

# CLIMATE RISK MANAGEMENT FOR SUSTAINABLE CROP PRODUCTION IN UGANDA: RAKAI AND KAPCHORWA DISTRICTS


Prepared by the International Institute for Sustainable Development (IISD)

January 2013

United Nations Development Programme

CRISIS PREVENTION AND RECOVERY





Copyright © UNDP 2013  
All rights reserved

This report was commissioned by the United Nations Development Programme's Bureau for Crisis Prevention and Recovery (BCPR), under the Climate Risk Management Technical Assistance Support Project (CRM TASP). The International Institute for Sustainable Development (IISD) implemented the CRM TASP in seven countries (Dominican Republic, Honduras, Kenya, Nicaragua, Niger, Peru and Uganda).

This CRM TASP country report was authored by:

Julie Dekens  
Jason Dion  
Sophie Kutegeka, Kenneth Nyombi  
Barbara Nakangu  
Robert Bagyenda  
Martha Mbosa  
Matt McCandless

Cite as: United Nations Development Programme (UNDP), Bureau for Crisis Prevention and Recovery (BCPR). 2013. *Climate Risk Management for Sustainable Crop Production in Uganda: Rakai and Kapchorwa Districts*. New York, NY: UNDP BCPR.

Published by

United Nations Development Programme (UNDP), Bureau for Crisis Prevention and Recovery (BCPR), One UN Plaza, New York–10017

UNDP partners with people at all levels of society to help build nations that can withstand crisis, and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in 177 countries and territories, we offer global perspective and local insight to help empower lives and build resilient nations. [www.undp.org](http://www.undp.org)

## CONTENTS

FOREWORD.....	4
ACKNOWLEDGEMENTS.....	6
LIST OF ABBREVIATIONS AND ACRONYMS .....	7
EXECUTIVE SUMMARY .....	8
INTRODUCTION .....	9
APPROACH AND METHODS.....	9
KEY CONCEPTS .....	11
REPORT STRUCTURE .....	12
DEVELOPMENT PROFILE.....	13
NATIONAL DEVELOPMENT CONDITIONS, TRENDS AND CHALLENGES .....	13
NATIONAL DEVELOPMENT VISION, OBJECTIVES AND PRIORITIES .....	15
THE AGRICULTURAL SECTOR.....	16
CLIMATE PROFILE .....	17
CURRENT CLIMATE VARIABILITY AND EXTREMES .....	17
OBSERVABLE CHANGES IN CLIMATE .....	19
PROJECTED CLIMATE TRENDS .....	19
STATUS OF NATIONAL AND REGIONAL CLIMATE AND HAZARD INFORMATION .....	20
CLIMATE IMPACTS AND RISKS.....	21
CLIMATE IMPACTS ON CROP PRODUCTION .....	22
EXPOSURE OF SMALLHOLDER FARMERS TO CLIMATE HAZARDS .....	26
SENSITIVITY OF FARMERS AND CROPS TO CLIMATE HAZARDS.....	28
ADAPTIVE CAPACITY OF SMALLHOLDER FARMERS TO FLOODS AND DROUGHTS .....	31
INSTITUTIONS AND POLICIES FOR CLIMATE RISK MANAGEMENT .....	38
DISASTER RISK MANAGEMENT .....	38
CLIMATE CHANGE .....	38
RECOGNITION OF CLIMATE RISK MANAGEMENT IN KEY POLICY DOCUMENTS .....	39
CLIMATE RISK MANAGEMENT ACTIVITIES.....	40
ASSESSMENT OF CLIMATE RISK MANAGEMENT CAPACITY .....	41
RECOMMENDATIONS FOR CLIMATE RISK MANAGEMENT .....	43
PRIORITY ACTIONS .....	43
GOVERNANCE.....	46
PRIORITY CLIMATE RISK MANAGEMENT OPTIONS .....	47
REFERENCES .....	50

## FOREWORD

Climate change has the potential to exacerbate conflict, cause humanitarian crises, displace people, destroy livelihoods and set-back development and the fight against poverty for millions of people across the globe.


For example it is estimated that over 20 million people in the Mekong Delta and 20 million in Bangladesh could be forced to move as their homes are affected by salt water incursion from rising sea levels. Entire populations of some low lying island states, such as Nauru or the Maldives may have to be relocated. In countries like Honduras, where more than half the population relies on agriculture, climate induced risks, such as Hurricane Mitch in 1998, which caused over US\$ 2 billion in agricultural losses, will continue to pose a staggering potential for damage. Similarly, climate risk assessments in Nicaragua show that changes in rainfall patterns, floods and drought could put human health at risk by increasing the prevalence of respiratory and water borne diseases and malnutrition.

Long-term incremental changes will mean that people everywhere must learn to adapt to weather or rainfall patterns changing or shifts in ecosystems that humans depend upon for food. Perhaps more worrying however, is that climate variability and change will also bring unpredictable weather patterns that will in-turn result in more extreme weather events. Heat waves, droughts, floods, and violent storms could be much more common in the decades to come. Climate change is “loading the dice” and making extreme weather events more likely. These disasters will undermine the sustainability of development and render some practices, such as certain types of agriculture, unsustainable; some places uninhabitable; and some lives unliveable.

As climate change creates new risks, better analysis is needed to understand a new level of uncertainty. In order to plan for disasters, we need to understand how climate change will impact on economies, livelihoods and development. We need to understand how likely changes in temperature, precipitation, as well as the frequency and magnitude of future extreme weather will affect any sector, including agriculture, water-use, human and animal health and the biodiversity of wetlands.

This report is a product of the Climate Risk Management – Technical Assistance Support Project, which is supported by UNDP’s Bureau for Crisis Prevention and Recovery and Bureau for Development Policy. This is one in a series of reports that examines high-risk countries and focusses on a specific socio-economic sector in each country. The series illustrates how people in different communities and across a range of socio-economic sectors may have to make adaptations to the way they generate income and cultivate livelihoods in the face of a changing climate. These reports present an evidence base for understanding how climatic risks are likely to unfold. They will help governments, development agencies and even the communities themselves to identify underlying risks, including inappropriately designed policies and plans and crucial capacity gaps.

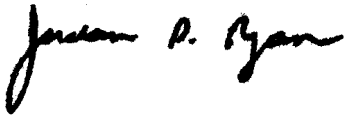
This series is part of a growing body of climate change adaptation resources being developed by UNDP. The Climate Risk Management – Technical Assistance Support Project has formulated a range of climate risk management assessments and strategies that bring together disaster risk reduction and climate change adaptation practices. The project is designing a common framework to assist countries in developing the necessary capacity to manage climate-induced risks to respond to this emerging threat. The climate risk assessments discussed in this report and others in the series will feed into a set of country-level projects and regional initiatives that will inform the practice of climate risk management for decades to come.



Addressing climate change is one of UNDP's strategic priorities. There is a strong demand for more information. People at all levels, including small communities want to understand the potential impact of climate change and learn how they can develop strategies to reduce their own vulnerability. UNDP is addressing this demand and enabling communities and nations to devise informed risk management solutions. UNDP recognises that climate change is a crucial challenge to sustainable development and the goal of building resilient nations.

As the full effect of climate change becomes apparent, it is assessments such as these that will become the lynchpin of national responses and adaptation strategies for many years to come. Like the threat from many disasters, there is still time to prepare for the worst impacts of climate change in developing countries if we expand our understanding now.

This knowledge must be combined with real preparedness and action at all levels. Only then will we be able to stave off the worst impacts of climate change in the most vulnerable and high risk countries of our world.



Jordan Ryan  
Assistant Administrator and Director  
Bureau for Crisis Prevention and Recovery  
United Nations Development Programme



Olav Kjørven  
Assistant Administrator and Director  
Bureau for Development Policy  
United Nations Development Programme

## ACKNOWLEDGEMENTS

This report, 'Climate Risk Management for Sustainable Crop Production in Uganda: Lessons from Rakai and Kapchorwa Districts' was commissioned under the Climate Risk Management – Technical Assistance Support Project (CRM TASP), a joint initiative by the Bureau for Crisis Prevention and Recovery (BCPR) and the Bureau for Development Policy (BDP), United Nations Development Programme (UNDP), implemented by the International Institute for Sustainable Development (IISD).

The general methodology and analytical framework of the CRM TASP was conceptualized by Maxx Dilley, disaster partnerships advisor, and Alain Lambert, senior policy advisor, with key inputs from Kamal Kishore, programme advisor, Disaster Risk Reduction and Recovery Team, BCPR, in consultation with Bo Lim, senior climate change advisor, Environment and Energy Group, BDP. Within BCPR, the project implementation process has been supervised by Alain Lambert, Rajeev Issar and Ioana Creitaru, who provided regular inputs to ensure in-depth climate risk assessments and identification of tangible risk reduction and adaptation options. From BDP, Mihoko Kumamoto and Jennifer Baumwoll provided their input, comments and oversight to refine the assessment and recommendations. The overall project implementation has benefitted immensely from the strategic guidance provided by Jo Scheuer, coordinator, Disaster Risk Reduction and Recovery Team, BCPR, and Veerle Vandeweerd, director, Environment and Energy Group, BDP.

The climate risk assessments under the CRM TASP have been undertaken with the funding support of the Government of Sweden.

Building upon the CRM TASP general framework to tailor the process to country-level analysis, IISD developed a more detailed methodological framework for assessing climate risks and identifying climate risk management options in seven countries, including Uganda. Within IISD, Anne Hammill supervised the overall project implementation. Julie Dekens supervised all in-country activities in Uganda and is the lead author of the present report, with support from Jason Dion and Matt McCandless of IISD; Sophie Kutegeka, Barbara Nakangu and Robert Bagyenda of International Union for Conservation of Nature (IUCN)-Uganda, Kenneth Nyombi of Makerere University, and consultant Martha Mbosa.

For their valuable contribution to the project implementation and climate risk assessment process, the project team and lead authors would like to gratefully acknowledge the unstinting support provided by colleagues from the UNDP Country Office, especially Lebogang Motlana, Wilson Kwamya, Daniel Omodo McMondo, Sarah Mujabi and Irene Agudu; the Ministry of Agriculture, Animal Husbandry and Fisheries, especially Annunciata Hakuza Nkezza and Alex Bambona; the Ministry of Water and Environment, especially Paul Isabirye and Lawrence Aribo; the national and regional stakeholders who participated in the interactions, the communities and the district officials of Rakai and Kapchorwa districts, the members of the national project committee, and all participants of the local and national workshops. Special thanks are also due to John Wasige for his support in the crop modelling, Livia Bizikova of IISD for her support in applying the participatory scenario development approach, and John B. Kaddu of Makerere University, consultant Philip Gwage, and Kennedy Igboke of the United Nations food and Agriculture Organization (FAO) Uganda for providing useful comments and feedback on drafts of this report.

## LIST OF ABBREVIATIONS AND ACRONYMS

BCPR	Bureau for Crisis Prevention and Recovery
BDP	Bureau for Development Policy
CA	conservation agriculture
CCU	Climate Change Unit
CRED	Centre for Research on the Epidemiology of Disasters
CRISTAL	Community-Based Risk Screening – Adaptation and Livelihoods
CRM TASP	Climate Risk Management Technical Assistance Support Project
CRM	climate risk management
DSSAT	Decision Support System for Agrotechnology Transfer
FAO	United Nations Food and Agriculture Organization
GDP	Gross Domestic Product
ICO	International Coffee Organization
IGAD	Intergovernmental Authority on Development
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MDGs	Millennium Development Goals
MWE	Ministry of Water and Environment
NAADS	National Agricultural Advisory Services
NAPA	national adaptation programme of action
NDP	national development plan
NEMA	National Environment Management Authority
NGOs	non-governmental organizations
NPA	National Planning Authority
OPM	Office of the Prime Minister
UBOS	Uganda Bureau of Statistics
UCDA	Uganda Coffee Development Authority
UNDP	United Nations Development Programme
WRI	World Resources Institute

## EXECUTIVE SUMMARY

Uganda is a development success story by regional standards, with increasing economic growth and declining poverty. Nevertheless, the country's economic dependence on agriculture makes it very sensitive to climate variability and change. Uganda is experiencing more frequent and intense droughts than it has historically. Temperatures have risen 0.37° C per decade since 1960. While no clear long-term rainfall trend is visible, heavy rainfalls, floods and landslides are on the rise. Climate forecasts predict that temperatures will continue to increase, extreme weather events will become more frequent and intense, and rainfall patterns will change, although it is not clear how. In a context of growing uncertainty resulting from climate and non-climate factors, balancing the needs of a growing population with environmental concerns will be difficult. This study was conducted to assess climate risks in crop production in two different agroecological zones of Uganda and to identify climate risk management options.

We conducted a climate risk assessment on maize, beans and coffee productivity in the Rakai District (southwestern region, west of Lake Victoria, in a savannah woodland and grassland ecosystem) and in the Kapchorwa District (eastern region, on the slopes of Mount Elgon, in a mountainous forested ecosystem). Both districts are characterized by a mixed rain-fed crop-livestock system dominated by small- and medium-scale farmers. Floods and droughts are the main climate hazards. Coffee is the main cash crop, while maize and beans are the main food crops. Data collection and analysis involved local consultations with 174 farmers in three parishes in Rakai (94 farmers) and Kapchorwa (80 farmers); crop modelling for maize and beans use the Decision Support System for Agrotechnology Transfer (DSSAT); literature reviews; 31 interviews with coffee actors at local, district and national levels; and district and national stakeholder consultations.

Our results highlight that the impacts of current climate hazards on crop production in Rakai and Kapchorwa already constitute a threat to the district's development objectives. Key actors perceive that they are exposed to increasing uncertainties due to a combination of climate and non-climate factors. As a result, farmers are no longer able to follow their normal farming calendar, and they are already using a range of strategies to avoid and minimize the negative impacts of climate hazards on their livelihoods. But some of these strategies are maladaptive and further increase vulnerability to climate risks. In general, environmental degradation, socio-economic conditions and the political context contribute to farmers' vulnerability to climate hazards. While climate change is a relatively new topic in Uganda, awareness is growing nationally. The institutions dealing with climate risk in the country are in place, but with limited financial and human capacities. A lot of good policies and strategies are also in place and have mainstreamed climate risks to some extent, but these plans remain to be translated into effective programming.

Key national and local stakeholders identified priority actions, under six broad themes, for managing climate risks to ensure sustainable crop production in Rakai and Kachporwa districts, and any other similar districts of Uganda:

- **Water, soil and land management.** Promote small-scale irrigation, conservation agriculture and a watershed-scale approach.
- **Agronomic practices.** Disseminate culturally acceptable and affordable, stress-resistant crop varieties; support optimum crop diversification and intercropping techniques; support optimum use of agroforestry and multipurpose shade trees; and support farmers in replacing old, unproductive coffee plantations.
- **Infrastructure and financing.** Promote appropriate storage for maize and coffee, improve road infrastructure and flood control structures, and support or expand rural microfinance.
- **Information and communication technologies.** Enhance the role of technology for providing accurate, reliable and timely climate information, and combine local and scientific knowledge for improved local weather forecasts and early warning systems.
- **Local governance and social organization.** Support strong farmers' institutions and organizations, especially for women.
- **Capacity development.** Build capacity in application of new stress-resistant seeds, conservation agriculture, intercropping and agroforestry, and in access to weather information.

To facilitate these actions, a strong national governance framework is required, including the need to:

- Implement existing key policies and strategies.
- Mainstream climate risk into key policy documents, such as the draft coffee policy.
- Mainstream climate risk at all levels of crop value chains, from production to consumption.
- Promote continuous improvement of coordination functions among government agencies, as well as between national institutions, local governments and communities.
- Involve local communities in detailed regional climate risk assessments and the design and implementation of adaptation options.



## INTRODUCTION

Climate risk management (CRM) is the systematic approach to and practice of considering climate-related trends and events in development decision-making to minimize potential harm. Historical experience with climate hazards provides a base for directing action, particularly in the absence of written historical data, but it may no longer be a sound basis for evaluating risk. Climate change is altering the nature of climate risk, increasing uncertainty and forcing us to re-evaluate conventional CRM practices. Observable trends and longer-term, model-generated projections must also be taken into account if development is to be truly sustainable.

Recognizing this shifting reality, the Climate Risk Management Technical Assistance Support Project (CRM TASP) of the United Nations Development Programme (UNDP) was designed to strengthen capacity in developing countries to manage climate risk. The International Institute for Sustainable Development (IISD) was commissioned to implement the project in seven countries in Latin America and the Caribbean (Dominican Republic, Honduras, Nicaragua and Peru) and Africa (Kenya, Niger and Uganda), in close collaboration with UNDP Country Offices, governments and other partners.

In each country the main outputs of the project are the prioritization of climate-related risks, a focused risk assessment for a priority sector or area, and identification of risk management options for that sector or area. This report summarizes the main results of the research conducted in Uganda, where the project stakeholders chose agriculture as the focus sector.

## APPROACH AND METHODS

Three key principles guided implementation of CRM TASP in each country. First, the project built on existing climate risk information and aimed to fill critical knowledge gaps. Second, the main research phase focused on one key sector, in order to produce useful and concrete recommendations. Third, with a view to building capacity to identify, prioritize and manage climate risk, IISD worked closely with in-country partners who executed important parts of the research. These principles were put into practice in each country through a generic six-step implementation process (see table 1).

**TABLE 1. SUMMARY OF PROJECT STEPS AND METHODS**

PROJECT STEP	PURPOSE	METHODS USED IN UGANDA
1. Engagement	<ul style="list-style-type: none"><li>• Raise awareness about CRM TASP.</li><li>• Secure country-level ownership and support for process.</li></ul>	<ul style="list-style-type: none"><li>• Inception visit and interactions with key stakeholders.</li></ul>
2. Broad climate risk assessment	<ul style="list-style-type: none"><li>• Understand and synthesize existing data and information on climate risk and risk management options.</li></ul>	<ul style="list-style-type: none"><li>• Literature review conducted by in-country experts.</li></ul>
3. Risk prioritization	<ul style="list-style-type: none"><li>• Identify gaps and priorities for climate risk assessment and management, which can be addressed in a focused risk assessment.</li></ul>	<ul style="list-style-type: none"><li>• National inception workshop with key stakeholders; agriculture identified as focus sector in group discussions.</li></ul>
4. Focused climate risk assessment	<ul style="list-style-type: none"><li>• Understand the nature of climate risk for a specific priority sector/ecosystem/social group (crop production—maize, beans and coffee—was chosen as the focus sector in the case of Uganda).</li></ul>	<ul style="list-style-type: none"><li>• Community consultations in 3 parishes in Rakai and Kapchorwa based on the CRISTAL tool (conducted by IUCN).</li><li>• Crop modelling (maize and beans) (IISD and Makerere University).</li><li>• Literature review and interviews with key stakeholders in the coffee chain district and national level (Makerere University).</li></ul>
5. Risk prioritization II	<ul style="list-style-type: none"><li>• Identify and prioritize climate risk management options based on the more focused assessment.</li></ul>	<ul style="list-style-type: none"><li>• National participatory scenario development workshop.</li></ul>
6. Reporting & dissemination	<ul style="list-style-type: none"><li>• Elaborate and validate results.</li><li>• Secure country-level ownership of results.</li></ul>	<ul style="list-style-type: none"><li>• National revision workshop.</li><li>• Publication of final report.</li></ul>

In January 2011 the participating ministries, research institutes, non-governmental organizations (NGOs) and donor agencies first identified, through a consultative process, agriculture as the priority sector. This was based on indicators of the national contribution of the sector, its vulnerability to the impacts of climate variability and change, and the feasibility of undertaking a risk assessment in the sector. Stakeholders further selected floods and droughts as the main hazards, based on indicators related to the number of studies already carried out and the impacts of those hazards. A series of further national consultations resulted in agreement to focus the risk assessment on maize, beans and coffee production, taking into account the orientation of the new 'Development Strategy and Investment Plan 2010/11–2014/15' of the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and the need to consider the food and cash crops most vulnerable to climate variability and change.

To avoid overgeneralization and deliver specific results, the climate risk assessment on crop production focused on the districts of Rakai (southwest) and Kapchorwa (east). These two districts were selected because they are highly prone to climate hazards (floods and droughts), their livelihoods mainly rely on coffee, beans and maize, and they are representative of different types of ecosystems (savannah woodland and grassland and mountain forests).

The assessment combined qualitative research methods with quantitative analysis, resulting in three independent but interlinked components: local consultations, crop modelling and coffee climate risk assessment.

The **local consultations** in Rakai and Kapchorwa were conducted by the International Union for Conservation of Nature (IUCN) Uganda over 10 days, with five days in each district, during April 2011. In total, IUCN consulted 174 farmers, including 94 from Rakai (55 men and 39 women) and 80 from Kapchorwa (52 men and 28 women). The consultations in both districts were undertaken using the Climate Vulnerability and Capacity Analysis Framework developed by CARE (Dazé et al., 2009). To avoid any bias, the team did not mention the term 'climate change' unless the interviewees raised it themselves. The team used rain and crop calendars, hazard mapping, and vulnerability matrices to understand the implications of climate hazards in the lives and livelihoods of people. In addition, focus group discussions on cross-cutting issues (i.e. poverty, gender and vulnerable groups, policy and institutional frameworks, and the role of information and communications technologies) were organized with young women, young men, old women and old men. Data analysis was carried out using the CRISTAL tool (Community-Based Risk Screening Tool – Adaptation and Livelihoods). District officials were involved in data collection and analysis, which presented an opportunity to promote ownership of the results and integration into their respective district development planning processes, enhance their capacity to incorporate climate risk in local development planning and to appreciate community local knowledge of local weather and crop management, and strengthen community-district relationships.



