrubland (40%) and savanna grassland (1%) (DNPWM, 1998). The plant checklist for GNP includes at least 924 species from 118 families and 364 genera, with 265 trees, 310 shrubs, 55 woody climbers and 137 grasses (DNPWM, 1998). The plant

checklist also includes some plant species that are endemic to the GNP. The more extensive plant communities in GNP are described by Sherry (1977). Table 1 shows the major plant communities in GNP and a classification on the ability of the plant communities to resist drought based on evidence from the field.

Table1: Major plant communities in GNP and classifications on their ability to resist drought. Data on plant communities are from Sherry (1977). Note: High–means high capacity to resist drought; Medium–means intermediate capacity to resist drought; Low–means low capacity to resist drought

Plant community	Ability to resist drought
1. *C. mopane* woodland	High
2. *C. mopane* scrub	High
3. *C. mopane*: sandveld ecotone complex	High
4. Dry deciduous sandveld woodland and scrub	High
5. *Brachystegia glaucescens* woodland	Medium
6. *Julbernadia globiflora* woodland	High
7. *Androstachys johnsonni* thicket	Low
8. *Guibourtia conjugata* woodland	High
9. *G. conjugata* and *Baphia obovata* thicket	High
10. *Combretum* bush savanna	High
11. *Acacia nigrescens* tree savanna	Medium
12. Riverine and alluvial woodland	Medium
13. *Spirostachys* woodland and *Terminalia prunoides* woodland	Low
14. *Milletia stuhlmannii* woodland	High
15. Rivers with phragmites reed beds and *Ficus capreifolia*	Medium
16. Streams and pans with *Spirostachys africana* characteristic	Low

The GNP has a diverse vertebrate fauna that includes mammals (at least 31 families, 71 genera and 84 species); birds (at least 71 families, 219 genera and 400 species); reptiles (at least 17 families, 51 genera and 76 species); amphibians (at least 4 families, 17 genera and 28 species) and fish (at least 19 families, 31 genera and 50 species) (DNPWM, 1998). The mammal fauna include 23 large herbivores and 8 carnivore species. However, although populations of browsers/grazers such as eland (*Taurotragus oryx*), giraffe (*Giraffa camelopardalis*), nyala (*Tragelaphus angasii*), waterbuck (*Kobus ellipsiprymnus*) and wildebeest (*Connochaetes taurinus*) are low for a park the size of GNP they are increasing and elephants (*Loxodonta africana*), hippopotamus (*Hippopotamus amphibius*), zebra (*Equus burchelli*), kudu (*Tragelaphus strepsiceros*) and buffalo (*Syncerus caffer*) are also increasing (Dunham *et al.*, 2010). Table 2 shows the present population abundances of selected wildlife species in GNP. About 1500 elephants died during the 1991–92 drought, much reducing the population in the GNP (Tafangenyasha, 1997). In addition, several other wildlife populations in the GNP suffered significant mortality in the 1991–92 drought (Leggett, 1994).

Table 2. Population estimates and statistics of selected large herbivores in Gonarezhou National Park, Zimbabwe. Data on wildlife populations are from Dunham et al. (2010). Note: High–means high capacity to resist drought; Medium–means intermediate capacity to resist drought; Low–means low capacity to resist drought

Species	Population estimate	Population range (lower and upper confidents limits)	Ability to resist drought
Elephant	9123	7221–11025	Low
Buffalo	2274	337–4212	Low
Eland	317	66–698	Low
Giraffe	251	96–405	Low
Kudu	2285	1607–2963	Low
Nyala	370	182–558	Low
Waterbuck	360	52–668	Low
Zebra	1385	965–1804	Low
Wildebeest	364	66–663	Low
Hippopotamus	277	120–560	Low

The bird community in the GNP include an array of (i) large birds including raptors, vultures and ostrich (*Struthio camelus*) and (ii) birds associated with habitats linked to the larger river systems and adjacent water pans such as pelicans, plovers, storks and fish owls (DNPWM, 1998). It is probable that the later group of birds is likely to be negatively affected by climate change as a result of reductions in precipitation, flow regime changes and changes in the pan system in terms of water availability and water holding capacity.

