19
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Adaptation to Climate Change in Semi-Arid Environments

Experience and Lessons from Mozambique

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FOREWORD

Southern Africa is one of the regions most vulnerable to the impacts of climate change. Mozambique, one of the least developing countries in the region and with 2 700 km of coastline, is already experiencing the devastating effects of the increasing frequency of droughts, floods and cyclones on agricultural livelihood (crops, livestock, forest and fisheries) in rural and coastal areas.

Climate change is also expected to have a significant impact on the Limpopo River Basin and its tributaries which enter the Chicualacuala District in the Gaza Province and flow across the vast areas of semi-arid plateau of the southern provinces of Mozambique towards the Indian Ocean. Aware of the urgent need to address the high vulnerability of the population in the Limpopo River Basin, the Government of Mozambique chose the District of Chicualacuala to initiate the United Nations Joint Programme (UNJP) on Environmental Mainstreaming and Adaptation to Climate Change for the period between 2008 and 2011 (total of US$7 million). The Programme, which is funded by the Government of Spain through the MDG F, has recently been extended until August 2012.

Ministry for the Co-ordination of Environmental Affairs (MICOA), through its partnership with FAO and the other partner UN agencies (UNDP, UNEP, UN-Habitat, UNIDO and WFP) has lead responsibility in the coordination of the largest component of the UNJP which deals with building the resilience of community and ecosystems to climate change and diversification of livelihood options. The collaboration of Provincial and District Government technical staff has been crucial to the success of project implementation. This publication documents the experiences, successes and challenges being faced in implementing the adaptation interventions in one of the remote districts where very few development agencies are operating. It identifies, at farm and community level, adaptive interventions that have been tested and applied and which have shown positive impact on productivity, broadening of the livelihood basis, and improving resilience to climate change. It also draws attention to those interventions that are not so promising and whose sustainability and expansion are questionable.

Valuable lessons learned are highlighted in several areas crucial for the success of future projects and programmes in climate change adaptation. These include:

project design and implementation, institutional arrangement and coordination, gender role, water harvesting and small-scale irrigation, crop and horticulture development, forest and rangeland management, livestock management, integrated small animals and fish farming and livelihood diversification. There is an urgent need to fund and implement programmes in support of national and local development plans that also serve to build climate resilience. Activities should continue building on the progress made by the UNJP in integrating adaption into local and national development plans guided by the needs of the beneficiaries. Programmes and projects in building climate resilience in southern Mozambique will be crucial in our efforts to improve food security, reduce poverty and maintain social stability. This further underscores the need to seek a follow-up intervention on the basis of the lessons learned from the project experiences highlighted in this publication.

We trust that this publication: "Adaptation to Climate Change in Semi-Arid Environments: Experience and Lessons from Mozambique" will serve as a useful guide to policy-makers at all levels of government, field practitioners and international development partners (both multilateral and bilateral agencies) in our joint effort to find new approaches and innovations to address the serious and urgent challenge of climate change.

Finally, in spite of some of the constraints faced in its implementation, we conclude that the "Delivering as One UN" at country level is still a conceptually sound and viable option in addressing complex environmental and climate change issues which require a cross-sectoral approach and collaboration. The Government of Mozambique, through MICOA, will do its part in improving this implementation mechanism for future climate change adaption programmes and projects.

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ABSTRACT

Southern Africa and Mozambique are highly vulnerable to the impacts of climate change. The region is regularly exposed to droughts, floods, variable rainfall and heat, which are expected to worsen, and sensitivity to such exposure of the natural resource-based livelihood system is very high. The area has a high developmental backlog, and the population is poor, food insecure, and not resilient to the impact of climate shocks. Due to water scarcity, not sufficient for humans and livestock except in a few communities along the Limpopo River, livelihood options are limited. Livelihoods are underpinned almost entirely by the little available water, agricultural lands and rangelands, and natural forests, and current practices and usage are threatening to become unsustainable. Existing coping mechanisms and safety nets are heavily reliant on the natural resources base, and livelihoods are seriously at risk under the projected climate changes. Urgent action is required to strengthen resilience now and into the future, when climate change will present significant additional stress.