*Figure 1. A group of women discussing and drawing their rain calendar. Photo: Sophie Kutegeka, IUCN*

IISD carried out **crop modelling** with the support of personnel from the University of Twente and Makerere University. The Decision Support System for Agrotechnology Transfer (DSSAT) model was used to evaluate the effects of climate change on maize and beans for parishes in Rakai and Kapchorwa. Climate change projections were generated by the MarkSim weather file generator. The climate change projections were validated through comparison with existing climate records supplied by the Department of Meteorology and downloaded from U.S. National Oceanic and Atmospheric Administration websites. IUCN gathered agronomic data directly from farmers in the districts during the local consultations. The National Agricultural Research Laboratory supplied soil data in GIS format.

Makerere University carried out the **coffee climate risk assessment**, which was based on a literature review covering coffee production, marketing, climate and other risks along the coffee chain in Uganda and globally. This was complemented by interviews at national and district levels. A total of 31 interviews were conducted through 22 face-to-face meetings with stakeholders in and around Kampala and 9 telephone interviews with district-level stakeholders. The interviewees were stratified into three categories: people involved in policy; climate information, research and development institutions; and coffee processors and exporters. A



Figure 3. Participants of the participatory scenario development workshop, Entebbe, July 2011. Photo: Julie Dekens, IISD

qualitative approach was used for this component because modelling perennial crops like coffee or bananas was too complex and time-consuming for this study. Indeed, coffee modelling is difficult due to coffee's growth model, the diversity of production systems, and the perennial nature of the crop, requiring a longer time to test and calibrate the model. This study also built on the findings from the local consultations and the results of the crop modelling described above.

A **national project technical committee** comprising representatives from relevant ministries, research institutions, NGOs and the private sector continuously reviewed and validated key project outputs. The preliminary results of the climate risk assessment were presented to key stakeholders in a participatory scenario development<sup>1</sup> workshop in July 2011. In group exercises and plenary discussions, workshop participants then identified and prioritized climate risk management options for maize, beans and coffee for the two districts.

This report summarizes the results of this process.

## KEY CONCEPTS

In this report, 'climate risk' refers to the probability of harmful consequences or expected losses resulting from the interaction of climate hazards with vulnerable conditions (UNISDR, 2004). 'Climate hazard' refers to a potentially damaging hydrometeorological event or phenomenon that can be characterized by its location, intensity, frequency, duration and probability of occurrence. This report considers both events with an identifiable onset and termination, such as a storm, flood or drought, and more permanent changes, such as a trend or transition from one climatic state to another, as hazards (Lim et al., 2005).

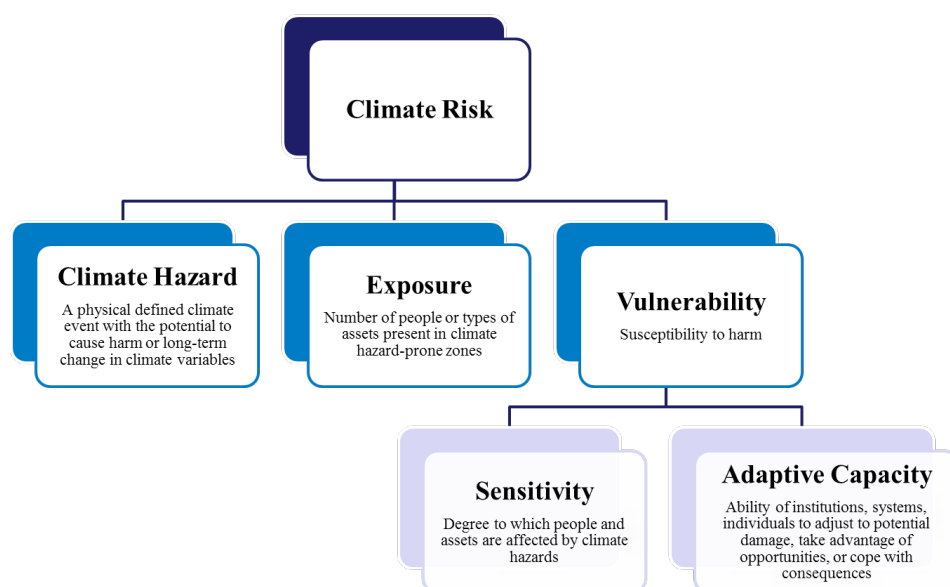



Figure 2. Components of climate risk

<sup>1</sup> For more information on the participatory scenario development approach, see Bizikova et al. (2009; 2010).




'Exposure' is a second element of climate risk. It refers to the presence of people and assets in areas where hazards may occur (Cardona et al., 2012). Finally, 'vulnerability' refers to the potential for a system to be harmed by something, and in the CRM TASP this 'something' is a climate hazard. When assessing vulnerability, we need to recognize the hazard specificity of people's vulnerability; indeed, the factors that make people vulnerable to earthquake are not necessarily the same as those that make people vulnerable to floods (UNDP 2004). We understand vulnerability to be a function of a system's sensitivity and its adaptive capacity, as depicted in Figure 2.

## REPORT STRUCTURE

This report has six chapters. 'Development Profile' (pp. 13–16) describes the current development conditions, trends and objectives, with a sub-section on agriculture, to set the baseline against which climate risks can be assessed. 'Climate Profile' (pp. 17–20), on climate conditions, variability and change, describes mainly the hazard side of the risk equation. Next, 'Climate Impacts and Risks' (pp. 21–37) provides an analysis of climate impacts and risks for crop production in two selected districts, building on the primary research tasks described above. 'Institutions and Policies for Climate Risk Management' (pp. 38–42) looks at the institutions, policies and initiatives that exist to deal with climate impacts and risks. Finally, 'Recommendations for Climate Risk Management' (pp. 43–49) concludes with recommendations to reduce negative impacts on crop production in the two study areas, as well as on the institutional and policy changes needed to facilitate the implementation of such actions.







Uganda's education and health systems are considered to be above average for the region. Uganda is seen as a relatively successful example of a developing African country employing market-oriented reforms to modernize its economy and raise living standards. While central Uganda has gained from the country's economic expansion, the north has not seen the same benefits. Insecurity issues there, as well as a different climate, have contributed to this disparity. As well, major urban/rural differences persist throughout the country.

## **Poverty and human development**

Poverty rates in Uganda have been trending downward for some time. In the early 1990s a little over half the population lived in poverty (Muwanga, 2001), whereas now the figure is approximately one-third (Bertelsmann Stiftung, 2009; NPA, 2010). These trends mask significant regional disparities: the northern part of the country has historically had higher rates of poverty, and significant differences exist between rural and urban rates, with rural poverty approximately triple that in urban centres (Muwanga, 2001; Republic of Uganda, 2010c). The vast majority of rural people depend on agriculture (Republic of Uganda, 2010c; Farm Africa, 2011).

Education, especially universal primary education, is a top government priority. Between 1997 and 2006, primary school enrolment increased 132 percent, to 86 percent net enrolment. Uganda implemented free secondary education in 2007 (UBOS 2010b). Progress has stagnated in recent years, with net enrolment hovering around 90 percent, and the completion rate remains low (Republic of Uganda, 2010b; UNDP, 2011). Considerable progress has occurred in numeracy and literacy at the primary level (Republic of Uganda, 2010b); however, the higher education system is considered relatively poor and is not addressing deficits in skilled human resources (Bertelsmann Stiftung, 2009; Republic of Uganda, 2010c).

Although the AIDS pandemic of the 1980s and 1990s exacted a heavy toll on the country's development, its spread has largely been contained through policy and strong leadership (Republic of Uganda, 2010c). However, the epidemic continues to be felt, increasing poverty and vulnerability, stalling health and infrastructure development, and holding back productivity (Republic of Uganda, 2010c). Significant progress has also been made on malaria, but "increasing resistance to commonly used treatments remains a serious challenge" (Republic of Uganda, 2010c). As in many African countries, no formal social safety net exists, and many Ugandans rely on family and village relationships for support; however, forces such as urbanization and mortality from AIDS have increasingly disrupted these networks. Those who rely on them have become more vulnerable and insecure (Bertelsmann Stiftung, 2009).

Traditional gender inequality still exists, but slow progress is being made (Bertelsmann Stiftung, 2009). The ratio of girls to boys in primary education has reached 1.0, and is 0.84 and 0.79 in secondary and tertiary education, respectively (Republic of Uganda, 2010b). Overall, women have more economic opportunity than in the past, but many have seen little change, as women are still concentrated in low-paying sectors. They form 70 percent of the labour force in agriculture, but seldom have control or ownership of the land they work or the tools they use, limiting their ability to move out of subsistence agriculture (NPA, 2010).

## **Economy and politics**

Uganda is seen as having a strong commitment to and success in implementing democratic and pragmatic, free-market oriented economic reform. Although corruption is still widespread (Transparency International, 2009), NGOs see the Ugandan Government as a credible and reliable partner (Bertelsmann Stiftung, 2009).

The country has experienced strong economic growth of 4 to 7 percent since the 1990s, but in recent years this growth has come from industry and services, with agricultural productivity slowing markedly (NPA, 2010). In terms of diversification and material infrastructure, the economy is still at an early stage, but is fairly well-developed relative to other countries in the region (Bertelsmann Stiftung, 2009). Key sectors include agriculture, forestry, manufacturing, tourism, mining, telecommunications and construction (NPA, 2010).

Agriculture remains an important part of Uganda's economy. Although agriculture's share of Gross Domestic Product (GDP) has fallen from approximately 50 percent in 1988 to 21 percent in 2009, it still provides 80 percent of employment and 90 percent of the country's foreign exchange earnings (NPA, 2010; UBOS, 2010a). While agricultural productivity grew an average of 3.9 percent per year between 1988 and 1997, and an average of 5.4 percent between 1988 and 2002, it has slowed since, growing at an average of 1.1 percent per year between 2004 and 2008 (Republic of Uganda, 2010c). Drought, instability, pest outbreaks, and declines

in productivity and prices contributed to this low productivity (NPA, 2010). The lack of productivity growth constitutes a serious obstacle in the fight against poverty in Uganda (NPA, 2010). Coffee is the main cash crop, with over 500,000 people depending on it for their livelihoods; beans and maize are the main food crops. Especially grown in the southwest, beans are an important source of protein for Ugandans, with 53 percent of smallholder farmers growing them. Maize doubles as both a food and minor cash crop, and is grown predominately in the eastern region. It is a “source of livelihoods to over two million households, 1,000 traders/agents, and 600 millers” (MAAIF, 2010).

## **Environment**

Soil fertility, biodiversity and fisheries are declining (MAAIF, 2010). Stresses on agricultural land and other natural resources are only expected to increase with a growing population. There have been improvements: for example, in hopes of getting better prices, some agricultural producers are beginning to use less environmentally disruptive techniques (e.g., organic coffee). However, on the whole, developmental concerns tend to trump environmental ones, as exemplified by the government’s recent decision to permit further damming of the Nile River despite concerns about the environmental impact (Bertelsmann Stiftung, 2009).

## **Barriers to development**

Uganda’s slow agricultural productivity growth, combined with its young and growing population and its increasingly stressed natural resource base, will increasingly act as a barrier to meaningful development. Indeed, Uganda’s high population growth rate (3.2 percent per annum) has been identified as one of the key challenges to the country’s development prospects (Bertelsmann Stiftung, 2009). Balancing the needs of its growing population with the integrity of its natural ecosystems will require enhanced agricultural productivity that does not come at the expense of the health of the environment.

Inadequate financing and financial services also act as barriers to development in Uganda. Other significant impediments to economic diversification include poor infrastructure, limited access to production inputs, low application of science and technology, and poorly developed human capital (NPA, 2010). Robust domestic financial investment and substantial foreign capital will be needed for meaningful progress to occur in these areas.

## **NATIONAL DEVELOPMENT VISION, OBJECTIVES AND PRIORITIES**

Uganda’s national vision is of a “transformed Ugandan society from a peasant to a modern and prosperous country within 30 years” (NPA, 2008). By implementing a series of six 5-year plans, the government seeks to improve political, economic and social conditions to create the environment necessary for development. The first of these, the current national development plan (NDP) for the years 2010/11 to 2014/15, is organized around the theme “growth, employment and socio-economic transformation for prosperity” (NPA, 2010). It seeks to eradicate poverty via export-led economic growth. Recognizing the early stage of Uganda’s industrial development, the plan intends to enhance the role of the state to support the development of a dynamic private sector and assist Ugandan firms in succeeding in export markets. It notes this will call for removal of institutional barriers, improved delivery of government services, and accountable, competent leadership. To this end, it proposes various measures to improve the performance of the Government’s policy development, planning, monitoring, regulatory and service-delivery functions.

The plan is forecast to make significant contributions to the achievement of the Millennium Development Goals (MDGs). But while progress until now in health and education has been notable, movement towards related MDG targets has been slow (NPA, 2010), and a number of these targets for 2015 will likely not be realized, notably those regarding under-five and maternal mortality and the universality of primary education. Environmental sustainability outcomes have also been poor, in some cases worsening (deforestation, for example). Progress on MDGs related to poverty, HIV and gender has, however, been encouraging, with HIV rates falling from 18 percent in 1992 to approximately 6.5 percent today (UBOS, 2010a; Republic of Uganda, 2010c).

The NDP also identifies strategies for encouraging development in primary, complementary, social, and enabling sectors, envisioning a labour force distribution in line with sectoral shares of GDP. In particular, it recognizes the essentiality of improving agricultural productivity for achieving overall economic development; proposing policies to improve agricultural technology development; controlling diseases, pests and vectors; providing better delivery of advisory services and improved technology; restoring agricultural production in northern Uganda; accelerating support for strategic selected crop enterprises; increasing access to and availability of farm inputs; enhancing the productivity of land; and promoting labour-saving technologies and mechanization (NPA, 2010).

## THE AGRICULTURAL SECTOR

Despite its shrinking share of GDP, agriculture continues to form the backbone of Uganda's economy, and most industries and services in the country depend on it. Agricultural households are estimated at 3.95 million (representing 19.3 million people), with the Western Region having the highest percentage (28.5 percent) and the Central Region the lowest (20.5 percent) (UBOS and MAAIF, 2011). In 2007, 45.9 percent of agricultural households relied on crop production as their main activity (UBOS and MAAIF, 2011).

The sector's productivity growth has slowed over the past several years. Stagnant productivity in this sector poses a significant problem for the Ugandan economy and the country's broader development prospects (MAAIF, 2010). Increased agricultural output is essential for Uganda's economic and social development; strong growth in the sector between 1987 and 2005 was a major driver of the decrease in poverty seen in this period (MAAIF, 2010). And while year-over-year agricultural output continues to grow, in recent years this is more attributable to the expansion of agriculture to marginal lands than to productivity gains (OPM, 2005). Continued expansion of agricultural lands will come at an enormous environmental cost, and any future growth in the sector must come from productivity improvements per unit area (World Bank, 2006).

Fortunately, there is considerable room for improved productivity in the sector. Most agriculture in Uganda is rain-fed (MAAIF, 2010), and so the development of efficient irrigation systems could offer the double dividend of increased yields and increased resilience to climate variation. As discussed, the NDP has substantial plans for the increased use of labour-saving technologies and other productivity-enhancing measures. Determining how best to increase the productivity of agriculture in a way that is environmentally sustainable will be an essential part of Ugandan economic and social development. It will also require the design and implementation of supporting measures, including, for example, increased value addition around primary agricultural products and improved access to global markets for farmers of cash crops.

As already mentioned, coffee remains the major cash crop exported, while maize and beans are major food-security crops and are becoming increasingly important export crops, especially at the regional level. Production of these crops is therefore central to the achievement of the NDP (2010–2015) and the MDGs (especially eradicating extreme poverty and hunger), and to MAAIF's new 'Development Strategy and Investment Plan' (DSIP).

The DSIP for the agricultural sector covers the period 2010/11 to 2014/15, parallel to the NDP, and addresses constraints in the development of the agricultural sector. The plan's vision of the future is to have "a competitive, profitable, and sustainable agricultural sector." One of the key objectives is to enhance sustainable crop production and productivity. This will be done by, among other things, increasing farmer access to relevant information and technology with increasing private sector involvement, reducing losses through improved control of pests, vectors and diseases, and enhancing productivity of land. The plan pursues a commodity-focused approach and has selected, based on various criteria, 10 priority commodities, including maize, beans and coffee (MAAIF, 2010).

### Key messages: Development profile

- Uganda is a development success story by regional standards. Notably, since the 1990s poverty rates have been declining, and economic growth has increased from 4 to 7 percent.
- Agriculture continues to form the backbone of the economy, representing 80 percent of employment and 90 percent of foreign exchange earnings. Most industries and services in the country depend on this sector. Most agriculture is rain-fed. Coffee is the main cash crop, while beans and maize are the main food crops.
- Agricultural productivity is slowing markedly, and significant regional disparities exist. Balancing the needs of a growing population with environmental concerns will be difficult.
- Uganda is taking its challenges seriously, putting comprehensive development plans in place, although much remains to be done and will require the input of a wide range of stakeholders. Increasing the growth of agricultural productivity is a national development priority.



## CLIMATE PROFILE

Uganda has an equatorial climate, experiencing relatively humid conditions and moderate temperatures throughout the year, with mean daily temperatures of 28° C (Ministry of Finance, Planning and Economic Development, 2009). Its climate is bimodal, exhibiting two rainy seasons (March to June and October to January), but in the country's Northern Region, these merge into one long rainy season (Republic of Uganda, 2007; MWE, 2002). Uganda's rainfall is influenced by a range of broader weather trends and phenomena. Uganda's bimodal rainfall is driven by the oscillation over the equator of the Intertropical Convergence Zone. The pattern of the zone's oscillation is in turn sensitive to the El Niño Southern Oscillation: El Niño brings about a wet phase in Uganda between October and December, which can cause flooding, while La Niña (the converse) brings about a dry phase, which can lead to drought. The effects of the oscillation on rainfall patterns can vary due to the influence of the Indian Ocean Dipole, an irregular oscillation of sea-surface temperatures in which the western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean. Lake Victoria also affects rainfall patterns due to differential heating and vapour transport (Republic of Uganda, 2010a).

Climatic conditions vary considerably within Uganda. The three main types of climate found in Uganda are highland, savannah tropical and semi-arid. Highland climates have cool temperatures and moderate rainfall; this climate is mostly found around Mount Elgon and the Rwenzori Mountains. Regions with a savannah tropical climate have moderate average temperatures and high mean annual rainfall. This climate is seen in the central and western parts of the Lake Victoria Basin, where most of Uganda's rainforests and wetlands can be found. Regions with semi-arid climates see high average temperatures and low mean annual rainfall. Animal husbandry is common in this type of climate, as in the "cattle corridor" of Uganda, which runs from the Karamoja region in the northeast to the Ankole region in the southwest (Republic of Uganda, 2007; Republic of Uganda, 2010a). Uganda's highland and semi-arid climates average approximately 900 mm of rainfall per year, while savannah tropical climates average 1200 mm per year. Social and economic activities in Uganda are more sensitive to rainfall than to any other climate variable (Republic of Uganda, 2007; NPA, 2010).

## CURRENT CLIMATE VARIABILITY AND EXTREMES

Uganda is well-endowed relative to most other African countries in terms of its climatic and ecological conditions; however, in some areas it experiences extremes of temperature and rainfall. The northern region is especially vulnerable, prone to both floods and droughts as a result of high rainfall variability (MWE, 2002).