Climate change and wildlife management in Gonarezhou National Park

The local ecosystems are currently experiencing changes in several facets, which have the potential consequences on the health of wildlife and humans (*e.g.*, Acevedo-Whitehouse & Duffus, 2009) and the GNP is not an exception. The increasing rates of disease, both infectious and noninfectious, in wildlife is of great concern since disease may be an indication that populations are in a state of stress which is negatively affecting immune functions (Acevedo-Whitehouse & Duffus, 2009). Shifting environmental conditions will likely mean the appearance of new wildlife-transmitted diseases to humans and livestock and redistribution of some existing diseases. For example, the recent emergence of bovine tuberculosis in wildlife in the GNP is of major concern for the management in the GNP and in the adjacent areas (de Garine-Wichatitsky *et al.*, 2010).

The effects of climate changes and fluctuations on savanna ecosystems can be seen in the extensive 1991–92 drought that extended across the GNP ecosystem decimating herbivore populations and negatively affecting the livelihoods of people living within and adjacent to GNP. An earlier study in the GNP by Leggett (1994) provided evidence that extreme climatic events such as the 1991–92 drought can strongly negatively affect elephant populations. Large mammals such as elephant, buffalo, hippopotamus and the large antelopes are likely to be threatened by climate change (Magadza, 1994).

Several climatic change related impacts have been recorded in GNP ecosystem before, during and after the 1982–84 and 1991–92 droughts. For example, firstly, competition from invading species have been recorded, particularly, plant invasions, which are affecting terrestrial and freshwater communities (*e.g.*, Chatanga, 2007). Secondly, changing fire regimes in the park (Tafangenyasha, 2001; Gandiwa & Kativu, 2009). Thirdly, changing nutrient concentrations in major rivers, changes in aquatic habitats, surface water availability and river flow regimes (Tafangenyasha & Dube, 2008). Fourthly, tree loss and mortality of many tree species including the rare *A. johnsonii, B. glaucescens* and the succulent *Euphorbia cooperi* during the 1991–92 drought (Magadza, 1994; Tafangenyasha, 1997) and differences in the phenology of plants (Tafangenyasha, 1998). Additionally, although the carnivore populations can do well during drought periods in a protected area such as GNP, it is possible that the lack of prey species after drought periods can lead to aggravated human–wildlife conflict as the carnivores turn to domesticated stock as a food source in cases where animal re-introductions are not quickly made.

Perceived impacts of climate change on ecosystem integrity

Climate change has an increasing impact on the distribution and functioning of species and habitats within the GNP. This has important implications for conservation practices and policy adherence and formulation in the area, within the context of transboundary natural resources management. Aquatic species and habitats in the GNP seem to be the most sensitive ones to climate change. Other habitats in upland areas and species occurring in the northern part of GNP also show signs of sensitivity and losses, which are confined to specific vegetation communities', *e.g.*, those dominated by *A. johnsonii* species.

Sensitivity to climate changes in GNP ecosystem also needs to be viewed alongside vulnerability, i.e., the ability of given species or habitats to adapt to climate change. Riparian habitats and isolated water pans scattered throughout the park are the most vulnerable ones since they have limited adaptation possibilities. The GNP pan ecosystems are home to endangered turquoise killifish *(Nothobrancius furzeri*) and changes in rainfall variability through seasons is a cause for concern (DNPWM, 1998). Birds are also responding to climatic variability and changes in the GNP, as evidenced by the recent sighting of some bird species that are known to be endemic to the East-African Coast in the GNP, e.g. the lemon-breasted canary (*Serinus citrinipectus*), whose population size seems to be increasing. Climate changes have thus resulted in habitat expansion for some species and shrinkage of home ranges for some other species.

Discussion

The future character of savannas, given their dynamic ecology, complexity of human–ecosystem interaction and response to atmospheric, climatic and land use change is uncertain (Marchant, 2010). Managing wildlife under uncertainty about the nature and extent of climate change and variability and its potential adverse impacts on wildlife poses a daunting challenge to wildlife managers (Prato, 2009). For management in the GNP, the ability to adapt is influenced by experience and training, availability of staff and financial resources, incentives, institutional flexibility and public support.