In response to this need, the Government of Mozambique (six ministries and national institutes) led by MICOA and the United Nations (six agencies) led by FAO initiated a Joint Programme (JP) for environmental mainstreaming and adaptation to climate change, with the latter component implemented in a remote district of southern Mozambique, Chicualacuala. This paper gives an account of the Government of Mozambique/FAO-led interventions on strengthening smallholder agriculture, community-based natural resources management, and livelihood diversification in the face of current and future climate-related stresses. It provides the rationale behind each of the activities, innovations and successes, but also barriers and challenges encountered over the three-year project period. The lessons learned are critically analysed, and the opportunities for replication and scaling-up, and for filling in some of the gaps during follow-up interventions, explored.

It can be concluded that key elements which are essential for climate change adaptation in semi-arid southern African regions such as Chicualacuala, include improved access to water for human, livestock and productive purposes, strengthening of dryland crop production by improving soil fertility and water holding capacity, integrated crop-livestock-agroforestry production practices, small-scale crop irrigation where possible, development of the livestock industry (rangeland nutritional management, health services, processing, and small animals), sustainable community forest management and regulation, and tried

and tested options for livelihood diversification (e.g. beekeeping). Supportive technologies which will make a significant contribution include renewable energy, district-level climate information and communications, and a local centre (CERUM) for development of climate-adaptive technologies.

To ensure success and sustainability, a project such as this UNJP should be strongly informed by careful and considered project design and formulation, sufficiently long design and inception phases, a phased approach to implementation with feedback loops built in to accommodate learning, and full involvement of the communities and intended beneficiaries from the start. With some adjustments, the "Delivering as One UN" approach working closely with the national and local partners is considered to be conceptually sound and should guide future directions in UN climate change adaptation programmes.

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The Support of the District Government of Chicualacuala where the UNJP is operating has been crucial and we would like to express our gratitude to Antonio Rafael dos Santos (District Administrator), Manuel Namburete (Director of District Service for Economic Activities), Carlos Cossa (Chief of Mapai Administrative Post), and Samuel Cossa (former Chief of Mapai Administrative Post). The warm welcome given to us by the rural communities and some of in-depth discussion held with men and women farmers in the targeted communities provided a deeper insight into the problems linked to climate change that the rural communities are facing. At the provincial level, the support and encouragement of the Provincial Directorate of Agriculture provided essential guidance and technical backup. Thank you especially to Raimo Baraca (Provincial Chief of the Forestry and Wildlife Service {SPFFB}), Mario Beca (Senior Technician of the SPFFB) and Luis Banze (Chief of the Provincial Livestock Service).

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CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

CA	Conservation Agriculture
CBNFM	Community-based Natural Forest Management
CERUM	Multiple Use and Resource Centre
CRiSTAL	Community-based Risk Screening Tool – Adaptation and Livelihoods
CSO	Civil Society Organization
CVCA	Climate Vulnerability and Capacity Analysis
ENSO	El Niño Southern Oscillation
ESAN II	Nutrition and Food Security Strategy
FAO	Food and Agriculture Organization of the United Nations
FfW	Food for Work
FMD	Foot-and-Mouth Disease
GCM	Global Circulation Model
GoM	Government of Mozambique
HDI	Human Development Index (UNDP)
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immune Deficiency Syndrome
ICS	Institute for Social Communication
IIAM	*Instituto de Investigação Agrária de Moçambique* / Institute of Agricultural Research of Mozambique
INAM	*Instituto Nacional de Meteorologia* / National Institute of Meteorology
INGC	*Instituto Nacional de Gestão de Calamidades* / National Disaster Management Institute
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JP	Joint Programme
LDC	Least Developed Country
LIMCOM	Limpopo River Basin Commission
MDG	Millennium Development Goal
MDG F	Millennium Development Goals Achievement Fund
MICOA	*Ministério para a Coordinação da Acção Ambiental* / Ministry for Coordination of the Environment
MINAG	*Ministério de Agricultura* / Ministry of Agriculture
NAPA	National Adaptation Programme of Action