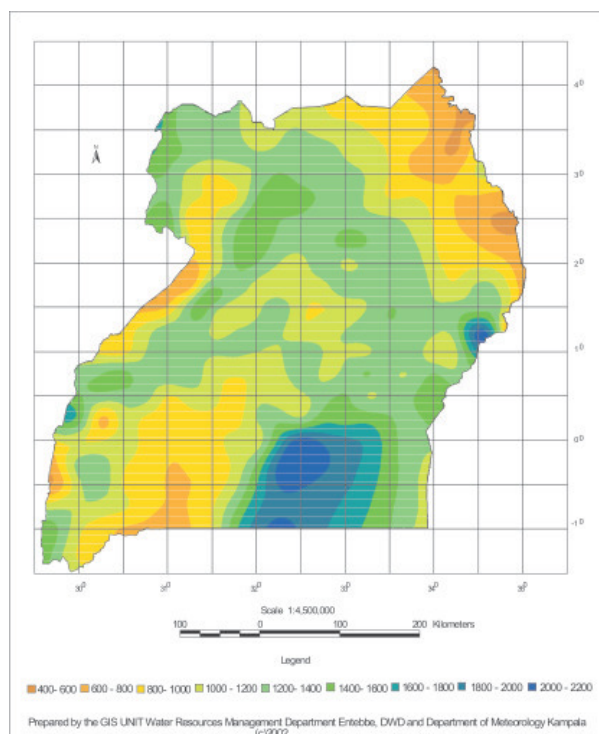
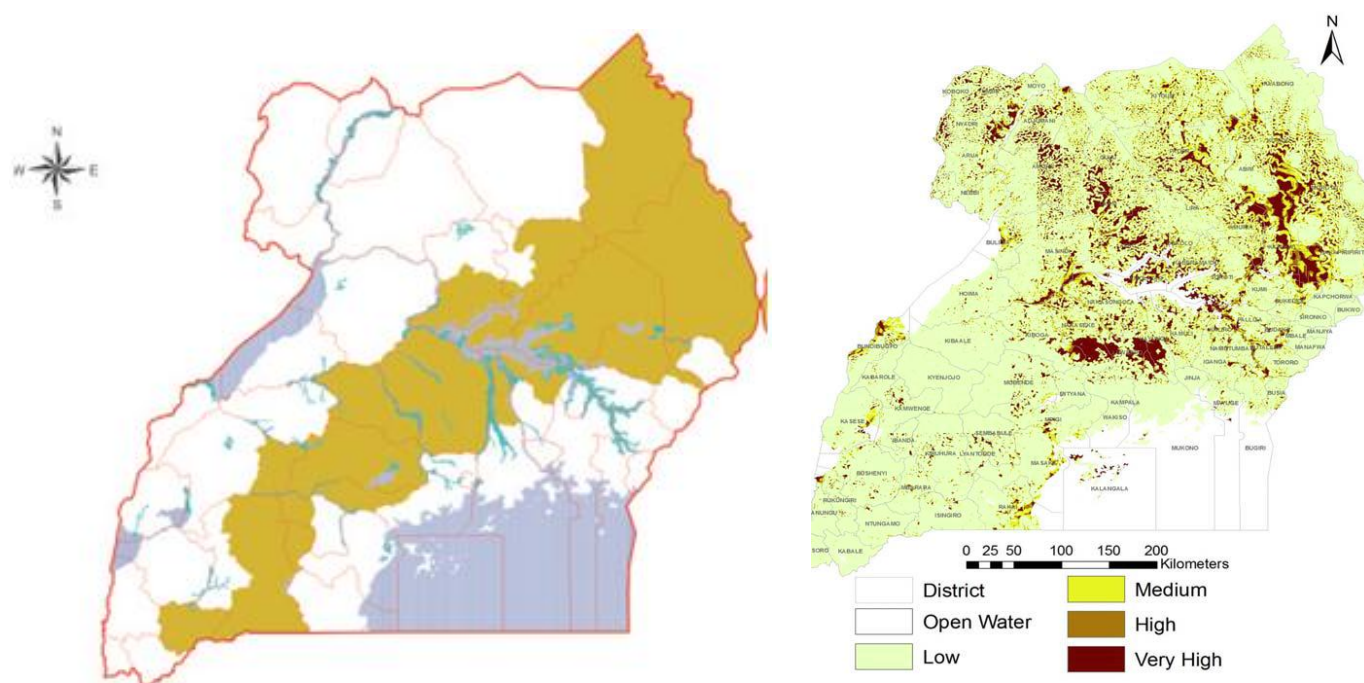


Figure 5. Mean annual rainfall in Uganda (reprinted with permission from Republic of Uganda, 2007)

Semi-arid climates within Uganda experience extreme temperatures. Although temperatures as high as 33° C have been recorded in Mbarara in the southwest of the country, the highest temperatures—up to and above 35° C—are found in the northeast in the Gulu, Kitgum and Moroto regions. Highland climates can see extreme lows in temperature, reaching as low as 4° C in Kabale in the western highlands, and temperatures below freezing are regularly experienced in the Rwenzori and Elgon ranges. The Rwenzoris, in fact, have a permanent (yet rapidly shrinking) ice cap (Republic of Uganda, 2007).

Rainfall levels in Uganda vary from extremes of 400 mm per year in Karamoja to 2,200 mm per year on the Ssesse Islands in Lake Victoria (figure 5). While Uganda is well-suited to agriculture and animal husbandry, droughts are a recurrent problem. The cattle corridor often experiences low levels of rainfall, which, combined with its poor soil fertility, can lead to chronic food insecurity in the area, and the Karamoja region in the north is virtually dependent on food aid because of the regular droughts experienced there (Republic of Uganda, 2007). The northeast, especially Karamoja and parts of the Kyoga basin, is also prone to flooding, which compounds food insecurity in the area (Republic of Uganda, 2007).



Figures 6 and 7. Drought-prone areas in Uganda's 'cattle corridor' (reprinted with permission from Republic of Uganda, 2007) and flood-prone areas in Uganda (reprinted with permission from NEMA, 2008)

Floods and droughts are the most frequent climate hazards, with 16 and 9 events, respectively, recorded from 1900 to 2011, followed by storms (four events) and landslides (three events); see table 2. During this period, drought was the climate hazard that affected people most, affecting nearly 5 million people, followed by floods (more than 1 million people). However, landslides are reported to have killed more people (419, compared with 255 for floods and 194 for droughts).

**TABLE 2. RECORDED CLIMATE HAZARDS IN UGANDA FROM 1900 TO 2011**

	NUMBER OF EVENTS	TOTAL KILLED	TOTAL AFFECTED	DAMAGE (000 US\$)
Droughts	9	194	4,975,000	1,800
Floods	16	255	1,022,400	1,071
Landslides	3	419	16,161	-
Storms	4	23	10,152	-
Total	32	891	6,023,713	2,871

Data source: CRED, 2012

According to the Ugandan Agricultural Census (UBOS and MAAIF, 2011), 7 percent of the country's 3.95 million agricultural households reported they were prone to flooding, with most incidences reported in the Eastern Region. Further, of the 2 million agricultural households that experienced food shortages, 1.8 million (91.5 percent) experienced drought and 1.3 million (66 percent) experienced pests or diseases (UBOS and MAAIF, 2011). Crop production has been negatively impacted by climate hazards and disasters; an average of 800,000 ha of crops are destroyed annually by climate-related effects, resulting in losses exceeding US\$47million (NEMA, 2008). During the 1997/1998 floods, coffee exports dropped 60 percent and tea estate operations were suspended in eastern parts of the country, while 300 ha of wheat were lost in the Kapchorwa District (MWE, 2002). The Kapchorwa District experienced massive soil erosion as a result of the 2007/2008 floods (NEMA, 2008). In September 2010, further flood disasters hit the Teso area (Eastern Region), leading to rotting cassava, sweet potato tubers and groundnuts worth over US\$3.1 million. In March 2010 a massive landslide triggered by heavy rain occurred on the steep slopes of Mount Elgon in Bududa district (adjacent to Kapchorwa), destroying three villages and killing at least 100 people. During the 1999/2000 droughts, the water table lowered, and the subsequent drying of wells and boreholes led to cattle deaths, low milk production and food insecurity within the cattle corridor (NEMA, 2008).

## OBSERVABLE CHANGES IN CLIMATE

While it is difficult to fully assess the degree to which changes in climate variables and hazards are part of a broader trend due to relatively poor historical data collection, important changes are nevertheless being observed in Uganda's climate.

The average temperature in semi-arid climates is on the rise, especially in the southwest (MWE, 2002). The country's national adaptation programme of action (NAPA) cites an average temperature increase of 0.28° C per decade between 1960 and 2010, with the months of January and February especially exhibiting this warming trend, averaging a 0.37° C increase per decade (Republic of Uganda, 2007; Republic of Uganda, 2010a). The frequency of hot days in the country has increased significantly, while that of cold days has decreased (Republic of Uganda, 2010a). Malaria is spreading into new areas in the country (Namanya, 2009; United Nations Office for the Coordination of Humanitarian Affairs, 2008). The ice cap on Rwenzori has shrunk significantly in the last 100 years (IGAD, 2010), and changing temperature patterns have been linked with drought and consequent increased cattle deaths (Oxfam, 2008).

Changes in rainfall patterns are also being observed. Rainfall has become lower, less reliable and more unevenly distributed (IGAD, 2010). Recent years have seen erratic onsets and ends to rainfall seasons, and rainfalls have been heavier and more violent (Republic of Uganda, 2007; 2010a). Floods and landslides are on the rise and increasing in intensity (Republic of Uganda 2007), and since 2000, extreme rainfall conditions have been regularly experienced in Eastern Uganda, where there has been an increase of approximately 1,500 mm of precipitation in the December-to-January rainy season (NEMA, 2008). El Niño Southern Oscillation events have also been shorter and more irregular (IGAD, 2010).

The Government of Uganda (MWE, 2002) and International Institute for Environmental Development (Twinomugisha, 2005) urge caution in making claims about the existence of a long-term trend in rainfall patterns, given the limited historical data. However, they acknowledge that droughts are on the rise. The west, north and northeast of the country have been experiencing more frequent and longer-lasting droughts than seen historically (Republic of Uganda, 2007). Between 1991 and 2000, seven droughts occurred in the Karamoja region, and the years 2001, 2002, 2005 and 2008 also saw major droughts (CRED, 2012). While there have always been droughts in Uganda, evidence suggests they are becoming more frequent and more severe (IGAD, 2010). The increased frequency and duration of droughts is the most significant climate-related change in Uganda (Republic of Uganda, 2007; 2010a).

## PROJECTED CLIMATE TRENDS

Goulden (2006) reviews the results of models that have been used to forecast the future East African climate. While there is considerable disagreement among the models as to future rainfall trends, there is somewhat of a consensus on future temperatures, with temperatures expected to increase between 0.7° C and 1.5° C in the short term (by 2020 to 2029), and between 1.5° C and 4.3° C by the 2080s. The severity and frequency of extreme weather events is expected to change, although what form these changes will take cannot be accurately predicted. Also, despite the wide range of results in predicted rainfall trends, on average, rainfall is expected to increase as much as 7 percent by 2080, and changes in the seasonal distribution of rainfall are expected as well.

The Working Group I of the Intergovernmental Panel on Climate Change (IPCC), in its review (2007), predicts an increase of 10 to 20 percent in average annual rainfall in the region over the next century. The group believes precipitation and temperature changes will likely result in wet areas becoming wetter and dry areas becoming drier (MWE, 2007), with an increase in the incidence of droughts (Hepworth and Goulden, 2008). However, precipitation increase may be minimal due to high uncertainty in circulation patterns above the Indian Ocean (Christensen et al., 2007; Williams and Funk, 2011). In Uganda, the impacts of climate change will differ among the country's agroclimatic zones, with the drier areas (cattle corridor) likely to receive less precipitation, and the wetter areas (around Lake Victoria) likely to receive up to 20 percent more precipitation (Christensen et al., 2007).

Global circulation models have been used to project Uganda's future climate. However, because they are used to forecast global and regional changes, we should employ caution in applying their results to Uganda's relatively small area. The results of 'Uganda's Climate Change Vulnerability Assessment, Adaptation Strategy and Action Plan for the Water Resources Sector in Uganda' (Republic of Uganda, 2010a), which employed global circulation models to forecast Uganda's climate, predicted that temperatures would continue to rise in Uganda, especially in semi-arid areas. Significant effects are expected in the northeast and southwest, but relatively little effect for the area around Lake Victoria. Mean temperature is estimated to increase between 0.3° C and 0.5° C per decade. Also predicted is a mean annual rainfall increase of 10 to 20 percent, and a change in the seasonal distribution of rainfall, with rainfall increasing from December to February and decreasing from June to August. However, the most significant anticipated changes are an increase in the frequency of high-intensity rainfalls and a decrease in the intensity of low-intensity rainfalls.

Very little literature has been published on recent climate trends in Uganda or East Africa, and all the models for Uganda presented here depend on past climate data, which are not well documented. The forecasts from these models should be taken as very rough sketches of Uganda's possible climate future.

## STATUS OF NATIONAL AND REGIONAL CLIMATE AND HAZARD INFORMATION

Availability and accessibility of climate data are major challenges in Uganda. The Department of Meteorology, in the Ministry of Water, Lands and Environment, is responsible for monitoring the Ugandan climate, operating a network of synoptic stations, climatological stations, upper air stations and rainfall stations. However, this network of monitoring stations is far from adequate (MWE, 2002). Historical meteorological data are also lacking, which makes climate forecasts speculative (MWE, 2010).

Research surrounding climate is carried out by the Uganda National Council for Science and Technology, which is responsible for co-ordination and overall policy guidance on scientific research. In addition to facing problems of poor-quality raw data, the council must contend with poor management and sharing of data. Data management is lacking at the Climate Change Unit (CCU) in the Ministry of Water and Environment, and the data management of the Office of the Prime Minister (OPM) is underdeveloped. Restricted access increases the challenge of information-sharing even when information is available. Nationally, major gaps remain in communication and dissemination of information among ministries and central and local governments. Information-sharing is not institutionalized, and each level has dysfunctional communication protocols. For these reasons, as well as the limited modelling work that has been done and the complex interactions that exist among land cover, oceanographic changes and climate, Uganda's climate projections are among the least reliable in the world (Halsnæs et al., 2008).

### Key messages: Climate profile

- Uganda is experiencing more frequent and intense droughts than it has historically. Temperatures have risen 0.37° C per decade since 1960. While no clear long-term rainfall trend is visible, heavy rainfalls, floods and landslides are on the rise.
- Climate forecasts predict that temperatures will continue to increase, extreme weather events will become more frequent and intense, and rainfall patterns will change, although it is not clear how.
- The impacts of climate change will differ among the country's agroclimatic zones, with drier areas likely to receive less precipitation and wetter areas likely to receive more.
- Collection of climate data in Uganda is limited, and there are problems with the accuracy and availability of historical data, so challenges remain regarding exact climate forecasts.

## CLIMATE IMPACTS AND RISKS

This chapter presents the results of a focused climate risk assessment on crop production (maize, beans and coffee) in the Rakai and Kapchorwa districts. Climate risk is understood as the probability of negative impacts on farmers, the environment and crop production resulting from the interaction of climate hazards and conditions of vulnerability. The analysis builds on the descriptions of the development context and climate hazards in the two previous chapters and looks at more specific information on exposure of smallholder farmers and crops to climate risks and the different elements of vulnerability—namely sensitivity and adaptive capacity—taking into account, whenever possible, both the current situation and future trends.

**Rakai District** is in the southwest of Uganda, west of Lake Victoria (figure 4, p. 13). The district has a diverse topography composed of the Lake Victoria shores, the northeastern and western hills (some as high as 1,520 m) and the northwestern plains, which host different ecosystems (forests, swamps and savannahs). The total area is 4,898 km<sup>2</sup>. The average annual minimum and maximum temperatures at the local weather station in Kibanda (at approximately 1,170 m) are 14.1° C and 26.7° C, respectively, with average annual precipitation of 952 mm.<sup>3</sup> Overall, the growing conditions in Rakai are representative of those in other parts of the country, except that rainfall is lower in Rakai due to its location in the cattle corridor. According to the latest 2002 population census, the population in 2011 was 475,300, with a population growth rate of 1.7 percent (registered for the period 1991 to 2002) (Rakai District Local Government, 2010).

**Kapchorwa District** is in the Eastern Region of Uganda, on the slopes of Mount Elgon (figure 4, p. 13). Thirty-seven percent of the district is within Mount Elgon National Park, a forested mountain ecosystem on the border with Kenya. The district is 5,197 km<sup>2</sup>, with altitudes ranging from 1,000 m in the lowlands to between 1,400 m and 2,000 m in the highlands, which host mixed mountainous forests. The average annual minimum and maximum temperatures at the local weather station in Buginyanya (at approximately 1,800 m) are 13.2° C and 23.2° C, respectively, with an average annual precipitation of 2,569 mm.<sup>4</sup> The district has a moist and cool agroecology favourable for growing Arabica coffee, and the land is considered to be of high productive value. It has fertile (volcanic) soils due to its proximity to Mount Elgon (Kapchorwa District Local Government, 2011a). Recent crop modelling done by Wasige (2009) in districts representative of Uganda's different agroecological zones revealed that Kapchorwa is the most productive maize-growing region in the country under current climate conditions. The population in 2011 was 109,300, with a population growth of 4.15 percent (Kapchorwa District Local Government, 2011a).

Both districts are characterized by a mixed, rain-fed crop-livestock system dominated by small- and medium-scale farmers with few commercial farmers, who grow maize. According to the last agricultural census in 2008/2009 (UBOS and MAAIF, 2011), Kapchorwa produced nearly three times more maize than Rakai in 2007. However, Rakai has a more diversified crop production system, including maize, bananas, cassava, sweet potatoes, Irish potatoes and beans; Kapchorwa farmers mainly rely on maize and bananas and, to a lesser extent, beans, Irish potatoes and cassava. Due to their different climates and topographies, farmers in Rakai primarily grow Robusta coffee together with some Arabica (lowland variety) in the hills, while farmers in Kapchorwa only grow the higher-value Arabica (highland variety). Cattle distribution is uneven across the country, with Rakai being one of the districts with the highest cattle numbers (MAAIF et al., 2010).

The local consultations and crop modelling conducted as part of CRM TASP focused on three parishes: Katatenga (1,277 m above sea level) and Kayonza (1,391 m above sea level) in Rakai, and Sanzara (1,356 m above sea level) in Kapchorwa. These parishes were selected to capitalize on the ongoing work done by IUCN in those areas.

<sup>3</sup> Based on the five-year data set (2006 to 2010) that the research team obtained from the local weather station.

<sup>4</sup> Idem.





Figure 8. Bean and maize garden in Kayonza parish, Rakai (27 April 2011). Photo: Sophie Kutegeka



Figure 9. Despite the fact that farmers applied diammonium phosphate fertilizer, insufficient rains in Kasongo parish, Kapchorwa, led to crop failure (bean and maize garden) (20 April 2011). Photo: Sophie Kutegeka

## CLIMATE IMPACTS ON CROP PRODUCTION

The Rakai district officials and local development actors identified weather change as a current major threat to the district's development (Rakai District Local Government, 2010). The district development plan (2010–2013) further mentions: "In some years... the weather patterns change with early onsets of dry seasons/droughts leading to crop failures" (Rakai District Local Government, 2010). The Kapchorwa District development plan (Kapchorwa District Local Government, 2011a) has identified natural disasters, including landslides, as a key threat to development. It also identifies unpredictable rainfall patterns and drought due to dry spells, especially in the lower part of the district, as one of the main problems in crop production.

As part of the NAPA (Republic of Uganda, 2007), local consultations were conducted in 12 districts (out of 111) representing five major ecosystems and using survey and participatory rural appraisal methods to document farmers' perceptions of changing climate. Farmers reported experiencing changes in weather patterns. Further local testimonies have been documented since then (e.g., Oxfam, 2008) to raise awareness on the issue among key national stakeholders. Such perceptions of increasing uncertainty and weather changes were further explored and validated for Rakai and Kapchorwa districts during consultations as part of the CRM TASP. Farmers, local development actors and district officials perceive they are increasingly exposed to the following changes:

- **Irregular, erratic seasons** in the past few years, which have made prediction of cultivation seasons more difficult (Rakai and Kapchorwa).
- **Changes in the timing, frequency, coverage and amount of climate hazards**, especially drought, floods, hailstorms and windstorms, greatly affecting farming practices (Rakai and Kapchorwa).
- **Irregular rainfall distribution within the season.** "The rains are coming late, there is not enough rain, especially for second season."; "Kapchorwa used to have two clearly distinct growing seasons for both maize and beans, but this is no longer always the case" (Rakai and Kapchorwa).
- **Shorter and more intense rains**, which prevent plants from flowering and producing fruit (Rakai and Kapchorwa).
- **Heavy rains and landslides.** Farmers reported that people tend to plant right next to the river banks and that floods have been a very big problem, especially because they cause soil erosion (Kapchorwa only).
- **More frequent and prolonged droughts.** For example, a normal drought period used to be between two and three months. However, in 2009 the drought in Rakai extended to nearly six months (Rakai and Kapchorwa).
- **Higher temperatures.** Local actors reported that crops are maturing faster because of increasing temperature. They also tend to associate higher temperatures with increased prevalence of crop diseases (Rakai and Kapchorwa).

One of the main lessons from the local consultations is that farmers clearly report they are no longer able to follow their normal farming calendar. This includes, for example, planting and coffee weeding time (which is normally determined by the crop planting time, the amount of rain necessary for germination and the age of the tree). However, precipitation and temperature trends could not be validated with long-term climate data currently available in the local stations. Osbhar et al. (2011) compared farmers' perceptions of climate change and variability in Mbarara District (southwest of Uganda, close to Rakai) with daily rainfall and temperature data. Results also highlight the lack of meteorological evidence in this specific location: data correlate with farmers' observations of increasing temperatures, but do not show the significant changes in seasonality or extreme events that farmers report.

### Direct impacts of climate hazards

Currently, the main impacts of climate hazards on crop production, as reported during local and national consultations, range from total crop failure (maize and beans) to decreased yield quality and quantity and increased susceptibility to pest and diseases (maize, beans, coffee). Focus groups with farmers in both districts did not reveal any major differentiated impacts across study areas in the two districts.

Farmers in Kapchorwa highlighted an increase in the occurrence of the "fly crop," which is described by farmers as the coffee crop flowering outside the normal cycle. According to a "normal" calendar, "fly crops" are harvested between September and March. Recently, however, farmers reported harvesting the fly crop between April and May, and in some cases throughout the year. They associate these changes with the observed changes in temperature and rainfall (increased frequency and quantity). Of main concern to farmers is that the "fly crop" produces low yields and smaller coffee beans, hence these changes further lower the value of this crop. To our knowledge, this observation has not been documented elsewhere, and further research needs to be done to validate it.

Research by the World Bank (Parizat et al., 2011) and CRMTASP has found a reduction in coffee quality in Uganda over the past several decades. Stakeholders along the coffee chain agree that the decline may be related to temperature changes and/or increasing climate hazards, among other factors (e.g., low nutrients, aging trees), but this should be further investigated.

### Indirect impacts of climate hazards

Focus groups at local and national levels highlighted other indirect impacts of climate hazards on agriculture. These include **decreased income, increased food prices** and **increased production costs**. Combined with the current environmental degradation and the socioeconomic and political context, these impacts further worsen the existing high poverty. This also contributes to **conflicts** over natural resources and the **degradation of the environment** (increased erosion, reduction of soil fertility). For example, communities in Kacheera (Rakai) and Kawowo (Kapchorwa) subcounties reported increasing conflicts between animal grazers and farmers over limited water resources along wetlands and rivers, especially during droughts. Conflicts between communities and the government agencies mandated to implement conservation regulations also occur.