Under continually changing climates, there will be a recurrent need to strategically adjust management goals and objectives in the GNP. It may not be possible to manage or adapt to the effects of climate change on the ecosystems and species. The decision not to manage for a particular species or ecosystem service might reflect a project or management so costly to undertake, fraught with failure that it renders other projects impossible to undertake by virtue of absorbing all available resources. Where climate change is going to have a significant effect on economically and culturally important species, for example elephants, they will have significant effects on people, local and regional economies. According to Joyce *et al*. (2009), the focus then might shift from maintaining existing ecosystem services to management that supports natural adaptive processes of given species, such as facilitating species migration or long-term seed bank storage for re-establishing populations in new and more ecologically suitable locations.

Although the current protected area network in southeast Zimbabwe and the Great Limpopo Transfrontier Conservation Area (GLTFCA) provides an important conservation direction, further expansion of this network is limited by competing demands for other land use options. The GLTFCA is a transboundary conservation area that straddles the borders of Mozambique, South Africa and Zimbabwe covering approximately 100,000 km^2 (Spenceley, 2006). The GLTFCA development was motivated by multifaceted objectives that include ecological, social and economical objectives. Therefore, conservationists in GNP and surrounding countries, i.e. Mozambique and South Africa, need to strengthen and operationalise the GLTFCA initiative. For effective wildlife species conservation, there is need to improve the ability of the animals to migrate by creating large management units and broad corridors, through initiatives such as GLTFCA.

Recommendations

Predicting the consequences of global environmental change on biodiversity is a complex task mainly because the effects encompass multiple and complex dynamic processes that rarely require single and clear-cut actions. Rather, the various effects appear to interact between them and can even have additive costs (Acevedo-Whitehouse & Duffus, 2009). Therefore, wildlife managers and policy makers need the best available data and analytical tools to create appropriate policy, legislation and management (DeWan & Zipkin, 2010).

We therefore recommend that GNP management: (i) gives priority to developing integrated, field-based monitoring and research programs, which aim to develop predictive models to allow for more detailed and comprehensive projections of possible climatic changes and their effects on the GNP ecosystem, (ii) focus on the development and implementation of appropriate adaptation of management strategies to climate change, wildlife and habitat conservation strategies. Furthermore, ecology, ecosystem modelling, archaeology and palaeoclimate research need to be woven together in a cross-disciplinary effort to assess the range of natural environmental variability and associated response of savanna ecosystems to environmental shifts in the past, at the present and into the future (Marchant, 2010). Finally, the training and employment of additional competent staff at all levels to carry

out biodiversity surveys, research, education and daily ecosystem management should be given priority.

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References

Acevedo-Whitehouse, K. and Duffus, A.L.J. (2009). Effects of environmental change on wildlife health. *Philosophical Transactions of the Royal Society of Biological Sciences,* 364: 3429–3438.

Chatanga, P. (2007). Impact of the invasive alien species, *Lantana camara* (L). on native vegetation in northern Gonarezhou National Park, Zimbabwe. MSc. Thesis, University of Zimbabwe, Harare.

de Garine-Wichatitsky, M., Caron, A., Gomo, C., Foggin, C., Dutlow, K., Pfukenyi, D., Lane, E., Le Bel, S., Hofmeyr, M., Hlokwe, T. and Michel, A. 2010. Bovine tuberculosis in buffaloes, Southern Africa. *Emerging Infectious Diseases,* 16(5): 884–885.

Department of National Parks and Wildlife Management (*cited as DNPWM*) (1998). Gonarezhou National Park Management Plan 1998-2002. Government Printers, Harare, Zimbabwe.

DeWan, A.A. and Zipkin, E.F. (2010). An integrated sampling and analysis approach for improved biodiversity monitoring. *Environmental Management,* 45:1223–1230.

Dunham, K.M., van der Westhuizen, E., van der Westhuizen, H.F. and Gandiwa, E. (2010). Aerial Survey of Elephants and other Large Herbivores in Gonarezhou National Park (Zimbabwe), Zinave National Park (Mozambique) and surrounds: 2009. Parks and Wildlife Management Authority, Harare.

Farrell, J. K. (1968). Preliminary notes on the vegetation of the Lower Lundi basin, Rhodesia. *Kirkia,* 6: 223–250.

Foley, C., Pettorelli, N. and Foley, L. (2008). Severe drought and calf survival in elephants. *Biology Letters,* 4: 541–544.

Gandiwa, E. and Kativu, S. (2009). Influence of fire frequency on *Colophospermum mopane* and *Combretum apiculatum* woodland structure and composition in northern Gonarezhou National Park, Zimbabwe. *Koedoe*, 51(1), Art. #685, 13 pages.