NGO	Non-Governmental Organization
OMM	National Women's Organization
PEDD	*Plano Estratégico Distrital de Desenvolvimento* / Strategic Development Plan for the District
SDAE	*Serviço Distrital de Actividades Económicas* / District Department for Economic Activities
SETSAN	Technical Secretariat for Food Security and Nutrition
UNAC	*União Nacional dos Camponeses* / National Farmers Trade Union
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention for Climate Change
UN-HABITAT	United Nations Human Settlements Programme
UNIDO	United Nations Industrial Development Organization
WFP	World Food Programme

CHAPTER 1

INTRODUCTION

Southern Africa is considered to be one of the most vulnerable regions in the world to the impacts of climate change (Boko *et al.* 2007). In particular, semi-arid areas characterized by marginal rainfall amounts restricting rainfed crop yields, highly seasonal rainfall with long dry seasons, unpredictable rainfall in the growth season, and scarcity of potable water for humans and livestock, are already experiencing the impacts of warming and shifting rainfall patterns. There is mounting evidence that climatic extremes such as droughts and floods are increasing in frequency and intensity across the region (INGC 2009).

Climate change is already, and will increasingly play a pivotal role in food security (Easterling *et al.* 2007; FAO 2007, 2010). It will likely alter the functioning and resilience of ecosystems such as rangelands and forests, which underpin the livelihoods of dryland inhabitants and which already provide important safety nets in times of need. In this respect, the achievement of the Millennium Development Goals (MDGs), particularly MDG-1 (eradicate extreme poverty and hunger) and MDG-7 (ensure environmental sustainability) (United Nations 2010), may well be jeopardized by the impacts of climate change (Chapman *et al.* 2011).

As an additional stressor, climate change will impact most strongly on those who are already food-insecure, subject to existing high levels of climate variability and stress, and unable to cope with, or adapt to, the added pressure. Many countries in southern Africa, notably the Least Developed Countries (LDCs), are over-reliant on rainfed agriculture for food production, have a large poor rural population engaged in subsistence farming, and poorly developed infrastructure. Southern Africa is one of the two regions likely to suffer negative impacts of climate change on several crops (e.g. maize and sorghum) that are very important to large food-insecure populations (Lobell *et al.* 2008).

Within southern Africa, Mozambique is one of the poorest countries (it is classified as a Least Developed Country, LDC) with a massive developmental backlog; it has the second-lowest Human Development Index (HDI) in the region (UNDP 2010). A prolonged civil war coupled with large-scale emigration

set the country back severely until the late 1990s. Poverty, food insecurity and malnutrition are pervasive, and combined with disease pressures such as malaria and HIV/AIDS are placing great strain on households and their ability to not only sustain themselves, but also to deal with, and recover from, climate-related and other hazards (INGC 2009). The underlying reasons for poverty and food insecurity are to a large extent structural, and must be addressed through development of the agricultural sector and investments in the socio-economic improvement of poor rural communities (IAASTD 2009).

Mozambique is highly exposed to harmful climatic events including droughts, massive floods, and cyclones. The impacts of climate hazards on the population and infrastructure are compounded by the widespread deep poverty and lack of resilience. Due to the severe limitations facing the government, where roughly half the national budget depends on foreign assistance, these burdens are not easily dealt with. The main objective of the Government of Mozambique (GoM) is to reduce absolute poverty through sustainable social and economic development and growth. Although some significant progress has been made, including reductions in absolute poverty and improvements in food security based on raised agricultural production, these achievements are not homogeneous across the country (Republic of Mozambique 2010).