Farmers in the study areas are very much aware of the impacts of climate hazards on their livelihoods. They associate both floods and droughts with **reduced soil fertility** and long-term negative impacts on crop production and **food security**, sometimes leading to **famines**. For example, in Kapchorwa, flooding in 2007 and 2009 caused a famine in Sanzara Parish. They also associate climate hazards with an overall **reduction of livelihood options** such as education, health and housing. Kapchorwa used to be malaria-free, but is no longer, according to district officials and farmers. Due to low immunity, those households are more vulnerable than in other regions where malaria is endemic. A recent study by Wandiga et al. (2010) analysed past climate (temperature and precipitation), hydrological and health data (1961 to 2001) in the highlands of Lake Victoria basin and concluded that a link exists between climate variability and the incidence and severity of malaria epidemics. Health impacts are reinforced by the high prevalence of HIV/AIDS in the districts (Rakai District Local Government, 2010; Kapchorwa District Local Government, 2011a), which decreases the labour needed for agriculture.

Farmers also associate changes in the local climate with the **disruption of social structures**. Much of the extra burden caused by climate hazards falls on women and children. Focus groups with women in the study areas reported an **increase in domestic violence** due to food shortages and water stress. Indeed, women can no longer fulfill their role in food production, and water shortages disrupt household activities, which challenges cultural norms (e.g., women come home late from walking longer distances for water). Women reported that because of such disruptions, more girls get married in other villages to avoid violence in

their homes. During national consultations, stakeholders highlighted that due to the shifting season, the weeding period may not always fall during the school break as it used to. Women have to weed alone without the support of the children, or else the children will not go to school. Stakeholders also highlighted that men staying idle during prolonged dry seasons sometimes contributes to **increased fertility**, increasing the household burden.

Loss of livestock due to climate hazards can contribute to **poverty** and a **reduction in manure availability**, which leads to further **decline in soil fertility**. Despite the importance of livestock for poor farmers and crop production (see MAAIF et al. 2010), little quantitative information is available on the impacts of climate hazards on livestock. NEMA (2009) reported that during periods of drought and pasture and water deficits, the number of cattle in Rakai can more than triple as cattle come from other areas in search of pasture and water, leading to land degradation and overgrazing. Nabikolo et al. (2010) also reports that “death of livestock from lack of water in the [cattle] corridor has been common and has forced traditional pastoralists to migrate with their herds during hard times to neighbouring districts or game reserves.”

Figure 10 summarizes the current impacts of climate hazards on crop production as perceived by key actors in Rakai and Kapchorwa. It illustrates that a range of environmental, socio-economic and political issues can reinforce negative impacts of climate hazards on crop production, increasing poverty. While the figure shows a sequence from A to D, the interactions between the different factors are not linear, but complex and interlinked. Figure 11 summarizes key actors’ perceptions of **future potential impacts** of climate risks on crop production in the two districts. Most actors perceive that climate change will contribute to the severity of climate hazards in combination with other socioeconomic trends.

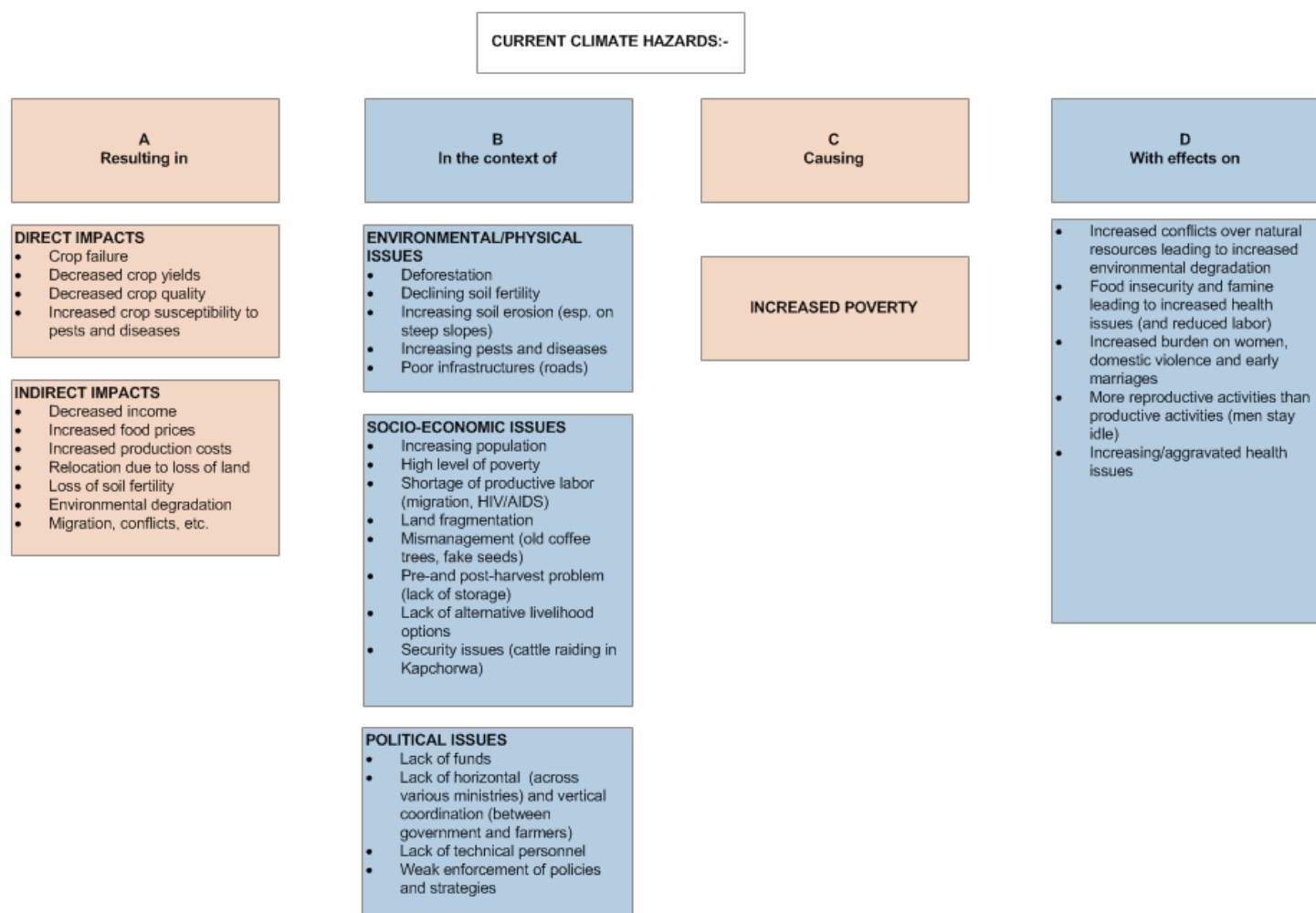


Figure 10. Perceived current impacts of climate hazards on crop production in Rakai and Kapchorwa



#### **INCREASED SEVERITY OF CURRENT RISKS**

- Dry areas becoming drier; wet areas becoming wetter
- Prolonged and more frequent droughts (7-9 months) and floods (also due more deforestation and increased population)
- More pronounced shift in the onset of rain (e.g., once in every 3 years)
- Irregular rainfall distribution
- Increased hailstorms, windstorms, thunderstorms, and lightening
- Switch from two growing seasons to one growing season (getting shorter)

#### **CROP PRODUCTION ISSUES**

- Decrease in quality
- Decreased yield expected due to shorter growing seasons due to reduced rainfall and less time for crops to grow
- Increased used of fertilizers with detrimental effects on the environment
- Destruction of agricultural investments
- Increased production costs and reduction in competitiveness
- Food insecurity (making agriculture a riskier enterprise; lower incomes, reduction of staple food in the households (maize and beans))
- Shift to faster growing species; coffee growing could be affected due to increasing land competition (coffee is space consuming)
- Increased droughts may compel more and more people to shift to animal grazing, leading to overgrazing

#### **ENVIRONMENTAL ISSUES**

- Drying out of water bodies
- Decreased soil fertility and productivity
- Degradation of natural resources through increased used of fertilizers
- Deforestation through bush fires
- Extinction of certain plants and animal species
- Increased prevalence of pest and diseases and occurrence of new diseases

#### **SOCIO-ECONOMIC ISSUES**

- Loss of human and animal lives
- Famines
- Chemical pollution hazardous to lives
- Loss of incomes and livelihoods
- Increased poverty and marginalization of the poorest from farming activities due to increased costs of production
- Increased child labor and low level of education
- Increased domestic violence
- Reduced socialization, home breaking up, HIV increase, decline in social capital
- Increase in early marriages
- Increased costs of resettlement
- Increased disaster management interventions and increased costs in disaster management interventions
- Increased of social tensions and conflicts
- Climate related conflicts in Karamoja (North of Kapchorwa) could spill over into Kapchorwa causing water related conflicts
- Increasing encroachment into conservation areas (Mt Elgon) causing increased deforestation and further increasing negative impacts of climate hazards

*Figure 11. Perceived future potential impacts of climate risks on crop production in Rakai and Kapchorwa districts*

To conclude, the literature provides limited information on the quantification of the direct and indirect impacts of past climate hazards and disasters on crop production at national and regional levels. In particular, most reports do not disaggregate the data according to the different crops and according to the socioeconomic groups. However, consultations at local and national levels confirm that people in Rakai and Kapchorwa have to deal with greater uncertainties related to climate hazards and other socio-economic and environmental changes. They are already negatively impacted by climate hazards and increasing climate variability, which supports existing studies done at the national level (e.g., Republic of Uganda, 2007; Oxfam, 2008). Those impacts are aggravated by the broader socioeconomic and environmental contexts. The future potential impacts of climate change will probably continue to worsen this situation, especially if environmental degradation and population growth continue to increase.

## EXPOSURE OF SMALLHOLDER FARMERS TO CLIMATE HAZARDS

In Rakai and Kapchorwa, as elsewhere in Uganda, agriculture is dominated by smallholder farmers. Maize and beans are cultivated in almost all districts of Uganda, and coffee is also cultivated in most districts, with the exception of the Northern Region. Holdings average 0.33 ha per household (MAAIF, 2011). Robusta is the main coffee variety, while Arabica is grown in the highlands in the east (Mount Elgon) and the west (Rwenzori Mountains). Generally maize, beans and coffee are intercropped and are therefore similarly exposed to climate hazards. Farmers in Rakai (southwest) and Kapchorwa (east) are exposed to both floods and drought. But due to differentiated topography and climate, farmers in Rakai tend to be more exposed to drought, while farmers in Kapchorwa tend to be more exposed to floods (especially flash floods due to heavy rains) and landslides.

As part of the CRM TASP, McCandless et al. (2012) used a weather generator, MarkSim,<sup>5</sup> to generate daily climate data for 2010 conditions and for climate change scenarios for 2030 and 2050 in the three parishes of interest. MarkSim was selected because it correlated with historical data from 2006 to 2010 (the most complete years in the data record). Figures 12, 13 and 14 show average monthly maximum and minimum temperatures and precipitation for the years 2010, 2030 and 2050 at experimental locations as predicted by MarkSim. The results suggest that the projected climatic changes do not lead to significant changes in temperature and rainfall patterns in all three parishes, but that Kayonza and Katatenga (Rakai) may see slight decreases in precipitation of around 1 percent below 2010 levels initially, followed by a slight increase by 2050 to 1 percent above current levels. Sanzara (Kapchorwa) may experience an increase in precipitation of around 2 percent by 2030 and 5 percent by 2050. Temperatures are predicted to increase for all sites by around 0.4° C to 0.6° C by 2030, followed by an additional increase of 0.6° C to 0.7° C by 2050.

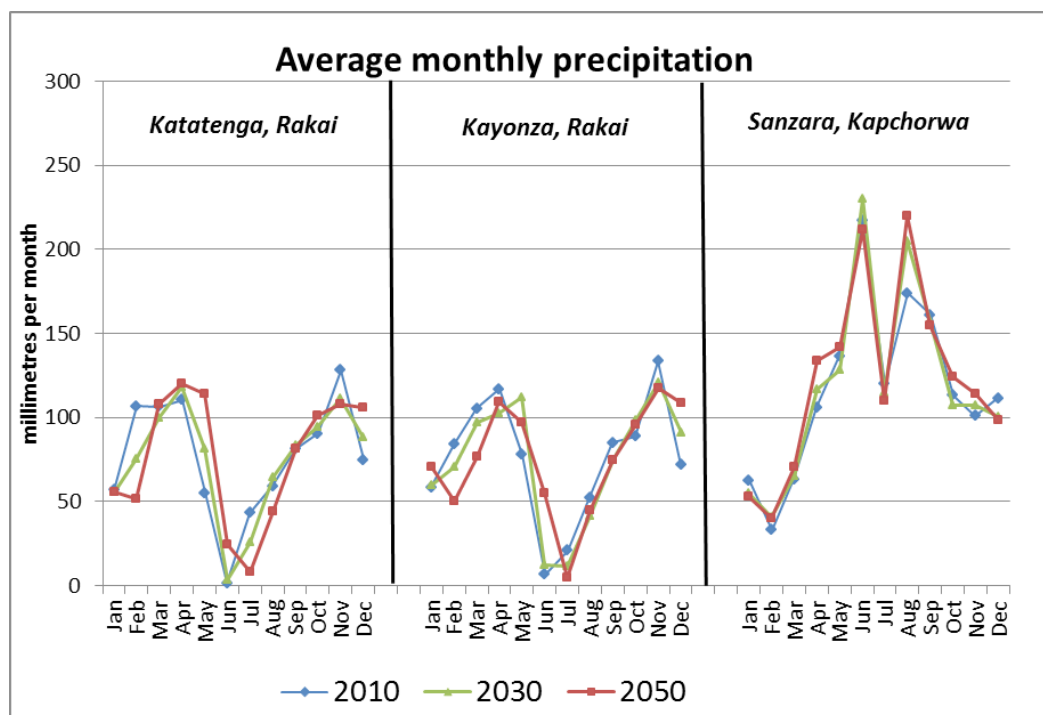


Figure 12. Marksim rainfall predictions

Even without accounting for climate change, a number of non-climate factors tend to increase people's exposure to climate hazards. For example, some farmers in Kapchorwa have been pushed to more hazard-prone areas for conservation reasons (e.g. for the formation of Mount Elgon National Park) and security (leaving land due to cattle rustling) (Kapchorwa District Local Government, 2011a; NEMA, 2009). High population growth in both districts also means that more people are likely to be exposed to climate hazards, causing additional physical and socio-economic damage.

<sup>5</sup> MarkSim is a stochastic weather generator created by the International Centre for Tropical Agriculture. For more information please see Jones et al. (2002) and Jones et al. (2009).

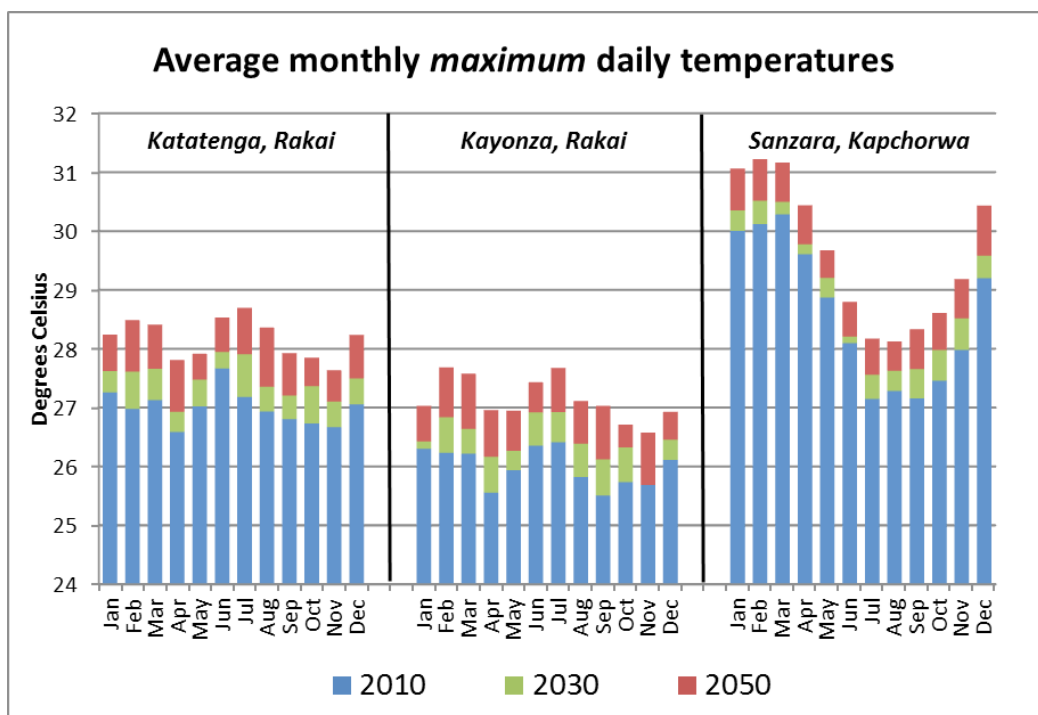


Figure 13. Marksim temperature predictions (maxima)

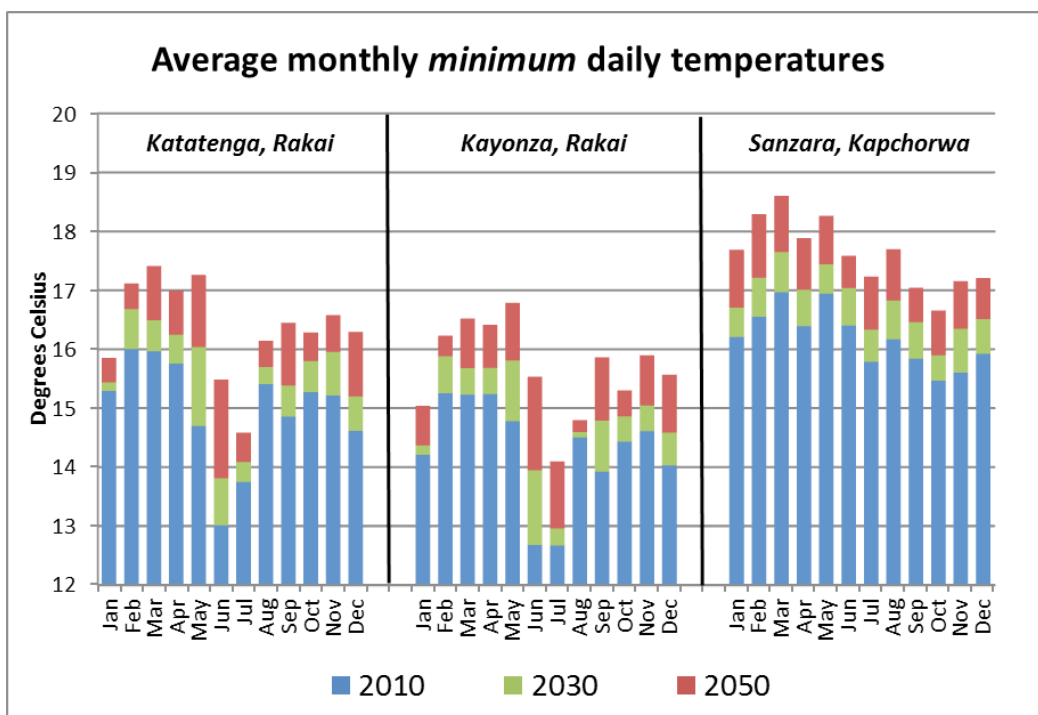


Figure 14. Marksim temperature predictions (minima)

## SENSITIVITY OF FARMERS AND CROPS TO CLIMATE HAZARDS

Maize and beans are critical crops for poor rural livelihoods, and coffee remains the main export crop for most smallholders. A decline in production would have catastrophic effects for the country's society and economy. The 'National Development Plan (2010/11–2014/15)' (NPA, 2010) aims to accelerate the development of select crops including coffee, maize and beans. This section focuses on the sensitivity of crop production to current climate hazards (floods, droughts, and changes in rainfall and temperature).

In Rakai and Kapchorwa, as in the rest of the country, livelihoods mainly rely on small-scale, subsistence, rain-fed agriculture, with high dependence on rainfall patterns and limited external inputs (i.e. use of traditional hand hoes, organic fertilizers and animal rearing—mainly goats, cows and chickens). Use of chemical fertilizer and irrigation is very low, due to cost. The combination of beans, maize, coffee and bananas constitutes the main livelihoods for most Ugandans. Most farmers are therefore very sensitive to climate hazards, especially because crop yields are already low compared with their potential, again due to low inputs. Limited livelihood diversification opportunities exist.

The ecophysiological requirements of maize, beans and coffee make these crops sensitive to climate variability (i.e. changes in factors such as temperature, moisture, carbon dioxide concentrations, pH and salinity). Too much or too little water at a certain time in crop development may negatively affect crop yield and quality, and may further increase sensitivity to pests and diseases, especially when combined with other stresses such as poor soil fertility. Different varieties of maize, beans and coffee are cultivated in Uganda, and each may respond differently to the impacts of climate variability. Annual crops like maize and beans are also more sensitive to climate hazards than perennial crops like coffee and bananas. Indeed, extreme events can quickly destroy the annual crop, leaving farmers with no harvest. Perennial crops might have lower yields or reduced quality, but will often survive, allowing farmers to continue benefiting from some harvest. Most Ugandans, and especially women in rural areas, depend on annual crops.