Intergovernmental Panel on Climate Change (*cited as IPCC*) (2007). Summary for policymakers. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (Eds.), Climate change 2007: Physical science

basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, 996 pp.

Joyce, L.A., Blate, G.M., McNulty, S.G., Millar, C.I., Moser, S., Neilson, R.P. and Peterson, D.L. (2009). Managing for multiple resources under climate change: national forests. *Environmental Management,* 44:1022–1032.

Leggett, K.E.A. (1994). Implications of the drought on elephants in Gonarezhou National Park: A preliminary report on the Raleigh International Expeditions 93K and 94B to Gonarezhou National Park, September 1993 to May 1994. Report to the Department of National Parks and Wild Life Management, Harare, Zimbabwe.

Magadza, C.H.D. (1994). Climate change: some likely multiple impacts in Southern Africa. *Food Policy,* 19(2): 165–191.

Marchant, R. (2010). Understanding complexity in savannas: climate, biodiversity and people. *Current Opinion in Environmental Sustainability,* 2:101–108.

Prato, T. (2009). Evaluating and managing wildlife impacts of climate change under uncertainty. *Ecological Modelling,* 220: 923–930.

Prowse, T.D., Furgal, C., Wrona, F.J. and Reist, J.D. (2009). Implications of Climate Change for Northern Canada: Freshwater, Marine, and Terrestrial Ecosystems. *Ambio,* 38(5): 282–289.

Rattray, J. M. and Wild, H. (1955). Report on the vegetation of the alluvial basin of the Sabi valley and adjacent areas. *Rhodesia Agricultural Journal,* 52: 484–501

Scholes, R.J. and Archer, S.R. (1997) Tree-grass interactions in savannas. *Annual Review of Ecology and Systematics,* 28: 517–544.

Sherry, B. Y. (1977). Basic vegetation types of the Gonarezhou National Park, Zimbabwe. Project No. GNP/3Y/2. Zimbabwe: Department National Parks and Wildlife Management.

Spenceley, A. (2006). Tourism in the Great Limpopo Transfrontier Park. *Development Southern Africa,* 23(5): 659–667.

Tafangenyasha, C. (1997). Tree loss in the Gonarezhou National Park (Zimbabwe) between 1970 and 1983. *Journal of Environmental Management,* 49: 355–366.

Tafangenyasha, C. (1998). Phenology and mortality of common woody plants during and after severe drought in south-eastern Zimbabwe. *Transactions of the Zimbabwean Scientific Association,* 72: 1–6.

Tafangenyasha, C. (2001). Decline of the mountain acacia, *Brachystegia glaucescens* in Gonarezhou National Park, southeast Zimbabwe. *Journal of Environmental Management,* 63: 37–50.

Tafangenyasha, C. and Dube, L.T. (2008). An investigation of the impacts of agricultural runoff on the water quality and aquatic organisms in a lowveld sand river system in southeast Zimbabwe. *Water Resources Management*, 22:119–130.

Wild, H. and Barbosa, L.A.G. (1968). Vegetation map of the flora Zambesiaca area. Supplement to Flora Zambesiaca, M.O. Collins, Harare.

Yu, X. (2010). Biodiversity conservation in China: barriers and future actions. *International Journal of Environmental Studies,* 67(2): 117–126.

Zambatis, N. and Briggs, H. C. (1995). Rainfall and temperatures during the 1991/92 drought in the Kruger National Park. *Koedoe,* 38: 1–16.

COUNTRY FOCUS: Chad

"The Republic of Chad, 1,284,000 square kilometres in size is in north central Africa. The country's capital is 1,060 km from the nearest seaport Douala in Cameroon. It is divided into multiple regions: a desert zone in the north, an arid Sahelian belt in the centre and a more fertile Sudanese savanna zone in the south. Lake Chad, after which the country is named, is the second largest wetland in Africa (Okavango Delta in Botswana is the largest wetland in Africa). Most Chadians derive their livelihoods as subsistence herders and farmers. Since 2003 crude oil has become the country's primary source of export earnings, superseding the traditional cotton industry."[1]

Nadji Tellro WAÏ[2]***,*** *Director of Biodiversity Conservation and Climate Change Adaptation and Coordinator of the National Adaptation Programme of Action to Climate Change (NAPA) talks about the key issues of climate variability and change in Republic of Chad.*

***Nature & Faune*: Briefly present to our readers the extent to which climate change is felt in your country Chad in general, and specifically in the water, fisheries, forestry and livestock sectors.**

Nadji Tellro Waï (NTW): Even though climate change is viewed as a global issue, its impacts are very dramatically felt in the most vulnerable Least Developed Countries, the majority of which are in Africa. With a surface area of 1,284,000 km² and a

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population of about 11 million, Chad has three different bioclimatic zones subjected to the adverse effects of climate change such as droughts, floods, sand storms, and extreme temperatures.