The interior regions of southern Mozambique, such as parts of the Gaza Province have a long dry season (rainfall that ranges from 500 to 600 mm annually) suffer from deep poverty (62.5 percent, Republic of Mozambique 2010), lack of access to water, limited livelihood opportunities with heavy reliance on subsistence farming, and exposure to high temperatures, severe droughts and occasional floods and cyclones. The natural resource base is under significant pressure from localized overgrazing, wildfires and rapid deforestation. The ability of the local communities and officials to deal with this situation is tested to the limit, and coping mechanisms rely heavily on migration and unsustainable use of natural resources. In the recent past, insufficient rains in the south have resulted in reduced crop production and availability of water for humans and livestock. The nutritional and health status of communities in the southern interior, which suffer the highest HIV/AIDS prevalence nationwide (Republic of Mozambique 2010), is fragile (Republic of Mozambique 2006). It is thus imperative to strengthen the preventive and adaptive capacity of the local population that is necessary to improve their current and future resilience under conditions of climate change.

Recognizing the need to identify and prioritize adaptation measures to reduce the vulnerability of communities and sectors, MICOA through the National

Directorate of Environmental Management (DNGA) and in coordination with the NAPA Team, conducted a participative evaluation of 31 districts to determine which districts should be included in the pilot phase of the NAPA programme (MICOA, 2007). The district of Chicualacuala is one of the prioritized districts. The actions undertaken by the UNJP described in this paper are fully aligned with the following specific objectives of the NAPA:

- strengthen the early warning system in the country;
- strengthen the capacities of family farmers to deal with the adverse effects of climate change;
- improve the knowledge and strengthen the management of river water;
- promote actions to limit erosion and to develop sustainable fishery activities;
- promote public education activities and information dissemination on climate change;
- improve the coordination between the various groups that work on issues related to the evaluation of climate change vulnerabilities and hazard risk reduction;
- promote the integration of climate change into decentralized district planning.

This first part of the paper discusses the dynamics of climate change and its consequences on the natural resources base and on well-being and livelihoods of the inhabitants of the arid and semi-arid regions of southern Mozambique. The second part of the paper draws out practical experiences and lessons learned through the joint climate change mainstreaming and adaptation programme, with particular emphasis on the efforts of the Government of Mozambique and FAO-led interventions in strengthening smallholder agriculture, community-based natural resources management, and livelihood diversification in the face of current and future climate-related stresses. The pilot nature of large parts of the programme present a valuable opportunity to document and critically assess successes and challenges, and contribute towards the scaling-up and follow-up of climate change adaptation programmes and projects in Mozambique and other regions with similar agro-ecological conditions.