Maize is generally most sensitive to drought, while beans tend to be most sensitive to excessive rainfall. Actors at local and national levels reported that maize production is more sensitive to climate risk compared with other food crops, due to its strong dependence on water. Beans do not tolerate flooding, which hinders flowering and fruit-setting. This observation is also supported by the perceptions of key actors at the national, regional and local levels. Three types of beans are found in Uganda, and each responds differently to changes in rainfall (personal communication, Michael Ugen, 2010). The government has been conducting trials to develop drought-resistant varieties of maize and beans. However, farmers during local consultations in Rakai and Kapchorwa reported that some of those hybrids are also more sensitive to pests and diseases.

### Sensitivity of maize and beans to future climate change

Crops may be sensitive to different elements of climate change such as increases in temperature and related potential changes in hydrology (e.g. availability of groundwater); changes in frequency, severity and extent of bush fires; and changes in wind and storm events (Glick et al., 2011). These changes can impact the length of a crop's growing period, and therefore yields, among other aspects.

As part of the CRM TASP, McCandless et al. (2012) studied the impacts of climate change on maize and bean yields in Katatenga and Kayonza villages in Rakai, and in Sanzara parish in Kapchorwa, where local consultations were also conducted. They used an ecophysiological crop model called the Decision Support System for Agrotechnology Transfer (DSSAT) to understand how predicted changes in temperature and precipitation will influence crop growth and yield.

Figures 15 and 16 show the average bean and maize yields determined by DSSAT for the years 2010, 2030 and 2050 with three different treatments (no inputs, perfect irrigation and perfect nitrogen fertilization). Bean production in Sanzara is projected to decrease by around 6 percent, while the impact on beans in Kayonza and Katatenga (Rakai) will be negligible (around 1 percent decrease) by 2050. Maize production for the sole growing season in Sanzara (Kapchorwa) may experience an 8 to 10 percent decrease by 2050, while the impacts on maize in Kayonza and Katatenga (Rakai) will remain negligible (around 0 to 2 percent increase). Unlike Kayonza and Katatenga (Rakai), Sanzara (Kachorwa) may experience the negative impact of climate change on maize and bean production by 2050.

Overall the results indicate that:

- The impact of climate change on maize and bean production will be limited in the three parishes and for both crop seasons, as compared with predictions from studies conducted elsewhere in East Africa.
- In the three sites, climate change impacts can be almost completely offset through investment in water management (irrigation), especially on bean production and, to a much lesser extent, through investment in fertilization. The model predicts irrigation investments will increase maize and bean production in Rakai and bean production in Kapchorwa well beyond the current output by 2050, notwithstanding climate change.

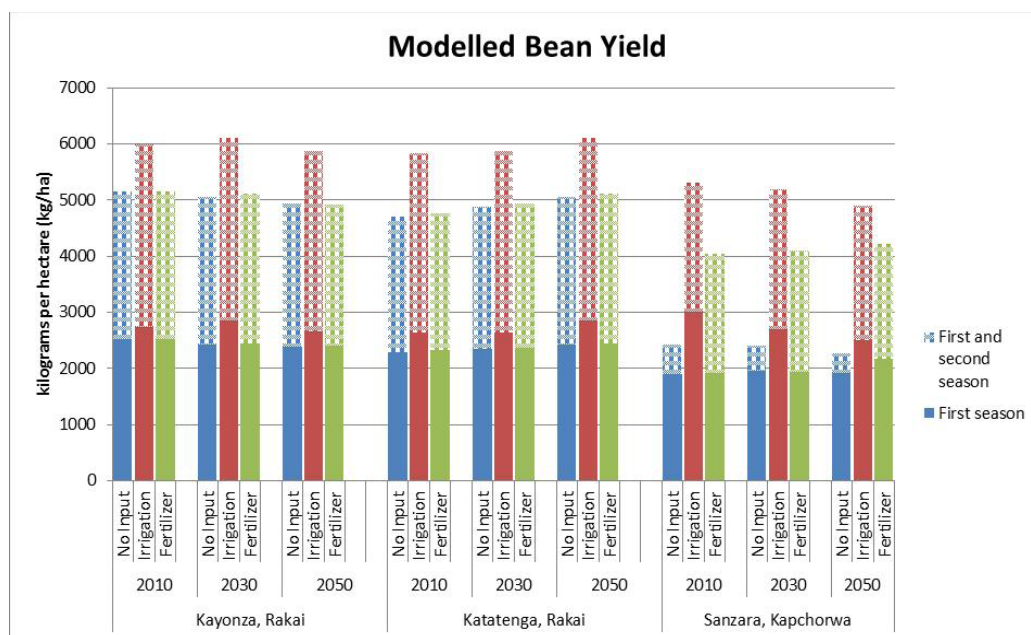


Figure 15. Average bean yield from 30 runs of DSSAT with three different treatments

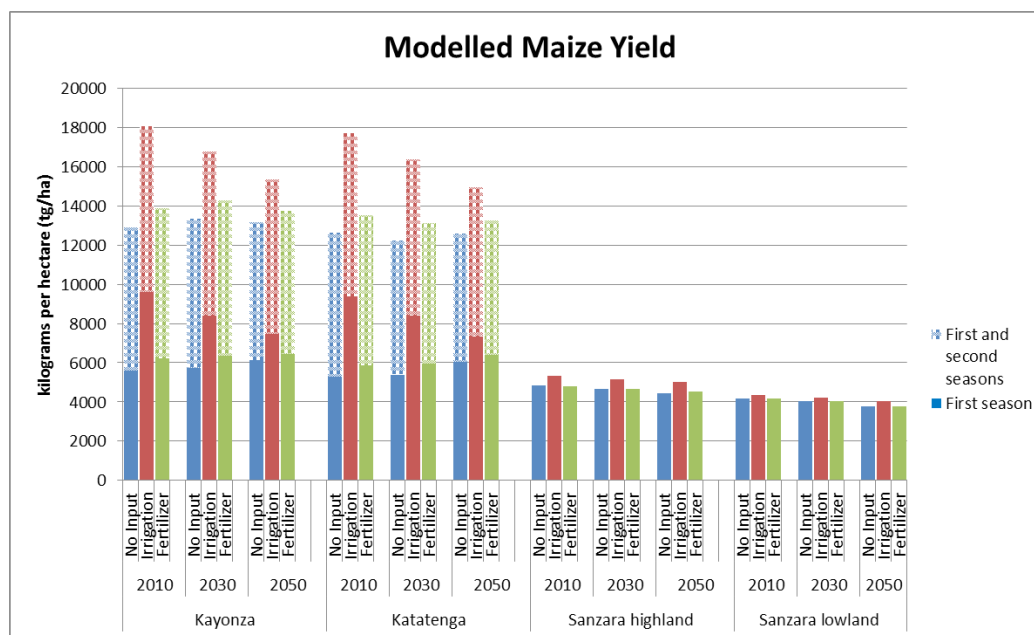



Figure 16. Average maize yield from 30 runs of DSSAT with three different treatments. Maize is grown only in first season, and agronomic practices differ in highland and lowland fields



McCandless et al. (2012) conclude that the relatively limited projected impacts on crops may be linked to the limited projected climate impacts on temperatures and rainfall (see section 4.3). The impacts of climate change may also be underestimated because DSSAT does not account for the impacts of extreme events, pests and diseases, which are likely to increase in frequency and intensity due to climate change, as well as other impacts (such as deforestation) that could increase crop sensitivity to climate hazards. The model does not consider increased demand from population growth, which means that even small decreases in maize and bean yields may have critical consequences considering Uganda's high population growth. Finally, the model was limited by a lack of available historical daily climate records for Rakai and Kapchorwa. It was calibrated using limited data sets, which are not enough to accurately define present and historical intra-annual climate variability. As a result, it is difficult to establish whether the expected climate changes are within the range of natural variability for these areas.

Rakai and Kapchorwa district officials validated the results during a national workshop in July 2011. The results also confirm Wasige's (2009) DSSAT results for maize production in Uganda under present climate conditions. McCandless et al. (2012) reviewed other studies on the impact of climate change on maize production in Uganda (such as Jones and Thornton, 2003; FAO, 2010), but concluded that those studies are not a suitable basis of comparison because they are based on a single growing season, use different assumptions of climate change impacts, and make differing assumptions of soil types and agronomic practices.

### **Coffee sensitivity to current climate hazards and climate change**

The Uganda Coffee Development Authority (UCDA) primarily attributes the high fluctuation of coffee production over the last 40 years to climate variability, together with other factors such as reduced soil fertility and mismanagement (UCDA, 2010). Other actors in the coffee chain interviewed as part of the CRM TASP further support this observation. Globally, the International Coffee Organization (ICO, 2009) also primarily attributes the fluctuation of coffee production to climate variability. Since coffee trees are shallow-rooted, floods and droughts can affect their growth directly.

In Kapchorwa, only Arabica coffee is grown due to its cool climate, while in Rakai both Robusta and Arabica are grown. Robusta and Arabica have high but differential sensitivity to temperature and rainfall conditions. In Rakai and Kapchorwa, both Robusta and Arabica are already living at the upper end of their optimum biological temperature range, so they may be less able to tolerate temperature increases (see, e.g., Glick et al., 2011). These assumptions would need to be further validated through crop modelling using the specific varieties grown in the districts. Importantly, different types of Robusta and Arabica are also grown in the districts, and these have different sensitivity to climate hazards. DaMatta et al. (2007), in a global review of coffee research on ecophysiology, call for further research in this field in relation to climate.

Most CRM TASP interviewees perceive a decline in coffee production, which they attribute primarily to climate variability and change, among other factors. However, limited data are available to confirm the decline in coffee production and its correlation with climate change. Some studies exist on the projected impact of climate change on coffee in Uganda and globally; however, the results of most of them are questionable. For example, a map developed by Simonett (1989) has been widely cited in Uganda (as well as outside Uganda) to illustrate the negative impact on Robusta distribution in Uganda of a 2° C increase. However, this study has never been validated.

More recent studies (e.g., Lane and Jarvis, 2007; Jaramillo et al., 2009; 2011) have been conducted at regional and global levels on the impacts of climate change on various crops, including coffee, using the 'ecological niche' approach. According to Lane and Jarvis (2007), a major global decrease (approx. -7 to -15 percent) in the area suitable for coffee agriculture is expected due to climate change by 2055. The authors further forecast a global increase in maize production (+5 to +8 percent) and a decrease in bean production (between 0 and -15 percent). According to Jaramillo et al. (2011), the increase in temperature by 2050 will increase the development rates and attack severity of key coffee pests such as the coffee berry borer in parts of East Africa. However, the IPCC has criticized the ecological niche modelling approach used in those studies, which provide broad-brush assessment but should not form the basis of adaptation decision-making (Easterling et al., 2007; Carter et al., 2007; Fischlin et al., 2007).

To sum up, while exposure to climate risk in Rakai and Kapchorwa is relatively high, the sensitivity of the systems may be different, influencing the overall vulnerability of the two areas. First, the crop system in Rakai appears to be more diversified than in Kapchorwa, including the possibility of growing both Robusta and Arabica. Second, while the results of the crop modelling do not show any negative impacts in Rakai, they show a negative impact on maize and beans in Kapchorwa. In addition, various factors increase the sensitivity of those crops, and of crop production more generally, to climate hazards. These factors include land fragmentation,



environmental degradation, poor soil fertility, pests and diseases (including the emergence of new ones), fake seeds (for maize and beans, which some dishonest seed companies sell to make a quick profit), lack of storage facilities, post-harvest loss, and general mismanagement. For example, most coffee plantations in Uganda are old (over 20 years), increasing susceptibility to some pests and diseases and to the negative impacts of climate variability and change. In Rakai, local actors reported crop failures not because of weather but because of fake seeds.

## ADAPTIVE CAPACITY OF SMALLHOLDER FARMERS TO FLOODS AND DROUGHTS

Communities in both districts are already responding to current climate hazards using a range of strategies to accept, avoid and minimize the negative impacts of climate risk. Most of those strategies relate to agricultural practices, soil and water management and conservation strategies, and livelihood diversification (see table 3).

**Diversifying** crop production and **intercropping** coffee with subsistence crops like maize, beans and bananas are the most common strategies to reduce risk: if one crop fails, farmers may still be able to rely on the other crops. Key stakeholders reported that intercropping is increasing due to land shortages. Farmers also frequently replant maize and beans after crops fail because of climate hazards.



Figure 17. Coffee, maize and beans intercropped in Kayonza, Rakai. Photo: Sophie Kutegeka, IUCN

Farmers use **soil and water conservation measures** to reduce soil erosion, maintain soil fertility, and control pests and the negative impacts of water scarcity and water excess. Mulching coffee trees using maize stalks, banana fibres and cow dung contributes to preventing weeds, erosion, water loss and overheating, and to conserving soil fertility. Small-scale farmers prefer mulching to fertilizer because the former is cheaper and lasts longer. However, commercial farmers with larger coffee plantations (2 ha or more) prefer fertilizers. It is also becoming more difficult to access mulching material due to increasing land pressure. Other examples, found in the hilly and highland regions, are the traditional East African methods called *fanya juu* (digging uphill ridges on steep slopes) and *fanya chini* (digging downhill ridges on gentle slopes), which reduce soil erosion and capture rainwater for crops by creating ridges and terraces.

Factors such as poverty, lack of financial and human resources, and HIV/AIDS prevent farmers from adapting to climate risks. Many strategies have been developed to help small-scale farmers respond to the immediate problems, but are not sustainable in the long run and have already led to **maladaptation**, with detrimental effects on the environment (e.g. encroachment onto wetlands and along river and lake boundaries to plant quick-maturing crops during drought, deforestation to sell charcoal and firewood, selling of livestock, pesticide pollution) and on socio-economic structures (e.g. migration, dropping out of school). Local consultations revealed that a major coping strategy, especially among youth, is to survive crop failure through means that destroy the environment. This contributes to siltation and overfishing in Lake Kacheera in Rakai and Atari River in Kapchorwa. Interviewees even noted that some responses to climate change may increase people's vulnerability to food insecurity. For example, initiatives for sequestering carbon may limit the land available for crop production, and the return to producers from carbon sequestration payments may not make up for the lost food production.

**TABLE 3. CURRENT LOCAL AND NATIONAL RESPONSES TO CLIMATE IMPACTS ON CROP PRODUCTION**

CURRENT COPING STRATEGY/RESPONSES	CLIMATE HAZARD	LEVEL	SUSTAINABILITY
<b>AGRICULTURAL PRACTICES</b>			
1. Replanting crops (maize, beans)	Locally relevant hazards	Household in Rakai and Kapchorwa	This only applies when rains are expected within the same period.
2. Crop diversification (food and cash crops)	Locally relevant hazards	National incl. Rakai and Kapchorwa	Yes, because it increases the flexibility of the systems to a range of environmental and economic factors.
3. Intercropping coffee with crops such as beans, maize and bananas	Locally relevant hazards	National incl. Rakai and Kapchorwa	Yes, because it improves soil fertility, saves time and land.
4. Agroforestry, including planting multipurpose shade trees (coffee)	Locally relevant hazards	Community in Rakai, and Rakai district extension service	Yes, because it enhances biodiversity, protects crops against climate extremes, improves coffee quality. Tradeoffs exist: some shade trees may host coffee pests and diseases, and commonly intercropped crops do not do as well in shade.
5. Testing drought- and pest-resistant varieties (maize, beans, coffee)	Drought	National	Yes, but farmers reported that despite being fast growing, new coffee varieties have a short lifespan, low harvest, and low resistance to drought, pests and diseases.
6. Switching to organic farming (including mulching)	Locally relevant hazards	National	Yes, due to price premiums, reduced costs of environmental restoration, fertilizer affordability, pest control, increased holding capacity for soil moisture, increased soil organic matter.
7. Supplying seedlings/establishing nursery gardens (coffee)	Locally relevant hazards	Rakai agricultural district officers using local government funds	Uncertain, as it could create a dependency where farmers wait for free seedlings.
<b>SOIL AND WATER MANAGEMENT</b>			
8. Mulching using maize stocks and banana fibres to cool the soil (coffee)	All	National Regional	Sustainable with external support.
9. Building soil and water conservation structures	Droughts	Local	Depends; requires good storage methods.
10. Using organic fertilizers (cow dung)	All	Local	Not sustainable, and often a source of conflict.
11. Using mineral fertilizers	All	Local	Sustainable; this is a traditional activity.
12. Establishing micro-irrigation (water channels) in coffee plantations	All	Local	Not sustainable.
<b>LAND-USE MANAGEMENT</b>			
13. Encroaching on wetlands to plant quick-maturing crops	Drought	Community in Rakai and Kapchorwa (esp. youth)	No (environmental degradation).
<b>LIVELIHOOD DIVERSIFICATION</b>			
14. Migration	Locally relevant hazards	Community in Rakai and Kapchorwa	No, it can destabilize the household and family.
15. Engaging in casual labour	Drought and floods	Community in Rakai and Kapchorwa	No, involves moving to other villages to cultivate other peoples' gardens for pay, which in the long run destabilizes families.
16. Children dropping out of school to supplement family labour needs	Drought	Community in Rakai and Kapchorwa	No.
17. Selling of charcoal and firewood	Drought and floods	Community in Rakai and Kapchorwa (esp. youth)	No, mainly done through illegal cutting of trees from forest, worsening environmental degradation and compounding negative impacts of climate risks.
18. Selling of livestock	Drought and floods	Community in Rakai and Kapchorwa	No, livestock is key for soil fertility and sustainable crop production.



TABLE 3 CONTINUED

CURRENT COPING STRATEGY/RESPONSES	CLIMATE HAZARD	LEVEL	SUSTAINABILITY
<b>FINANCE</b>			
19. Obtaining loans to buy pesticides	Drought and floods	Community in Rakai and Kapchorwa	Depends, only members of farmer groups can access loans.
<b>CAPACITY BUILDING AND EXTERNAL SUPPORT</b>			
20. Providing agricultural advisory services (include the introduction of new agricultural technologies, advice on agroforestry and contours)	Locally relevant hazards	Local government	Yes, government and NGOs have done contours, and communities are responsible for maintenance; adoption is high. However, land fragmentation creates some challenges, as contours do not align with land boundaries.
21. Providing humanitarian support (during famine)	Locally relevant hazards	National/local government	Yes, because limited incidences reported during major disasters. Communities do not rely on humanitarian aid.
<b>KNOWLEDGE MANAGEMENT, INFORMATION AND COMMUNICATION</b>			
22. Using local indigenous knowledge to forecast changes in seasons	Locally relevant hazards	Community in Rakai	Yes, but some of this local indigenous knowledge is eroding due to rapid changes in the local environment.

At the national and district levels, agricultural extension and advisory services help farmers respond to and address some of the underlying issues; ultimately aiming to increase farmers' adaptive capacity. Local governments provide advice on varieties, methods, pest and disease management, pre- and post-harvest approaches to avoid losses, and soil and water conservation techniques. National research institutes, community-based organizations and local government offices work with farmers to develop new crop varieties (maize, beans and coffee) through research and on-farm trials. Research on maize has focused on controlling diseases, increasing yields and developing early-maturing varieties, while UCDA and the National Coffee Research Centre are focusing on breeding and selecting hybrid coffee varieties for disease resistance and drought tolerance.

Local farmers in Rakai and Kapchorwa perceive the impacts of advisory services to be mixed, and adoption of some technologies remains low, partly due to limited funds. For example, most risk management strategies for coffee production are still at pilot stages and need to be evaluated and scaled up. In Kapchorwa, the local government introduced new coffee varieties, which farmers have tested. But farmers reported that despite being fast-growing, these new varieties have a short lifespan, low harvest, and low resistance to drought, pests and diseases. In Rakai, the local government introduced water-harvesting technologies, but these caused conflicts among users, and mismanagement because the local government did not support communities to jointly manage the facilities. Communities further expressed concern about the introduction of new seed varieties that cannot be replanted after the first harvest, requiring frequent, expensive procurement.

Both districts have the potential to help themselves adapt to the negative impacts of climate risks on crop production. But constraints at various levels also prevent them from sustainably responding to the changes. We have identified key strengths and weaknesses based on a review of the literature, interviews with key actors along the coffee chain, and national and local consultations (using the Climate Vulnerability and Capacity Analysis and CRISTAL tools).

**A rich environment under high pressure.** Both Rakai and Kapchorwa benefit from a rich natural environment and a relatively mild climate, with two growing seasons. So they are relatively well-off compared with other districts of Uganda, such as the semi-arid Karamoja, which already faces regular food shortages due to frequent droughts, among other factors. Rakai benefits from good freshwater resources, with lakes, wetlands and proximity to Lake Victoria. Wetlands account for about 25.2 percent (i.e. approximately 1,234 km<sup>2</sup>) of the total land area of the district, representing a big part of the country's wetland system. Similarly, Kapchorwa is within the Mount Elgon protected ecosystem, a major catchment area for large water bodies like lakes Victoria, Turkana and Kyoga and the Nile River system, and houses a rich and unique fauna and flora of conservation importance. The district's volcanic soils tend to be more fertile compared with other Arabica-growing areas. However, both districts face major environmental issues due to poverty, urbanization, population growth, land ownership issues related to increasing land fragmentation, and changes in weather

patterns. Deforestation, declining soil fertility,<sup>6</sup> and pests, vectors and diseases<sup>7</sup> are undermining the natural resource base upon which communities rely for mitigating and adapting to climate risks. The development plans for Rakai and Kapchorwa<sup>8</sup> are largely consistent with the NDP, but the district plans devote much more attention to environmental concerns. They emphasize the need to improve natural resource management and agriculture in particular, providing a framework for addressing the challenges within the sector. However, there is limited focus on crop production in both plans, and limited reference to climate risk.