Rainfall variations also show that the 1950-70 decades correspond to rainy periods, while from the 1970's to the present, the decrease in rainfall trend has worsened.

In view of these observed climatic risks, the water resources of lakes and permanent watercourses have declined or totally disappeared for some, and changed their hydrological regimes for others.

The agro-sylvo-pastoral and fisheries sectors which constitute the basis of our country's economy are the most affected, leading to food insecurity, loss of human lives and biodiversity, migration of populations and livestock which lead to several conflicts between the various communities of farmers, breeders and even fishermen.

What is Chad doing to address these felt impacts of climate change and variability?

NTW: Following the example of other Least Developped Countries Chad is preparing to reduce its vulnerability to climate change and variability. Thus, urgent and immediate needs to face challenges of climate change have been developed with the support of the Global Environmental Fund and are included in the National Adaptation Programme of Action (NAPA) for Chad. These needs were expressed in terms of projects as adaptation measures reflecting the choice made by the local communities in the three bioclimatic zones. As a reminder, Chad's NAPA finalized in November 2009 is posted on the website of the United Nations Framework Convention on Climate Change (UNFCCC).

Is there any international community involvement in addressing Climate change issues in Chad?

NTW : Yes, the international community is actively involved in the issue of climate change thanks to UNDP's technical, technological, financial and logistical support through its national office in Ndjamena and its regional office in Dakar, ENDA Tiers Monde based in Dakar, the United Nations Institute for Training and Research (UNITAR), the Regional AGRHYMET Centre, ACMAD, and FAO, among others.

Please inform our readers of any impact of climate change on Lake Chad.

NTW: The impacts of climate variability on Lake Chad are numerous. The most important among them are: difficulty in accessing water at local level; deficit harvests; livestock depletion; collapse of fisheries; decrease of the use of wetlands; increase of soil salinity; destruction of the plant cover and; degradation of the biodiversity across the region.

The problems and challenges you enumerated are huge and cross-boundary in nature; what are the existing institutional arrangements to address these problems?

NTW: At sub-regional level, regarding the transboundary challenges and issues, the various existing institutions have integrated the adaptation and alleviation aspects in their regional programmes and projects as illustrated in the cases of the Niger Basin Authority, the Lake Chad Basin Commission, the Central African Economic and Monetary Union, etc. It should also be noted that the Government of Chad recently set up a new technical Directorate through the Ministry of Environment and Fishery Resources named "Directorate for the Conservation of Biodiversity and Adaptation to Climate Change" symbolizing our country's fight against negative climate change impacts.

What are these institutions (e.g. the Lake Chad Basin Commission) doing to address these problems?

NTW: Among the numerous examples, we can mention two adaptive activities by the Lake Chad Basin Commission to face the effects of climate change. They are the project for the transfer of water from Oubangui towards Chad for the restoration of its level in order to revitalize the various ecosystems, on the one part the formulation of the water charter enabling the use of the basin's water resources in an equitable manner for the sustainable development of more than thirty million people. These are good examples of the fight against the adverse effects of climate change.

Let's talk about the recent Lake Chad Basin Summit held from 29 October to 1 November 2010. Was there any resolution related to climate change?

NTW : The Africa Session of the Eighth World Forum Summit on Sustainable Development for the preservation of Lake Chad of which the objective was to reflect, analyze and propose solutions to reverse the land and water degradation trend of this ecosystem, adopted resolutions.