**Comparative advantages for farming and cross-border trade.** The southern part of Rakai shares its boundary with Tanzania, while the eastern part of Kapchorwa is close to the Kenyan border. These geographical situations provide an opportunity for cross-border trade (maize, beans, coffee) and occasionally lead to an influx of refugees (Rakai District Local Government, 2010).

**High poverty levels, with high disparities within the districts.** According to Uganda's latest poverty maps (for 2005) (MWE et al., 2009), the poverty rate is much higher in the north (including Kapchorwa) than the south (including Rakai), with higher poverty along the cattle corridor. In Rakai, about 15 to 30 percent of the population was below the poverty line. These figures can also hide important disparities within the district. For example, the percentage of people below the poverty line in Kacheera subcounty (Rakai) was higher (30 to 40 percent) than in the rest of the district. In Kapchorwa, 30 to 40 percent of the population lived below the poverty line. According to the local governments (Rakai District Local Government, 2010; Kapchorwa District Local Government, 2011a), communities report that their poverty is increasing.

**Land tenure issues limiting adaptive capacity.** Population pressure is decreasing the already limited land available. Land tenure is an issue in Rakai and Kapchorwa as well as nationally. For example, cattle theft affected Sanzara Parish (Kapchorwa) and resulted in people migrating to upper areas while still owning land in Sanzara. Absentee landlords living in cities tend to focus on immediate profit from the land, while their tenants are not interested in investing in a piece of land they do not own. These issues contribute to poor land-management practices (e.g. deforestation) and decreasing availability of mulch reinforcing the issues of decreasing productivity and increasing soil erosion. Most landowners also prefer to lease their land for food crops rather than perennial cash crops, because the former mature quickly and allow for more land-use flexibility. This trend, combined with an increasing population, land fragmentation and labour shortages, limits the possibilities for farmers to expand coffee plantations. This issue is exacerbated in Kapchorwa, as some people have been evicted to create a national park.

**National agriculture programming is in place, but implementation remains limited.** In the 2010/11 fiscal year, the agriculture budget was raised by 6.7 percent. Government is committed to continuously raising the budget allocation for agriculture every year. Most national agricultural strategies are implemented through the National Agricultural Advisory Services (NAADS) programme initiated in 2001. The NAADS is a 25-programme system covering the entire country that aims to promote food and nutrition security and household incomes through increased productivity and market-oriented farming. The approach is demand-driven, bottom-up and decentralized. In practice, however, implementation, supervision and monitoring are limited, due partly to limited funds.<sup>9</sup> In addition, poor coordination and lack of harmonization of programs in the study areas is a big challenge, leading to duplication and escalating the dependency syndrome among communities. This is exacerbated by political intervention, especially during political campaigns, when handouts are given to communities and permission granted for them to access vulnerable ecosystems in cases of climate hazards. The NAADS program is an example of a program that has been politicized, thereby limiting the number of beneficiaries.

<sup>6</sup> Declining soil fertility due to continuous farming without replenishing nutrients is a national issue (MAAIF, 2010). According to MAAIF (2010), "the amount of fertilizer used in Uganda is among the lowest in the world."

<sup>7</sup> Key actors and farmers reported the emergence of new pests and shifts in pest and disease occurrence and severity. For example, the World Bank (2008 in MAAIF, 2010) has reported that "Coffee Wilt Disease, which started in 1993 has destroyed about 56 percent or 160 million of the old Robusta trees, equivalent to some 1.5 million bags or about US\$170 million."

<sup>8</sup> Through the decentralization process that started in Uganda in the 1990s, the district council became the highest political authority at the local level. Districts and subcounties have to develop their development plans (three- to four-year plans).

<sup>9</sup> Nationally, the 'Agricultural Census 2008/2009' (UBOS and MAAIF, 2011) reveals that "out of 3.6 million agricultural households that responded, only 19 percent reported having been visited by an Extension Worker during the reference period with fewer visits reported in the Eastern Region." James (2010), in a survey conducted in nine subcounties in central and southern Uganda in 2008 also identified that the most vulnerable groups with lower average incomes and fewer off-farm income sources were also the ones who participated and benefited the least from the NAADS. Some of these limitations are already acknowledged at the national level, and MAAIF's strategy focuses on improving farmers' groups (MAAIF, 2010).

**Ongoing research on drought-tolerant varieties, but limited to pilot stage.** Despite the limited research funding available, a strong national research emphasis exists on developing high-yield, drought-tolerant varieties, particularly for maize. Africa-wide projects also exist. Some drought-tolerant and fast-maturing varieties are already promoted under the National Agricultural Research Organization in the semi-arid region of Karamoja. The organization is also conducting ongoing research on breeding heat-resistant maize, millet and rice varieties. However, so far most of this research remains at a pilot stage and needs to be scaled up. Farmers also reported a lack of follow-up by local government, especially in difficult-to-access subcounties on the periphery (like Katatenga in Rakai).

Overall, the research-extension-farmer links remain weak, as highlighted in the draft national coffee policy (MAAIF, 2011). This draft policy highlights the need to increase research in the coffee sector. This is much needed, since coffee is often still lumped with other crops. A standalone institute for coffee would receive more funds from the government, which is planning to establish a coffee research fund. Although coffee replanting and multiplication of improved coffee materials are listed in the key policy documents and are part of a coffee production campaign for 2006 to 2015, spearheaded by UCDA and Café Africa, few funds have been committed to date.

**A rich but eroding local knowledge base on weather and crop management.** Local and national consultations conducted as part of the CRM TASP revealed that farmers in both districts have a wealth of local, indigenous knowledge on local weather and crop management (e.g., knowledge of which crop varieties survive best in specific conditions or can co-exist with others for intercropping). The traditional farming calendar has been developed over generations based on observations of the local environment. Local people use environmental indicators (e.g. occurrence of specific insects, colour of sky/clouds at a certain time of the year) to predict climate hazards, and these predictions help them plan their farming activities. For example, a large population of mature butterflies indicates upcoming rain. However, some of this knowledge is eroding due to changes in the local environment and climate, and this is affecting farmers' ability to predict seasons.

**Limited technology adoption and knowledge application due to lack of resources.** Fieldwork revealed that farmers in both districts have a relatively good knowledge of farming practices to reduce the negative impacts of climate risks. These include using early-maturing crops, diversifying crops, planting early and embracing advisory services. In a case study done in Kapchorwa, Tororo and Bugiri districts, Kalule et al. (2006) also documented farmers' awareness of the maize stem borer problem and related traditional pest-control methods. But farmers' knowledge is not always translated into action. Poor agronomic practices may arise from cost issues, labour shortages and poor advisory services, among other things, rather than lack of knowledge. While technologies such as irrigation or rainwater harvesting may be available, adoption by farmers is low due to lack of resources. Furthermore, both districts are relatively remote and have poor infrastructure, limiting their access to government support. The poor road network is highlighted as a key district weakness in the district development plan in Kapchorwa (Kapchorwa District Local Government, 2011a). This is a major barrier, especially during the rainy season, to linking farmers to markets, and it increases costs. However, district officials reported that better roads in Rakai have also led to an increase in market expansion and cross-border trade with Tanzania. New coffee factories have also been established in Rakai that should enable farmers to capitalize on the current high market prices for coffee.

**Inadequate labour availability, primarily attributed to HIV/AIDS.** Despite a high population growth rate in both districts, labour shortages in rural areas are a problem because youth prefer to get involved in off-farm activities. The impact of HIV/AIDS accentuates this trend because it tends to affect the most productive age group. While HIV/AIDS is decreasing nationally, it is increasing in Rakai (Rakai District Local Government, 2010). HIV prevalence is 12 percent in Rakai, nearly twice the national average of 6.4 percent (Rakai District Local Government, 2010). The negative impact of HIV/AIDS on agriculture is strongly highlighted in the Rakai District development plan. HIV -positive people and their families have limited capacity to invest in agricultural inputs and farming technologies and tend to shift to less labour-intensive techniques, and they are more likely to sell their land to access health services and treatment. HIV/AIDS-affected households are therefore very vulnerable to the impacts of climate hazards (Rakai District Local Development, 2010). HIV/AIDS is also an issue in Kapchorwa; however, limited data are available to quantify its impact. Between 10,000 and 11,000 people may be infected with HIV/AIDS in the district (Kapchorwa District Development Plan, 2010).

**Increased farmer access to information, but limited benefit from national weather information.** Overall, access to information on crop production and markets has improved in the last 10 years due to the increasing use of radio stations and mobile phones and the presence of agricultural officers at the subcounty level. In Rakai, agricultural officials interviewed as part of the CRM TASP attribute the increase in coffee yields to increased access to coffee production information and linkages with traders and markets. However, community and national consultations revealed poor communication mechanisms between national and local levels

on issues related to climate risks and weather information. For example, field observations as part of the CRM TASP revealed that community information systems, such as community facilitators within the villages or notice boards at subcounty offices, are not functional. When communities have access to weather information, it is mostly provided in English, which few people can read. In addition, communities have limited trust in national weather information because they do not always access timely and accurate weather/climate information, and they prefer using their local traditional knowledge. Local actors reported that hydrometeorological information to provide early warning is inadequate. Most weather stations in the districts are no longer functional, and the districts depend on information from the central government. This is worsened by the poor coordination between the central and local governments, wherein information is received late. Actors reported past initiatives on the use of information and communications technologies tools to support farmers with timely weather forecasting (through the use of cell phones, community meetings, radios and extension services), but these activities stopped after the projects completed. Farmers also noted that information sent through mobile phone messages is received late because most communities do not access permanent telephone signals.

**Importance of farmer groups in supporting adaptation.** Local structures, such as the local councils and farmer groups formed under the NAADS programme, provide a forum for communities to express their views and build trust. District NAADS coordinators and the community development officers act as liaisons between the government and communities. An estimated 906,000 agricultural household members were members of farmers' groups in 2008/2009 (UBOS and MAAIF, 2011). Farmers in Rakai and Kapchorwa recognized that farmers' groups support them in accessing relevant information and improving their skills and knowledge on farming practices. Since extension and information services are demand-driven under the NAADS, farmers groups are important platforms to collectively advocate for their priorities and concerns. Based on local consultations, it appears most farmers see the advantage of being organized in groups and value these institutions as a social resource, especially for accessing technical advice and sharing experiences.

**Overall lack of collective organization and regulation.** With the liberalization of coffee prices and marketing in 1991, coffee traders, processors, farmers' groups or organizations, and exporters replaced cooperative unions. The opening of the sector to various actors (including private players) contributed to competition. Farmers continue to engage mostly in production, with limited participation in post-farm processes due to limited financial and organizational capacity (MAAIF, 2011; MAAIF, 2010). They mainly market their coffee individually, limiting collective bargaining (this is also true for maize). The number of national farmers' associations or cooperatives remains low (NUCAFE 2008). Interviews with farmers and district officials reveal that low-income farmers lack trust in the actors of the value chain and prefer to sell their coffee to get cash immediately. Many middlemen or dealers operate between the farmers and the exporters. Actors report deterioration in coffee quality at primary levels and an increase in malpractice due to limited control (e.g., middlemen add stones and water to coffee beans to increase weight). To avoid this, exporters are increasing direct linkages with farmers. This lack of regulation affects other crops, such as beans and maize. For example, farmers receive fake seeds or adulterated fertilizer, leading to considerable income losses (MAAIF, 2010).

**Limited capacity of women to adapt to risks.** Women have less capacity to diversify their livelihoods than men because they lack control over land and productive resources in general. According to the Rakai District development plan (Rakai District Local Government, 2010), women's representation in local government is often limited, so their specific needs are often overlooked. Similar issues have been highlighted in the Kapchorwa District development plan (Kapchorwa District Local Government, 2011a). Women are mainly engaged in raising subsistence crops; their involvement in coffee marketing and related benefits is limited. During the local consultations, women mentioned they are interested in engaging in coffee marketing because they acknowledge that coffee is less sensitive to flooding and droughts and because market prices were high at the time of the study. This growing interest in coffee farming and related interest in cash may have implications for food security. Focus groups revealed that women also tend to have different access to information (e.g., in some cases, women are not allowed to talk to visitors in their home, and so may not be informed), which may limit their ability to make adequate decisions regarding farming.

To sum up, farmers' overall adaptive capacity is relatively low due to high dependency on subsistence agriculture, low inputs, poor soil fertility, environmental degradation, labour shortages, limited organizational capacity, poor communication and infrastructure, land tenure issues, high poverty levels and limited livelihood diversification options. Women, children and HIV/AIDS-affected households are particularly vulnerable to the negative impacts of climate risk. However, farmers in Rakai and Kapchorwa are already pursuing a range of simple, low-cost strategies, including risk retention (replanting crops after crop failure), risk avoidance (migration), and risk reduction (crop diversification, intercropping, agroforestry, etc.). While national efforts are ongoing to support the community through research and extension services, maladaptation is still common, so communities need to be further supported so they can benefit and build upon existing key strengths such as farmer groups, their strategic location for cross-border trade, and good freshwater resources.

### Key messages: Climate risks

- The impacts of current climate hazards on crop production in Rakai and Kapchorwa already constitute a threat to the district's development objectives. Key actors perceive they are exposed to increasing uncertainties due to a combination of climate and non-climate factors. As a result of these uncertainties, farmers are no longer able to follow their normal farming calendar.
- Regardless of the lack of meteorological evidence, climate change will increase uncertainties and the negative impacts of climate hazards.
- The immediate strategies used by farmers in Rakai and Kapchorwa to respond to floods and droughts are similar. Some responses are maladaptive and increase vulnerability to climate hazards. In some cases, farmers are already adopting some best practices. However, farmers need to be further supported in managing climate risks.
- High poverty, less diversified crop systems and security issues increase Kapchorwa's vulnerability to climate hazards; in Rakai, high HIV/AIDS rates and heavy land degradation increase vulnerability.

## INSTITUTIONS AND POLICIES FOR CLIMATE RISK MANAGEMENT

Increasing farmers' capacity to manage climate risks requires adequate national institutions and policies. This chapter looks at current institutional and policy arrangements for climate change adaptation and disaster risk reduction as well as key actions, followed by an analysis of current national risk management capacity, especially in the context of agriculture and crop production. Based on this evaluation, we make recommendations for improving the institutional and policy environment. The analysis is based on a review of existing documents and national consultations.

### DISASTER RISK MANAGEMENT

Disaster risk management is the responsibility of Department of Relief, Disaster Preparedness and Management, within the Office of the Prime Minister. The department is responsible for coordinating risk reduction, preparedness, prevention, mitigation and response actions. It is also charged with consulting with other ministries, local governments and the private sector, and with humanitarian and development partners. The Minister of the Department serves as the link between the Department and Cabinet, which directs policy and advises the President. The Minister sets policy by crafting rules and regulations governing the management of potential disasters, and presents annual reports of his activities to Cabinet. He also serves as a liaison on matters related to disaster risk management between intergovernmental organizations, the donor community, the private sector, and the regional and international bodies of which Uganda is a member (OPM, 2011).

The '**National Policy for Disaster Preparedness and Management**' (OPM, 2010) was passed in 2010. The policy calls for the establishment of an act to enforce key provisions of the policy, and a fund bill. The **National Platform for Disaster Preparedness and Management**, chaired by OPM, and the **National Emergency Coordination and Operations Centre** have been established to facilitate coordination of disaster management at all levels. The policy plans to establish disaster policy and technical committees at all levels (city, district, subcounty and village). Currently, **district disaster management technical committees** operate in 13 districts (in the Acholi, Lango, Teso and Karamoja subregions) and convene on an as-needed basis. So far, and due to limited resources, OPM has been mainly carrying out emergency relief, capacity development, and coordination and planning activities, especially in northern Uganda.

### CLIMATE CHANGE

Climate change is the responsibility of the Climate Change Unit (CCU), created in 2008 under the Office of the Permanent Secretary in the Ministry of Water and Environment. Its main key functions (MWE, 2011) are to:

- Be the point of contact for the United Nations Framework Convention on Climate Change.
- Coordinate national climate change actions.
- Review and develop policies, laws and programs related to climate change.
- Organize and administer Clean Development Mechanism activities.
- Educate, raise awareness and promote engagement on climate change issues.
- Develop and disseminate technologies and practices to mitigate and adapt to climate change.

The unit is currently focused on increasing its technical capacity, developing an overarching climate change policy and implementation strategy, and participating in climate change negotiations. It is also in charge of harmonizing climate change-related efforts currently underway and raising awareness at the local government and community levels (MWE, 2011).

In 2007 the Government identified nine priority projects for climate change adaptation as part of the NAPA process. Currently, due to lack of funds, the NAPA projects are being piloted in three ecosystems (mountain, dryland and lowland) in partnership with local governments and NGOs, and the Government continues to move towards accessing funds for those projects.



Other institutional arrangements established to address climate change include the **Climate Change Policy Committee** (intersectoral/institutional) and a national climate change parliamentary forum. The climate change policy committee is chaired by the permanent secretary for the Ministry of Water and Environment and comprises 14 members from the public and private sectors. The coordinator of the Climate Change Unit is the secretary to the committee. The Climate Change Policy Committee guides the Ministry of Water and Environment on climate change-related issues and assists the Ministry in decision-making on carbon finance activities. It is also the Clean Development Mechanism designated national authority for Uganda. The committee is moving towards reconstituting itself as a project steering committee that will guide implementation of the Ministry's climate change projects (MWE, 2011).

The **Parliamentary Forum on Climate Change**, created in late 2008, is a loose coalition based on parliamentarians' interests. The main objective is to update each other, discuss key priorities, and promote awareness and action in their respective constituencies about the effects of climate change.

The CCU has requested all stakeholders designate climate change desk officers to improve coordination among agencies.

## RECOGNITION OF CLIMATE RISK MANAGEMENT IN KEY POLICY DOCUMENTS

The government has made a substantial effort to integrate climate risk considerations into policy planning. As outlined above, agriculture is a key sector in Uganda and is very exposed to the risks surrounding climate change, so the extent to which climate change issues are mainstreamed into agriculture-related planning documents is an important factor in determining how successful the sector will be in adapting.

The key planning documents that consider agriculture are provided below and assessed in terms of how well they integrate climate change considerations.

Well-integrated:

- **'National Development Plan (2010/11–2014/14)' (2010):** Climate change and disasters are identified as key constraints to growth; agriculture is only one of many sectors considered, but the document identifies it as one of eight key sectors and outlines changes needed to make the sector more resilient to climate change.
- **'Development and Investment Plan for the Agricultural Sector 2010/11–2014/15' (2010):** Climate change is identified as a key cross-cutting issue, and climate change considerations are central to provisions concerning agriculture, including a number of crop-specific interventions, including maize, beans and coffee.
- **'National Adaptation Plan of Action' (2007):** Climate change risk and adaptation are the focus and are therefore fully integrated; the document also looks specifically at the implications of anticipated climate change effects on maize and coffee.
- **'National Policy for Disaster Preparedness and Management' (2010):** The entire document focuses on risks, including those related to climate hazards (especially droughts, floods and landslides); the document identifies policy actions to make agriculture less vulnerable to extreme weather events and offers a number of specific interventions to achieve this goal; climate change is among the policy's guiding principles. It recognizes the importance of climate change and the need to develop adaptation and mitigation measures. However, the linkages between climate hazards and climate change are not addressed.

Somewhat integrated:

- **National Agricultural Advisory Services (NAADS) (2001):** The threat of climate change is not explicitly discussed, but the document offers interventions for the agricultural sector that are congruent with actions that would be required to adapt to climate change.
- **National coffee policy (draft 2011):** Adaptation to climate change through agroforestry is a guiding principle, but the document mostly focuses on interventions for overall commercial and environmental sustainability rather than adaptation to climate change per se.

- **Kapchorwa District development plan (2011):** Identifies climate change as a challenge for the natural resources sector. Droughts and floods are identified as factors of poverty. It is explicitly mentioned that “climate change results in unexpected prolonged droughts, heavy rains, flooding, soil erosion, landslides, siltation of wetlands and riverbeds.”
- **Rakai District development plan 2010/11–2012/13’ (2010):** The document does not explicitly refer to climate change, but “drastic and unpredictable weather changes” are identified as a key development threat. A number of strategies for mainstreaming “environmental concerns in all development projects/plans” are identified.

Not/poorly integrated:

- **‘Uganda Food and Nutrition Strategy’ (2010):** Contains little to no discussion on the relationship between food security and climate change; however, such discussion is mostly left to the ‘Plan for the Modernization of Agriculture.’
- **Draft information technology policy (2010):** Climate risk is not mentioned. However, such considerations may improve in the future since the Ministry is interested in establishing a ministerial climate change forum (Ministry of Information and Communication Technology. 2010).

Climate change is well integrated into agricultural sector planning overall. Even when it is not explicitly considered, strategies offered do not contradict or undermine other adaptive measures. While some documents are clearly intended to provide overall vision for the sector, considerable room exists to better integrate planning efforts by having a greater integrative framework. Even without a strong overarching strategy that harmonizes disparate measures, the plans are at least all heading in the same direction when it comes to agriculture and climate change.

## CLIMATE RISK MANAGEMENT ACTIVITIES

Many activities are ongoing on the part of the government and donors, and the two sectors are collaborating on many efforts, which are seeking to make agriculture more resilient to changes in climate. Many efforts are national, while some are regional and others subnational. The Karamoja region (northeast) is of particular geographic focus in climate risk management for agriculture, given its vulnerability to both droughts and flooding. The United Nations Joint Programme on Climate Change (Republic of Uganda and United Nations, 2010) proposes to focus primarily on the dryland ecosystem of Karamoja, the Moroto River basin ecosystem, incorporating parts of Acholi, Lango and Teso, the mountain ecosystems (Mount Elgon and the Rwenzoris), and urban Kampala.