These relevant proposals generated during the working sessions of internationally renowned scientists from Chad, Africa, Europe, America and Asia, were adopted by the Heads of States and of Governments. They are, among others:

- The sand removal and development of Lake Chad and of its tributaries (Rivers Logone Chari and Koumadugu-Yobé) are the early stages of water transfer;
- The interbasin transfer of waters from the Oubangui to Lake Chad;
- The maintenance and optimization of all agricultural, pastoral, touristic, fishing and trade activities;
- The rehabilitation of improved living conditions for Lake Chad riparian communities: access to potable water, health, education, transportation, trade, etc.;
- Registration of Lake Chad as World Heritage.

You will agree with me that all these resolutions are geared towards fighting the effects of climate change.

Cereals are produced in Chad as subsistence crops by a multitude of small holder farmers using traditional methods of production systems. How is this fragile production system coping with climate change and variability? What are the initiatives taken by the government and other actors (e.g. NGOs, private sector and donor community etc) to help subsistence farmers overcome the adverse situation?

NTW : In view of the climatic risks usually observed and mentioned above, the production systems currently in use are aligned to the climatic seasonal variation. For example new drought-resistant crop varieties have been adopted in the various bioclimates of the country. The use of flood-recession crops in the floodplains of depression zones as well as in fluvial floodplains is also the standard practice today.

To promote these initiatives, the government of Chad established a Ministry in charge of micro-finance which is yielding promising results. This initiative of the Government is supported by several of its partners intervening in various development sectors.

Thank you Mr. Wai, for sharing your insight, knowledge and experiences on the ramifications of climate change in Republic of Chad.

FAO Activities

In each issue, this page presents one or two key activities of FAO related to the theme.

Africa crop tool launched; interactive 43-nation guide on what to plant, when and where! As well as crops, it advises on tried and tested seed varieties that are adapted to the soil and climate conditions of each area. A key mandate of the FAO is "to raise levels of nutrition, improve agricultural productivity, better the lives of rural populations and contribute to the growth of the world economy". This is important for African countries vulnerable to climate change as FAO advocates for synergies between mitigation, adaptation and sustainable use of natural resources for increased production, income and food security.

In pursuit of realization of its mandate, FAO has launched a quick reference calendar covering 43 major African countries that advises which crops to plant when, according to the type of agricultural zone from drylands to highlands. The web-based tool, developed by FAO experts, covers more than 130 crops from beans to beetroot to wheat to watermelon. It is aimed at all donors, agencies, government extension workers and non-governmental organizations working with farmers on the continent.

The FAO crop calendar is especially useful in case of an emergency such as drought or floods or for rehabilitation efforts following a natural or manmade disaster. As well as crops, it advises on tried and tested seed varieties that are adapted to the soil and climate conditions of each area. "Seeds are critical for addressing the dual challenges of food insecurity and climate change," said Shivaji Pandey, Director of FAO's Plant Production and Protection Division. "The right choice of crops and seeds is crucial both for improving the livelihoods of the rural poor and hungry and for dealing with climate change. To be able to make that choice, you have to make sure seeds and planting materials are available and accessible at the right place and at the right time."

There are 283 agro-ecological zones covered in the calendar, representing the vast richness and variety of the African ecology as well as challenges of land degradation, sand encroachment and floods.

An estimated 50 percent of the global increase in yields over the past ten years has come from improving the quality of seeds. The other fifty percent has come from better water management and irrigation practices.

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LINK

Agrhymet Regional Centre. This site informs on Sahelien food security, desertification control & management
: *http://www.agrhymet.ne/eng/index.html*

Atlas on Regional Integration in West Africa: This site is based on the work carried out by ECOWAS and the Sahel and West Africa Club (SWAC) in order to promote regional integration in West Africa. This work aims to emphasise the relevance of the West African region, transnational dynamics and the veritable intensity of the regional dimension of some agricultural, environmental, industrial or trade issues by using maps, graphics and short analyses
http://www.atlas-ouestafrique.org/spip.php?rubrique36

Carbon projects in Africa – Carbon Catalog (2010): Carbon Catalog is a free and independent directory of carbon credits, listing 130 carbon providers and 594 projects worldwide. Carbon credits neutralize a company's or individual's contribution to global warming. The carbon emissions are balanced out by funding projects which cause an equal reduction in emissions elsewhere.
Website: http://www.carboncatalog.org/prjects/africa/

Climate watch Africa bulletin produced by African Centre of Meteorological Applications for Development (ACMAD) 5, Avenue des Ministères BP : 13184 Niamey-Niger. Tel: (227) 20 73 49 92; Fax: (227) 20 72 36 27; email: dgacmad@acmad.ne;
Website: http//www.acmad.org