The bulk of activity to manage climate change risks in the agricultural sector centres on capacity development. Efforts exist to strengthen state and local government capacity to conduct risk assessment and to increase their capacity to set adaptive policy and coordinate and focus efforts. Improved management of land and water is an important theme, such as through joint World Bank and Government of Uganda efforts in the form of the climate initiatives under NAADS. A number of efforts aim to better understand and manage the risks and resources involved in the climate change–agriculture intersection, such as the work of the National Agricultural Research Organization and the Rockefeller Foundation. Some efforts are also focused on gathering and employing indigenous knowledge (e.g. the NAPA process in 2007 and the African Innovations Institute’s work in the cattle corridor).

The balance of the other activities is mostly focused on productivity improvement. This is addressed through improved management of water resources; development and dissemination of improved crop varieties or technological developments, such as in the World Bank’s East African Agricultural Productivity Project; and research into and dissemination of soil management techniques and intercrop systems, such as in the U.S. Agency for International Development’s Livelihoods and Enterprises for Agricultural Development Project.

This dual focus on capacity development around risk management and efforts to improve productivity is a valuable way of dividing risk management efforts. However, again, an overarching, coordinating framework is missing. Some of the planning documents (especially the NDP) and ministries do provide some of this framework, and efforts are underway to fill this challenging coordinator role more effectively, such as through the institutional innovation aspect of the International Crops Research Institutes for the Semi-Arid Tropics’ Climate Risk Management Proof of Concept Projects, but more can be done. This is the most obvious gap in the policy architecture for climate risk management.



## ASSESSMENT OF CLIMATE RISK MANAGEMENT CAPACITY

Based on the World Resources Institute's 'National Adaptive Capacity Framework' (World Resources Institute, 2009), we have conducted a desk-based capacity assessment on climate risk management functions. The framework evaluates capacities based on the availability of risk assessments and the capacity to conduct them, as well as their systematization and mainstreaming; the existence of explicit risk management priorities and a process to revise these priorities; the existence of coordination processes and bodies; the sound management of information; the identification of risks for priority areas; and the evaluation of adaptation options and their implementation.

**Assessment.** In 2002 the 'Initial National Communication to the UNFCCC' reported that a few vulnerability assessments have been done in a few sectors (agriculture, water, forestry) (MWE, 2002). Since then, additional studies have been conducted in those sectors and others, but most assessments (mainly vulnerability assessments) remain general and qualitative due to inadequate modelling capacity, poor data quality, poor historical data collection and a general lack of technical and research capacity. Most initiatives in the forestry and biodiversity sectors tend to focus on mitigation rather than adaptation. Few studies address vulnerable groups and gender dimensions in detail, and no economic assessment of climate risks exists. So far the focus on climate change has mainly been on advocacy for awareness-raising. At the same time, the tendency exists to blame everything on climate change, so more research and capacity development is needed to continue improve key actors' understanding on this issue.

**Prioritization.** Immediate priorities for climate change adaptation were identified through the NAPA process in 2007. Some funding has recently been allocated to implement some of the priorities identified. The NAPA process has also been criticized for the "lack of coordination with line ministries in the formulation phase" (Halsnæs et al., 2008). A number of planning documents, such as the NAPA and the 'Development Strategy and Investment Plan,' also seek to prioritize problems and solutions around climate change adaptation, and this is often in line with the priorities identified in the NAPA. Most of those documents tend to have a short- and medium-term planning horizon, up to 2015 to 2025. A longer-term prioritization (2035 to 2050) has yet to be developed through Vision 2035. Recently the Ministry of Finance has set up a national allocation to ensure funds are available for climate change.

**Coordination.** Coordination efforts are ongoing, and different platforms have been established to improve information-sharing and avoid duplication (e.g. the disaster risk reduction platform and the National Climate Change Donor Meeting). The United Nations in Uganda also aims to address climate change through the United Nations Joint Programme on Climate Change, which should help avoid duplication of activities among United Nations organizations (although the proposed five-year program is not yet funded). These initiatives support the role of the CCU. In practice, the fact that climate change is a cross-cutting theme also creates coordination challenges between OPM and. The challenge remains to keep abreast of the actors and initiatives, and more focus and unity of purpose is needed. The creation of the CCU is instrumental in moving this agenda forward, and the supporting Climate Change Policy Committee's planned transition to a Project Steering Committee will also help. The institutional infrastructure these organizations provide is highly valuable, but translating this authority into meaningful coordination of diffuse activities to deliver quality adaptation programming is another matter. So far, the CCU is donor-funded and runs with only four staff; therefore, capacity is quite low. Improved coordination will require additional funds and capacity at all levels. For crop production, strengthening coordination among the relevant ministries and departments (agriculture, environment and meteorology) is key.

**Information management.** Issues of information management occur on at least at two levels in Uganda: collection and sharing. Much of the information developed is not easily communicated and made available, especially from national to district and local levels. For example, few people know about the CCU or the NAPA. Studies are scattered among institutions and individuals. Information-sharing conventions and mechanisms are not well-developed. Since the CCU has the mandate to act as a national resource centre, key stakeholders have a strong expectation of using the CCU as a data centre to centralize all relevant information on climate risks. The CCU and the Climate Change Policy Committees are already engaged on this front, but a more comprehensive effort to generate, aggregate and disseminate useful information would have a strong impact on outcomes. Additionally, data (especially weather and climate data) are lacking. The Department of Meteorology has limited funds to buy improved weather equipment, and limited personnel to collect and synthesize data. Climate data collection also lacks consistency. At the moment, only 12 meteorological stations operate. Installation of automatic stations is supposed to be ongoing, but the Meteorology Department is still calibrating data to fit the Ugandan context. Strengthening meteorological services has been identified in the NAPA as one of the key immediate priorities for climate change adaptation; however, the equipment is very expensive (a single new station costs US\$12,400 to US\$16,600 ). Other issues include raising awareness at the district level to improve cooperation between districts and the Meteorology Department for monitoring stations. To resolve some of these challenges, a restructuring of

Meteorological Services is pending. MAAIF and OPM (2008) further identifies weaknesses surrounding the “flow of disaster/drought early-warning information and limited means for dissemination in the more remote regions.” At OPM, the department essentially has data about those hazards that have resulted in disasters and government intervention. The impacts of regular climate hazards that have devastating effects on livelihoods are not documented.

**Climate risk reduction.** Uganda receives a great deal of aid and international assistance for assessing climate risks and developing adaptive capacity, and it is working towards improving the organization and function of governmental institutions that deal with the issue. Nevertheless, significant gaps remain in terms of overall policy coordination, which inhibit the effectiveness of efforts to reduce risk. This issue flows from those identified above: with better assessment, prioritization, coordination and information management would come better risk reduction. Assistance from non-governmental actors is valuable in enhancing government capacity to deliver effective solutions, and so the overall picture is not one of inefficacy and wasted resources (i.e., poor climate risk reduction capacity). However, a comprehensive effort to provide more focused and informed programming would help further limit the country’s exposure to climate risks.

#### **Key messages: Institutions and Policies**

- While climate change is a relatively new topic in Uganda, national awareness is present and growing.
- Institutions dealing with climate risk are in place, but have limited financial and human capacity.
- A lot of good policies and strategies are also in place and have somewhat mainstreamed climate risks, but this authority remains to be translated into effective programming.

## RECOMMENDATIONS FOR CLIMATE RISK MANAGEMENT

Reducing climate risk is essential for achieving key development goals such as reducing poverty or enhancing food security. This chapter proposes a range of management options to address risks in Rakai and Kapchorwa. Most options were identified by coffee stakeholders during local and national consultations and interviews. These options are based on two main assumptions. First, crop production is dominated by smallholder farmers (about half of whom are women), and a combination of food and cash crops is likely to remain the key source of income for Ugandan households. Second, farmers have to adapt to greater uncertainties due to a combination of climate risk and other non-climate risks (globalization, urbanization, land-use change, etc.). Key stakeholders need to identify 'no-regret' measures that are beneficial regardless of the magnitude of climate risks.

### PRIORITY ACTIONS

The proposed risk management strategies fall under six themes: management of water, soil and land; agronomic practices; infrastructure and financing; information and communications technologies; social organization; and capacity development.

#### Water, soil and land management

Results from the DSSAT modelling show that fertilization techniques and irrigation can substantially contribute to offsetting the negative impacts of climate change in Rakai and Kapchorwa. Specific recommendations include:

**Promote small-scale irrigation.** Use of irrigation on smallholder farms is very limited in Uganda. In 2008 and 2009, only 0.9 percent of agricultural households practised irrigation (UBOS and MAAIF, 2011). However, in the current context of increasing uncertainties (due to climate and non-climate risks), rural livelihoods in Uganda cannot afford to rely solely on rain-fed agriculture (MAAIF, 2010). Specific efforts should be made to promote integrated water management at the catchment level and simple and affordable community-based gravity irrigation schemes in the highlands, to ensure the sustainability of community-based irrigation management. Evaluating the needs of different users both vertically (between upstream and downstream communities) and horizontally (for example, between fishermen and farmers) could help prevent water-related conflicts, as could creating institutions (or using existing ones) to help users resolve issues.

**Promote conservation agriculture.** Preserving ecosystem goods and services is essential to promoting sustainable crop production and adapting to climate risks. Conservation agriculture (CA) provides an alternative to conventional agriculture and concerns agroecological management of soil, water, nutrients, plants and animals. It is based on three key principles: minimum soil disturbance, maintenance of permanent soil cover and diversifying crop rotations (Milder et al., 2011). Specific efforts should be made to scale up the results of applying CA in pilot districts, adopt and mainstream CA practices in government planning (especially locally), train farmers and extension officers on the principles and application of CA, promote the use of various simple and low-cost techniques (such as application of compost and organic manures or construction of ditches, terraces or trenches), and encourage farmers to use locally available organic inputs (cow dung and mulch) and develop better links between grazers and cultivators in pastoral areas.

**Promote a watershed-scale approach.** Milder et al. (2011) have already indicated, in a review of CA in sub-Saharan Africa, that it should be implemented at multiple scales, from field to farm to community and landscape, to realize its full potential. A concerted and integrated approach is especially necessary to protect water sources at the farm and community level.

#### Agronomic practices

**Disseminate culturally acceptable and affordable, stress-resistant crop varieties.** Combined with good agronomic practices, acceptable, affordable drought-, flood- and pest-resistant and fast-maturing crop varieties can support farmers in adapting to climate risks. Additional research should be conducted to determine which crops' characteristics could be modified to further increase not only resistance to climate stresses, but also productivity, and to assess future caloric requirements and how the demand for calories could be satisfied from a range of stress-resistant crops. Crop modelling should be systematically used to evaluate the impacts

of climate change on all key crops in Uganda so as to identify options for switching crops. The need to reintroduce and promote local crop varieties (such as cassava) that are currently disappearing (due to dietary cultural habits and market orientation, among other potential factors) should also be assessed, because some of these crops may be more resistant to pests and diseases and/or temperature changes than the new varieties. Stronger links between researchers, extension workers, farmers and consumers should be encouraged so new varieties are acceptable and affordable and respond to farmers' needs. Such research will need to account for dietary cultural habits to ensure that farmers and consumers adopt new varieties. The government and the private sector need to ensure that the new varieties developed are properly disseminated, with a consistent supply.

**Support optimum crop diversification and intercropping techniques.** Crop diversification refers to relying on a range of cash and food crops. This is important since food crops are very sensitive to climate hazards, while the benefits from cash crops fluctuate depending on volatile market prices, among other factors. Specific efforts should be made to promote research and training on best practices for intercropping. For example, intercropping may be most beneficial at a certain stage of coffee growth combined with a range of other factors (that is, a specific combination of crops planted at a specific time of year and under specific proportions to reduce competition for resources, replace lost nutrients through crop harvests and avoid excessive nutrient-mining). In addition, MAAIF should revisit the 2004 zoning strategy to account for the potential impacts of future climate change on the agroecological zones and their suitability to specific crops.

**Support optimum use of agroforestry/multipurpose shade trees.** Careful selection of shade tree species, building on local knowledge, is required to ensure they provide maximum advantages and do not harbour pests.

**Support farmers in replacing old, unproductive coffee plantations.** According to the UCDA website, "most of the coffee in Uganda... has surpassed its biological optimum potential and therefore [is] not economically productive... The old trees, coupled with poorly managed and leached soils, have led to very low yields." Interviewees mentioned that old coffee trees contribute to susceptibility to coffee wilt disease and to the negative impacts of climate change. Specific efforts should be made to sensitize farmers to the long-term benefits of replacing old coffee trees, especially in the context of climate change adaptation, and to explore policy options (such as market mechanisms) to compensate farmers for the income gap experienced when they replace old coffee trees. The government may support coffee production in areas that may not be appropriate for coffee growing in the future due to climate change. The government, in collaboration with research institutions and the private sector, should conduct additional research to improve understanding of the potential consequences of future climate change on the coffee varieties grown in Uganda. This may involve the development of an ecophysiological model that accounts for the environmental and socio-economic specificities of coffee production in Uganda.

## Infrastructure and financing

**Promote appropriate storage systems for maize and coffee.** Most farmers do not have the capacity to safely store their products. They therefore tend to sell their products rapidly to avoid deterioration, even if prices are not favourable (they have less bargaining power). This lack of storage also means yields are at risk of further deteriorating from increasing frequency and intensity of climate hazards. It is also, among other factors, the reason crops such as maize and beans are often not processed at the farm level. Farmers tend to commercialize raw products, and soils do not benefit from the crops' nutrients (wastes), which further increases the negative impact of climate hazards on soil productivity and threatens food security. Specific efforts should be made to promote and institutionalize the use of appropriate food-storage systems, building on local institutions for collective storage, and on traditional knowledge and practices, such as the traditional granaries already in use. In addition, research institutions should support the development of innovative solutions to ensure that any technology promoted by the government, such as food-storage systems, takes into account present and future potential climate risks. This may require the documentation of existing best practices within and outside Uganda.

**Improve road infrastructure and flood control structures:** Improving market infrastructure (roads) is a big problem, especially in highland areas like Kapchorwa, where Arabica is grown. Poor road networks increase transaction costs, leading to low farm gate prices. It also constrains information sharing and access to extension services (community members in Katatenga, for example, indicated they rarely get support from NAADS because of poor accessibility), adding barriers to adapting to climate risk. Floods often have major impacts on road infrastructure and worsen existing conditions. Sustainable crop production in Uganda in the context of climate variability and change requires investments in road infrastructure and flood-control structures (including drainage systems) that account for the potential increase in frequency and intensity of flood risks due to climate change and other socio-economic changes.

**Support and expand rural micro-finance.** Most farmers will need to increase their acreage and will bear additional labour costs due to climate risks. The Ministry of Planning and Economic Development recognizes the need for financial innovation and has already developed a low-interest agricultural loan scheme. Farmers should access financial mechanisms to help them compensate for the changes and losses due to climate risks. Government, with the support of civil society organizations, should also train farmers so they have the capacity to access, and benefit from, those services.

## **Information and communications technologies**

**Enhance the role of information and communications technologies for accurate, reliable and timely climate information.** Much information is often available but not adequately shared. In particular, generation, dissemination and use of climate information need to be enhanced to support farmer decision-making. Farmers need timely weather information to adjust planting decisions, anticipate the emergence of pests and diseases, and plan for the best control strategy. ICT can help farmers adapt to climate risk. Specific efforts should be made to localize national information on climate risk so it can be understood at the local level. This involves translating the information into local languages, training local stewards to act as links between local government and communities and to interpret and disseminate information with the communities, and building on local indigenous knowledge. Immediate strategies should build on existing means of communication (i.e., radio and farmer-to-farmer transfer), while further research could improve the use and transfer of new technologies. Community-based early-warning systems should also be introduced to help communities that deal with irregular seasons. Some best practices already exist and need to be scaled up, with the support of the private sector. Nationally, stronger collaboration is required among the Ministry of Information and Communications Technology, the Meteorological Department, the Ministry of Environment (responsible for climate change), the Office of the Prime Minister (responsible for disaster risk reduction), MAAIF and the private sector to creatively help farmers adapt to climate risk in order to ensure sustainable crop production.

**Combine local and scientific knowledge for improved local weather forecast and early-warning systems.** The need to account for local indigenous knowledge in climate risk management has already been somewhat recognized at the national level (e.g., NAPA) and in some recent case studies (e.g., Osbahr et al. 2011). Local consultations in Rakai and Kapchorwa indicated that farmers often rely on their local, traditional knowledge for weather predictions and improving crop yields. Such knowledge should be strengthened to ensure that information and technologies developed respond to local priorities. A stronger collaboration among extension staff, scientists, farmers and cultural institutions is required to combine 'outside' knowledge of climate with local, indigenous knowledge and practices, for example through developing community-based early-warning systems and local weather forecasts.

## **Local governance and social organization**

**Support strong farmers' institutions and organizations.** Investment in infrastructure and new crop varieties is not enough. Local consultations indicated that communities that have been supported to form farmers' groups have stronger bargaining power and ability to access advisory services. Farmers need to be supported to organize through strong institutions (including religious institutions and cultural leaders) and local organizations to help them increase benefits from crop production and support livelihood diversification.

**Empower women farmers in crop production.** Women play a major role in production of both cash and food crops, but their role in marketing (e.g. for coffee) remains limited. Specific efforts should be made to improve representation of disadvantaged groups, such as women in farmers' groups, and to raise awareness of the role women play in promoting food security. The wording and timing of communication of agricultural information should be gender sensitive. For example, while radio remains one of the most important sources of information at the household level, women rarely own radios and cannot always decide freely when they can listen and what they should listen to. The broadcast may also occur when women are most busy with other tasks, such as fetching water.

## **Capacity development**

Capacity development is cross-cutting and is required at all levels to support farmers in the context of increasing uncertainty related to climate risks and other changes. In particular, capacity development is required in application of new stress-resistant seeds; application of CA, intercropping and agroforestry; and access to weather information. Local training should use an action-



learning approach through farmer field schools, and this should be spearheaded by both governments and civil society actors. The government, donors and the private sector should stimulate in-country researchers to systematically integrate climate risks into their work.

## GOVERNANCE

With many key policies and strategies already developed or underway (e.g. a draft coffee policy, draft cassava policy, draft organic agriculture policy, draft seeds policy and new agricultural policy), and efforts to improve coordination also underway, the focus can begin to shift to implementation. This should be undertaken by all relevant institutions. Danish International Development Assistance (Halsnæs et al., 2008) recommends that “comprehensive and targeted information activities should be initiated.” MAAIF and OPM (2008) points to weaknesses surrounding “delays in allocation, approval and disbursement of funds.” These examples highlight that although properly planned and coordinated policies are essential, they are useless without implementation follow-through. Planned interventions need to get off the ground. This is happening, slowly: a number of projects were commissioned in November 2011 to start implementing some of the priorities identified in the NAPA, which launched in 2007. The ‘National Adaptive Capacity Framework’ (WRI, 2009) used in this study appears a very useful tool; its use could be institutionalized to serve as a common monitoring tool for strengthening the capacity of CCU and OPM to support the government in documenting its progress towards climate risk management.

**Mainstream climate risk into key public policy documents.** Climate change vulnerability is such an overarching issue and so important to the country’s future well-being that it should be considered in all government planning processes. Mainstreaming climate considerations into planning documents is essential. Water management, for example, affects livelihoods broadly and human well-being directly, and since water shortages are going to be an important issue for Uganda going forward, it is not realistic to consider the issue only within the mandate of the Ministry of Water and Environment. Effective water management requires that plans regarding energy, agriculture, land use, economic development, etc. all be on the same page. These cross-cutting issues are the norm in climate change risk management, and unless these issues are factored into all levels of policy planning, outcomes will not be as successful as they might otherwise be. Mainstreaming of climate change adaptation also often remains abstract. Key policies and strategies may mention the issue of ‘climate variability and change,’ but analysis related to its implications and the changes it may concretely require is limited. The draft coffee policy (2010) should explicitly integrate the issue of climate variability and change.

**Mainstream climate risk at all levels of crop value chains.** It is important to improve value-chain governance to ensure that all actors (including farmers) along the value chain benefit. MAAIF should further ensure that climate risks are systematically mainstreamed at all levels of the value chain for maize, beans, coffee and other relevant strategic commodity crops.

**Continue to improve coordination functions.** By designating a centralized authority to deal with climate change and act as a point of contact, Uganda is moving in the right direction in effectively coordinating adaptation policy efforts. It is also supporting this authority with valuable, complementary institutions to ensure effective program delivery and coordination with stakeholders. However, getting ministries, departments and other agencies to work collaboratively is an immense challenge for any government. Strong and continuous political support is necessary to support the synergies between the CCU and the Department of Relief, Disaster Preparedness and Management. Improved coordination will require fostering both horizontal links (among relevant government ministries), and vertical links (between the relevant ministries and other levels and actors, including local governments and communities).

**Involve local communities in detailed (regional) risk assessments and development of adaptation options.** Those at the community and local level who possess the most valuable bottom-up knowledge can inform policy-making. MAAIF and OPM (2008) echoes this, pointing to a “lack of community awareness and participation in implementation of drought programmes at the community level,” and recommending “community participation in drought risk reduction programmes” and the “adoption of a participatory and holistic approach” to intervention. Engaging with local communities will generate better-targeted and more effective interventions. This will also help use local, indigenous knowledge for climate risk management. Some tools (e.g., Climate Vulnerability and Capacity Analysis, CRISTAL) used to document this knowledge in the context of climate risks already exist, as does the capacity to use these tools in-country.

## PRIORITY CLIMATE RISK MANAGEMENT OPTIONS

Table 4 summarizes prioritized risk management options mentioned in the subsections above by strategic theme. The third column indicates the focus regions.

**TABLE 4. PRIORITY CLIMATE RISK MANAGEMENT OPTIONS FOR CROP PRODUCTION IN RAKAI AND KAPCHORWA**

STRATEGIC THEME	CLIMATE RISK MANAGEMENT OPTIONS	EXPECTED BENEFITS	LEVEL
Water, soil and land management	Promote simple and low-cost infrastructure for water management and distribution (water-harvesting technologies, small dams, irrigation) at community and district levels.	Reduced climate sensitivity of crops due to reduced water stress.	National, district, community
	Support and improve simple and low-cost soil and water conservation practices, such as agroforestry, tree planting, mulching, compost, organic manures, terrace farming, etc. (i.e., CA).	Reduced climate sensitivity of crops due to reduced water stress or excess water.	National, district, community
	Promote a watershed-scale approach to protect water sources at farm and community levels and develop specific protocols and guidelines for watershed management in the context of climate risks.	Reduced climate sensitivity due to better protection of watersheds; increased adaptive capacity.	District, community
	Support watershed payments for ecosystem services.	Increased equity and environmental conservation as an underlying driver of adaptive capacity.	National, district
	Involve communities in ecosystem restoration programs (e.g., tree planting).	Reduced environmental degradation as an underlying driver of climate sensitivity.	National, district
Agronomic practices	Disseminate culturally acceptable and affordable, stress-resistant crop varieties (resistant to stresses such as droughts, floods, pests and diseases).	Reduced sensitivity of crops to climate risks; increased adaptive capacity.	National, district
	Support proper crop diversification and intercropping techniques.	Spread and diversified risk; increased adaptive capacity.	National, district
	Support proper agroforestry.	Reduced sensitivity of coffee to water stress.	National, district
	Support farmers in replacing old, unproductive coffee plantations.	Reduced sensitivity of coffee trees to climate risks and related pests and diseases.	National, district
	Support proper fertilizer management, including improving the links between pastoralists and cultivators in pastoral areas.	Reduced sensitivity of crops through increased soil fertility while maintaining environmental and human health.	National, district
	Support integrated pest and disease management through the use of the Farmer Field School approach.	Reduced climate sensitivity of crops while maintaining environmental and human health.	National, district
Poverty reduction	Promote alternative income-generation activities to prevent food shortages and environmental degradation and diversify production systems (e.g., large-scale grazing should include some level of farming).	Spread risks and reduced poverty as an underlying driver of climate sensitivity.	National, district
Infrastructure and financing	Promote appropriate storage systems for maize and coffee.	Reduced climate sensitivity of crops.	District (Kapchorwa)
	Improve road infrastructure and flood-control structures.	Increased adaptive capacity.	District (Kapchorwa)
	Support/expand rural microfinance.	Increased adaptive capacity.	National

TABLE 4 CONTINUED

STRATEGIC THEME	CLIMATE RISK MANAGEMENT OPTIONS	EXPECTED BENEFITS	LEVEL
Information and communication technologies	Strengthen meteorological services to provide improved climate information/data (timeliness, specificity, packaging for end users).	Improved disaster preparedness.	National
	Localize national information on climate risks so that farmers can understand, trust, use and benefit from it, and support the dissemination of information on climate risks among farmers through community-based information and communications technology systems.	Improved generation, dissemination and use of climate information for farmer decision-making, contributing to increased adaptive capacity.	National, district, community
	Combine local and scientific knowledge for improved local weather forecasts and early-warning systems.	Improved disaster preparedness.	National, district, community
	Establish community-based early-warning systems that are closer to communities' needs, priorities and understanding.	Increased adaptive capacity.	National, district, community
	Package and disseminate relevant information and research findings on climate risk.	Increased awareness-raising and adaptive capacity.	National, district
	Improve technologies to help communities adapt to climate change (e.g., post-harvesting, irrigation, soil and water management, food preservation) (role of research).	Increased adaptive capacity.	National, district
Local governance and social organization	Strengthen farmers' organizations.	Increased adaptive capacity.	National, district, community
	Support women farmers' empowerment in crop production.	Reduced gender-based climate vulnerability; reduced inequalities; increased adaptive capacity.	National, district, community
Capacity development and research	Build capacity of local communities and district officials on climate change by using an action-learning approach.	Improved disaster preparedness.	National
	Continue to promote environmental education to farmers.	Improved disaster preparedness.	National, district
	Strengthen institutional capacities at national and district levels for mainstreaming climate risks.	Improved disaster preparedness.	National, district
	Develop an ecophysiological model for coffee.	Increased adaptive capacity.	National
Governance	Mainstream climate risk into key public policy documents.	Increased adaptive capacity.	All
	Strengthen coordination mechanisms through horizontal and vertical links, including harmonizing national policies on climate change.		
	Improved disaster preparedness.	National	
	Foster political will to support climate change and to improve the synergies between climate change adaptation and disaster risk reduction.	Improved disaster preparedness.	National
	Enforce policies, laws, bylaws and ordinances at all levels (policies are there but need to be implemented).	Improved disaster preparedness.	National, district
	Resettle some communities to less hazard-prone areas.	Reduced exposure to climate risks.	National, district
	Allocate financial resources for all of the above, both at national and local levels.	Increased adaptive capacity.	National, district

### **Key messages: Climate risk management options**

- Climate risk should be addressed holistically, in combination with other socio-economic factors such as environmental degradation, poverty reduction and reproductive health.
- Many climate risk management options for crop production suggested here are in line with key policies and strategies, including the NAPA's recommendations. They provide an opportunity and avenue for implementation.
- Governance is key to implementing any of the suggested options. To effectively deal with climate risks, the government needs to implement existing policies and strategies, continue to mainstream climate risk into key public policy documents, ensure strong political will to support continued improvement of coordination functions (through horizontal and vertical linkages), and involve local communities in detailed (regional) risk assessments and in the development of adaptation options.

## REFERENCES

- Bertelsmann Stiftung (2009). *Transformation Index (BTI) 2010 — Uganda country report*. Gütersloh: Bertelsmann Stiftung. Munich University, Germany.
- Bizikova L., S. Boardley and S. Mead (2010). *Economics of Adaptation to Climate Change. Participatory Scenario Development (PSD) Approaches for Identifying Pro-Poor Adaptation Options*. Discussion Paper Series no. 18. Washington, D.C.: World Bank.
- Bizikova L., T. Dickinson and L. Pinter (2009). Opportunities for participation and learning when translating impacts of climate change into adaptations. *Participatory Learning and Action*, vol. 60, pp. 167–173.
- Cardona, O.D., and others (2012). Determinants of Risk: Exposure and Vulnerability."Pp. 65–108 in *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC)*, C.B. Field and others, eds. Cambridge, UK, and New York, USA: Cambridge University Press.
- Carter, T.R., and others (2007). New Assessment Methods and the Characterisation of Future Conditions. Pp. 133–171 in *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 and others, eds. , Cambridge, UK, and New York, USA: Cambridge University Press.
- Centre for Research on the Epidemiology of Disasters (CRED) (2012). EM-DAT: The International Disasters Database – Uganda. Retrieved 05 May 2012 from <http://www.emdat.be>
- Christensen, J. H., and others (2007). Regional climate projections. Pp. 847–940 in: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon and others, eds. Cambridge, UK, and New York, USA: Cambridge University Press.
- DaMatta F. M., and others (2007). Ecophysiology of coffee growth and production. *Brazilian Journal Plant Physiology*, vol. 19, No. 4, pp 485–510. Available from <http://dx.doi.org/10.1590/S1677-04202007000400014>
- Dazé, A., K. Ambrose, and C. Ehrhart (2009). *Climate Vulnerability and Capacity Analysis: Handbook*. CARE. Available from [http://www.careclimatechange.org/cvca/CARE\\_CVCAHandbook.pdf](http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf).
- Easterling, W.E., and others (2007). Food, fibre and forest products. Pp. 273–313 in: *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, and others, eds. Cambridge UK: Cambridge University Press.
- Farm Africa (2011). Facts about Uganda. Available from <http://www.farmafrica.org.uk/where-we-work/uganda>.
- Fischlin, A., and others (2007). Ecosystems, Their Properties, Goods, and Services. Pp. 211–272 in *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 and others, eds. Cambridge, UK, and New York, USA: Cambridge University Press.
- Food and Agriculture Organization of the United Nations (FAO) (2010). *"Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation*. The Hague Conference on Agriculture, Food Security, and Climate Change.
- Glick, P., B. A. Stein, N. A. Edelson (eds.) (2011). *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*. Washington, D.C.: National Wildlife Federation.
- Goulden, M. (2006). *Livelihood Diversification, Social Capital and Resilience to Climate Variability Amongst Natural Resource Dependent Societies in Uganda*. PhD dissertation, University of East Anglia.
- Halsnæs, K., P. R. Shukla, and A. Garg (2008). Sustainable development and climate change: lessons from country studies. *Climate Policy*, vol. 8, No. 2, pp. 202–219.



Halsnæs, K., and others (2008). *Climate Change Screening of Danish Development Cooperation with Uganda. Final Report*. Copenhagen, Denmark: Danish International Development Assistance (DANIDA), Ministry of Foreign Affairs of Denmark.

Hepworth, N., and M. Goulden (2008). *Climate Change in Uganda: Understanding the Implications and Appraising the Response*. Edinburgh, UK: LTS International.

Intergovernmental Authority on Development (IGAD) (2010). *IGAD Environment Outlook*. Available from [http://igad.int/index.php?option=com\\_docman&task=cat\\_view&gid=58&Itemid=144](http://igad.int/index.php?option=com_docman&task=cat_view&gid=58&Itemid=144)

Intergovernmental Panel on Climate Change (IPCC) (2007). *Climate Change 2007: the Physical Science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon and others, eds. Cambridge, UK: Cambridge University Press.

International Coffee Organization (ICO) (2009). *Climate Change and Coffee*. International Coffee Council 103rd Session. London, UK, 23–25 September 2009.

James, P.A.S. (2010). Using Farmers' Preferences to Assess Development Policy: A Case Study of Uganda. *Development Policy Review*, vol. 28, No. 3, pp. 359–378.

Jaramillo, J., and others (2011). Some like it hot: The influence and implications of climate change on coffee berry borer (*Hypothenemus hampei*) and coffee production in East Africa. *PLoS ONE*, vol. 6, No. 9, e24528, doi:10.1371/journal.pone.0024528.

Jaramillo, J., and others (2009). Thermal tolerance of the coffee berry borer *Hypothenemus hampei*: Predictions of climate change impact on a tropical insect pest. *PLoS ONE*, vol. 4, No. 8, e6487, doi:10.1371/journal.pone.0006487.

Jones, P.G., and P.K. Thornton (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. *Global Environmental Change*, vol. 13, pp. 51–59.

Jones, P.G., P.K. Thornton and J. Heinke (2009). *Generating characteristic daily weather data using downscaled climate model data from the IPCC's Fourth Assessment*. Project report. Nairobi, Kenya: International Livestock Research Institute.

Jones, P.G., and others (2002). *MarkSim: A Computer Tool That Generates Simulated Weather Data for Crop Modelling and Risk Assessment*. Cali, Columbia: International Centre for Tropical Agriculture.

Kalule T., and others (2006). Farmers' perceptions of importance, control practices and alternative hosts of maize stemborers in Uganda. *International Journal of Tropical Insect Science*, vol. 26, No. 2, pp. 71–77.

Kapchorwa District Local Government (2011a). *Approved Five Year District Development Plan 2011/2012 –2015/2015*. Kampala: Republic of Uganda.

Kapchorwa District Local Government (2011b). *Kawowo Sub-county Development Plan, 2011/2012 –2013/2014 – 2015/2016*. Kampala: Republic of Uganda.

Lane, A., and A. Jarvis (2007). Changes in climate will modify the geography of crop suitability: Agricultural biodiversity can help with adaptation. *SAT eJournal*, vol. 4, No. 1 (December), pp. 1–12.

Lim, B., and others (2005). *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*. Cambridge, UK: Cambridge University Press.

McCandless, M., and others (2012). *Impacts of Climate Change on Maize and Beans in Rakai and Kapchorwa Districts, Uganda*. Unpublished document. International Institute for Sustainable Development.

Milder, J.C., T. Majanen and S.J. Scherr (2011). *Performance and Potential of Conservation Agriculture for Climate Change Adaptation and Mitigation in Sub-Saharan Africa*. Ecoagriculturepartners, CARE, WWF and World Agroforestry Centre.

Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) (2011). *The Draft National Coffee Policy. Revitalization of the Coffee Sector in Uganda*. Republic of Uganda.

Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) (2010). *Agriculture Sector Development Strategy and Investment Plan – 2010/11-2014/15*. Agriculture for Food and Income Security. Republic of Uganda.

Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and Office of the Prime Minister (OPM), Department of Disaster Preparedness and Refugees (2008). *Review and Analysis of Existing Drought Risk Reduction Policies and Programmes in Uganda. National Report on Drought Risk Reduction Policies and Programmes*. Republic of Uganda. United Nations International Strategy for Disaster Reduction (UNISDR) and SIDA.

Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), and others (2010). *Mapping a Better Future: Spatial Analysis and Pro-Poor Livestock Strategies in Uganda*. Washington, D.C., USA, and Kampala, Republic of Uganda: World Resources Institute.

Ministry of Finance, Planning and Economic Development (2009). *The State of Uganda Population Report 2009: Addressing the Effects of Climate Change on Migration Patterns and Women*. Kampala, Republic of Uganda.

Ministry of Information and Communication Technology (2010). *Information Technology Policy for Uganda*. Final Draft. Kampala: Republic of Uganda.

Ministry of Water and Environment (MWE) (2011). *About CCU*. Climate Change Unit. Available from <http://www.ccu.go.ug/about-ccu>.

Ministry of Water and Environment (MWE) (2010). *Water and Environment Sector Performance Report 2010*. Kampala, Republic of Uganda.

Ministry of Water and Environment (MWE) (2007). *Environment and Natural Resources Sector Investment Plan: 2008/09 – 2017/18*. Republic of Uganda.

Ministry of Water and Environment (MWE) (2002). *Initial National Communication to the UNFCCC*. Kampala, Republic of Uganda.

Ministry of Water and Environment (MWE) and others (2009). *Mapping a better future. How spatial analysis can benefit wetlands and reduce poverty in Uganda*. Washington, D.C., USA, and Kampala, Republic of Uganda: World Resources Institute. Available from <http://www.wri.org/publication/mapping-a-better-future>

Muwanga, N. K. (2001). *The Differences in Perceptions of Poverty*. Kampala, Republic of Uganda: Uganda National NGO Forum.

Nabikolo, D., and others (2010). *Assessing the Impact of Climate Change Adaptation on Agriculture Production in Eastern Uganda*. Research application summary at Second RUFORUM Biennial Meeting. Entebbe, Republic of Uganda, 20–24 September 2010.

Namanya, D. B. (2009). *An Assessment of the Impact of Climate Change on the Health Sector in Uganda: A Case of Malaria and Cholera Epidemics and How to Improve Planning for Effective Preparedness and Response*. Kampala, Republic of Uganda: Ministry of Health.

National Environment Management Authority (NEMA) (2009). *Uganda Atlas of Our Changing Environment*. Available from <http://www.grida.no/files/publications/uganda-atlas-2009.pdf>.

National Environment Management Authority (NEMA) (2008). *Uganda National Environment Report*. Kampala, Republic of Uganda.

National Planning Authority (NPA) (2010). *National Development Plan (2010/11–2014/15)*. Kampala, Republic of Uganda.

National Planning Authority (NPA) (2008). *Vision 2035: Towards a Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 Years. Working Draft for National Dialogue*. Republic of Uganda: Ministry of Finance, Planning and Economic Development.

National Union of Coffee Agribusinesses and Farm Enterprises (NUCAFE) (2008). *Enhancing Competitiveness of Uganda Coffee on the World Market through Good Policy and Regulatory Framework*. Report of the Uganda coffee Policy and Regulatory Framework. Available at <http://www.nucale.org/index.php/publications/reports/quarterly-reports>

Office of the Prime Minister (OPM) (2011). *Disaster Preparedness, Management & Refugees*. Available from [http://www.opm.go.ug/departments.php?center\\_id=5](http://www.opm.go.ug/departments.php?center_id=5)

Office of the Prime Minister (OPM) (2010). *The National Policy for Disaster Preparedness and Management*. Kampala, Republic of Uganda: Directorate of Relief, Disaster Preparedness and Refugees.

Osbahr, H., and others (2011). Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variability with farmer perceptions. *Experimental Agriculture*, vol. 47, No. 2, pp. 293–316.

Oxfam (2008). *Turning up the Heat: Climate Change and Poverty in Uganda*. Kampala, Uganda and Oxford, UK: Oxfam GB.

Oxford Policy Management (OPM) (2005). *Evaluation of the Plan for the Modernisation of Agriculture, Uganda*. Available from: <http://www.opml.co.uk/news-publication/evaluation-uganda-plan-modernisation-agriculture>

Parizat, R., and others (2011). *Ugandan Coffee Supply Chain Risk Assessment*. World Bank. Available from <http://www.agriskmanagementforum.org/doc/ugandan-coffee-supply-chain-risk-assessment-june-2011>

Rakai District Local Government (2010). *Rakai District Approved Development Plan for the Period 2010/2011 – 2012/2013*. Republic of Uganda.

Republic of Uganda (2010a). *Climate Change Vulnerability Assessment, Adaptation Strategy and Action Plan for the Water Resources Sector in Uganda*.

Republic of Uganda (2010b). *Millennium Development Goals Report for Uganda 2010*. Ministry of finance, Planning and Economic Development: Kampala, Republic of Uganda.

Republic of Uganda (2010c). *The State of Uganda Population Report 2010*. Kampala, Republic of Uganda.

Republic of Uganda (2007). *Climate Change: Uganda National Adaptation Programmes of Action*. GEF, UNEP and Environmental Alert.

Republic of Uganda and United Nations (2010). *United Nations Joint Programme on Climate Change*. Available at <http://www.ugandaclusters.ug>

Simonett, O. 1989. *Impact of Temperature Rise on Robusta Coffee in Uganda*. Case Studies on Climatic Change. Geneva, Switzerland: GRID-Geneva. Retrieved 16 September 2011 from <http://maps.grida.no/go/graphic/impact-of-temperature-rise-on-robusta-coffee-in-uganda>

Transparency International (2009). *Overview of Corruption in Uganda*. Bergen, Norway: U4 Anti-Corruption Resource Centre and Chr. Michelsen Institute.

Twinomugisha, B. (2005). *A Content Analysis Report on Climate Change Impacts, Vulnerability and Adaptation in Uganda*. International Institute for Environmental Development. Available from <http://pubs.iied.org/pdfs/10011IIED.pdf>.

Uganda Bureau of Statistics (UBOS) (2010a). *Statistical Abstract 2010*. Kampala, Republic of Uganda.

Uganda Bureau of Statistics (UBOS) (2010b). *Uganda National Household Survey 2009 – 2010*. Kampala, Republic of Uganda.

Uganda Bureau of Statistics (UBOS), and Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) (2011). *Uganda Census of Agriculture 2008/2009 at a Glance*. Kampala: Republic of Uganda.

Uganda Coffee Development Authority (UCDA) (2010). *Annual Report 2009/10*. Available from [www.ugandacoffee.org](http://www.ugandacoffee.org).

United Nations (2003). Country Maps: Uganda. UN Cartographic section. Available from <http://www.un.org/depts/Cartographic/english/htmain.htm>.

United Nations Development Programme (UNDP) (2012). Crisis Prevention and Recovery. Disaster Reduction Unit. What We Do – Risk Reduction Tools. New York. Retrieved February 2012 from <http://www.undp.org/cpr/disred/english/wedo/rrt/dri.htm>

United Nations Development Programme (UNDP) (2011). MDGs in Uganda. Available from <http://www.undp.or.ug/mdgs/25>

United Nations Development Programme (UNDP) (2004). *Reducing Disaster Risk: A Challenge for Development. A Global Report*. New York: UNDP.

United Nations Office for Disaster Risk Reduction (UNISDR) (2004). *Living With Risk: United Nations International Strategy for Disaster Reduction*. Geneva.

United Nations Office for the Coordination of Humanitarian Affairs (2008). *Uganda disaster Preparedness Plan: Disaster Preparedness for Effective Response – Supporting the Implementation of Priority 5 of the Hyogo Framework for Action in Uganda* (Draft). Kampala, Republic of Uganda.

Wandiga, S. O., and others (2010). Vulnerability to epidemic malaria in the highland of Lake Victoria basin: the role of climate change/variability, hydrology and socio-economic factors. *Climatic Change*, vol. 99, pp. 473–497.

Wasige, J. E. (2009). *Assessment of the Impact of Climate Change and Climate Variability on Crop Production in Uganda*. Kampala, Uganda: Makerere University and Vital Science Africa.

Williams A. P., and C. Funk (2011). A westward extension of the warm pool leads to a westward extension of the Walker circulation, drying eastern Africa. *Climate Dynamics*, vol. 31, No. 11, pp. 2417–2435.

World Bank (2006). *Uganda: Agriculture Sector Performance – A Review for the Country Economic Memorandum*. Kampala: World Bank Uganda.

World Resources Institute (WRI) (2009). *The National Adaptive Capacity Framework. Key Institutional Functions for a Changing Climate*. Pilot draft. Washington, D.C.



*Empowered lives.  
Resilient nations.*

**iisd** International  
Institute for  
Sustainable  
Development Institut  
international du  
développement  
durable



For more information: [www.undp.org](http://www.undp.org)

**United Nations Development Programme**

One United Nations Plaza • New York, NY 10017 USA