Collaborative Partnership on Forests (CPF, 2008): A report titled *Strategic Framework for forests and climate change: A proposal by the Collaborative Partnership on Forests for a coordinated forest-sector response to climate change.* The full report can be obtained at *website: www.fao.org/forestry/cpf-climatechange*

FAO (2009), Profile for Climate Change *: www.fao.org/docrep/012/i1323e/i1323e00.htm*

FAO (2010), Climate change implications for food security and natural resources management in Africa: *www.fao.org/docrep/meeting/018/k7542f01.pdf*

FAO : Site on Climate Changes : *http://www.fao.org/climatechange/en/*

FAO – Climpag site is aimed at bringing together the various aspects and interactions between weather, climate and agriculture in the general context of food security.
http://www.fao.org/nr/climpag/index_en.asp

FAO – High-level Conference on World Food Security : This is an archived site containing all information related to the High-Level Conference on World Food Security: the Challenges of Climate Change and Bioenergy held in Rome, Italy in 3-5 June 2008.: *www.fao.org/foodclimate/en*

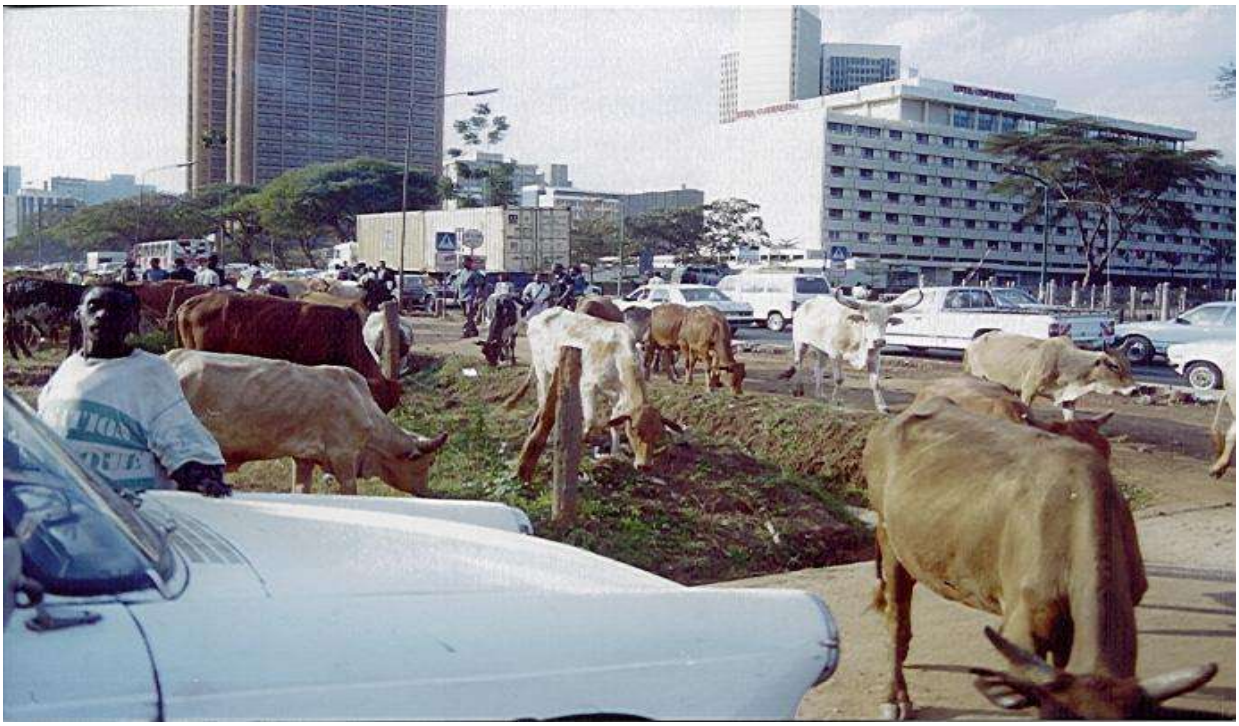
Integrated River Basin Management: Challenges of the Lake Chad Basin, Vision 2025. Lake Chad Basin Commission, P.O. Box 727, N'Djamena-Chad, Phone:235 22524145; 235 22524029. Email: cblt lcbc@yahoo.com / cblt@intnet.td *Website: www.cblt.org*

Intergovernmental Panel on Climate Change Report (IPCC, 2007): *Climate Change 2007*. Fourth Assessment Report (AR4) *: www.ipcc.ch/ipccreports/ar4-syr.htm*

International Year of Forests, 2011 (Forests 2011). The theme: "Forests for People" *Web site: http://www.un.org/en/events/iyof2011/*

Issues on developing quantification of scenarios and combination with climate-to-fish models within the QUEST_fish project*: http://web.pml.ac.uk/quest-fish/default.htm*

Sahel and West Africa Club, CILSS, FAO (2008), Climate and Climate Change in West Africa. Atlas on Regional Integration in West Africa : *http://www.fao.org/nr/clim/abst/clim_080502_en.htm*



Human- Livestock conflicts due to droughts

Theme and deadline for Next Issue

The General Assembly of the United Nations in its 83rd plenary meeting on 20 December 2006 adopted Resolution 61/193 in which it decided to declare 2011 the International Year of Forests, popularly referred to as "*Forests 2011*". It offers the world's citizenry the opportunity to express the importance it attaches to its forest resources. This declaration is symbolic of the myriad of avenues for people to celebrate the various actions they can undertake each day to sustainably manage their forests - the world's forests! *Forests 2011*, has chosen as its theme "Forests for People" and will seek to raise awareness on good management, conservation and sustainable development of all types of forests (http://www.un.org/en/events/iyof2011/).

Nature & Faune magazine will be contributing to this celebration by dedicating all its publications in 2011 to reflections and activities related to "*Forests 2011*". In view of this, the topic for the next issue of the magazine is *"**Economic and social significance of forests for Africa's sustainable development**"*.

Forests and woodlands occupy 674.4 million ha, or 23 percent of Africa's land area, forming an integral part of the African landscape. Moreover, a significant percentage of Africa's population relies on forest resources for their livelihoods; many using trees on farms to generate food and cash. Forests provide a variety of wood and non-wood products as well as vital ecosystem services – preventing erosion from wind and water, preserving water quality, shading crops and livestock, absorbing carbon which contributes to countering climate change, and providing habitats for many species of plants and animals, thus helping to conserve biological diversity. In many African countries people use fuelwood to meet 90% of their energy requirements. In addition to productive and conservation roles forests are also valued as beautiful natural settings for recreation and spiritual reflection. Despite the importance of forest resources for the wide range of economic, environmental, social and cultural benefits, data on such dimensions are either sketchy or not available. Therefore, the extent to which they contribute to national development, reduce poverty, and enhance food security for vulnerable populations is not well recognized or appreciated. Increasingly however, case studies and other efforts are documenting the role forests and trees-outside-forests play in national economic growth, rural development and livelihoods. Thus, the topic for the next issue is aiming to explore in more depth the impact of forests on our lives.

In Africa, forest and tree resources directly provide, not only food, fuel for cooking and heating, medicine, shelter and clothing, but they also function as safety nets in crises or emergencies. For *example*, when crops fail due to drought, forest resources can generate alternate income through employment or through the sale of goods and services. A significant percentage of Africa's poor and hungry people reside in rural areas where, forests and trees outside forests perform a range of economic, ecological, cultural and social functions which are critical to their wellbeing and sustainable development of the continent as a whole.

The next edition of *Nature & Faune* will accordingly explore efforts that help nations sustainably manage their forests. It will be seeking management approaches that balance social, economic and environmental objectives so that present users can reap the benefits of

forest resources, while conserving them to meet the needs of future generations. For this upcoming edition, we would also like to receive articles that encourage forest and natural resources managers to work more effectively to reach outside the traditional forest sector, to engage in partnerships with new stakeholders.

Nature & Faune invites you to submit manuscript(s) on successes, problems and concerns related to the above theme. In order to facilitate contributions from potential authors, we have created guidelines for the preparation of manuscripts for Nature & Faune. Short and succinct papers are preferred. Please visit our website or send us an email to receive a copy of the *'Guidelines for Authors'*. **Email: nature-faune@fao.org or Ada.Ndesoatanga@fao.org**
Website: http://www.fao.org/africa/publications/nature-and-faune-magazine/

Deadline for submission of manuscript(s) and other contributions is 31st March 2011

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