CHAPTER 2

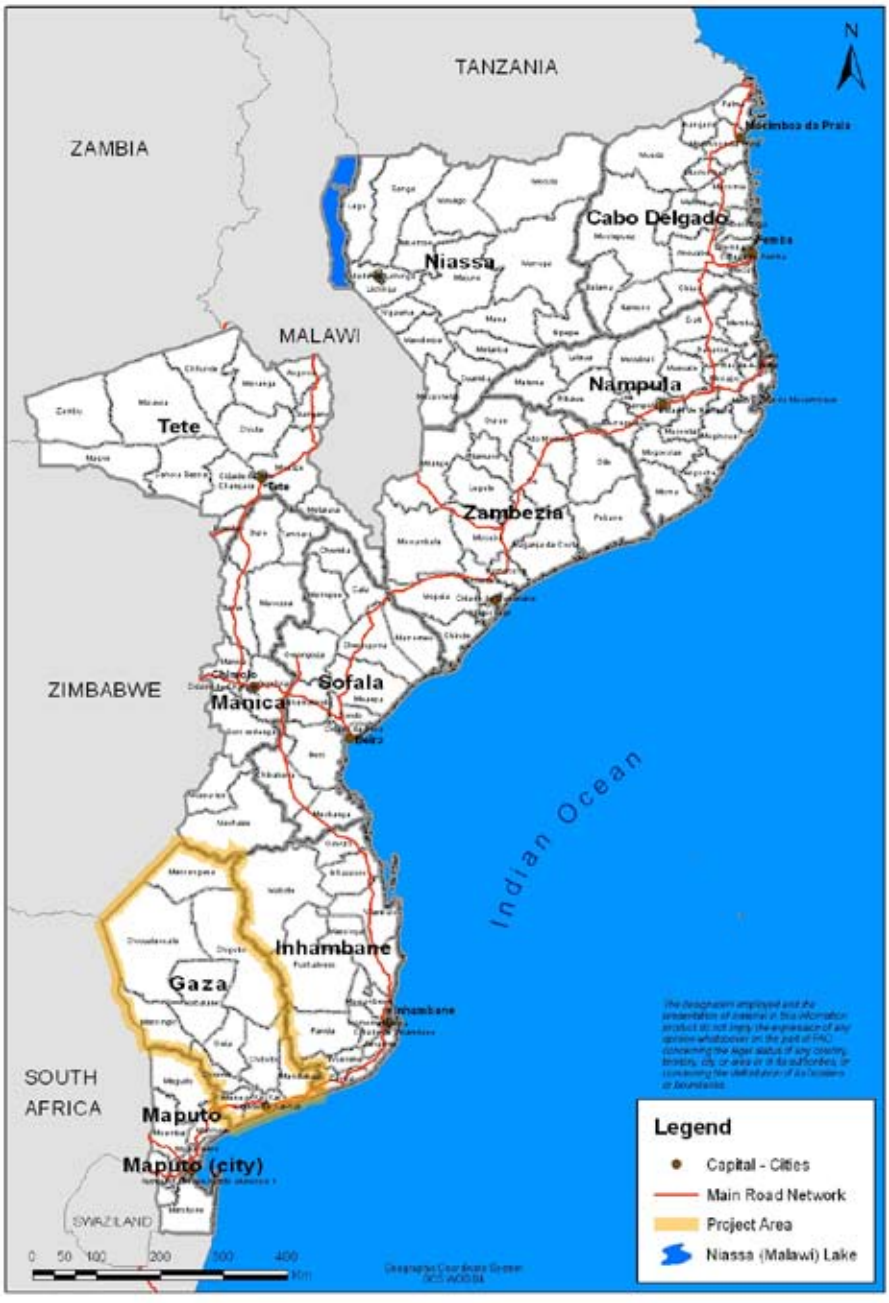
CLIMATE CHANGE AND VARIABILITY IN SOUTHERN AFRICA AND MOZAMBIQUE

Mozambique is characterized by a 2 700 km-long coastline running roughly north-south from the tropical to subtropical humid northern and central regions, to the semi-arid/arid subtropical southern region (Fig. 1). Convective thunderstorms during the wet season (October to April) bring higher rainfall to the northern and central regions than to the southern region. Lowest annual rainfall (300 mm) is recorded in the Pafuri District, the Gaza Province, in the interior south. Temperature gradients are generally north-south (latitudinal influence) and east-west (coastal influence). Larger river valleys, notably those of the Limpopo and Zambezi Rivers, can get almost unbearably hot in mid-summer.

Southern Africa is accustomed to climate variability and extreme climate events. The region's rainfall is heavily influenced by El Niño Southern Oscillation (ENSO), a global oceanic temperature anomaly (Lindesay and Vogel 1990). The ENSO phenomenon is associated with year-to-year rainfall variability: periods of heavy, extended rainfall are characteristic of the La Niña phase of ENSO. Conversely, the El Niño phase of ENSO causes dry conditions over central and southern Mozambique, Malawi, Zambia, Zimbabwe and parts of South Africa. Recent serious droughts include the 1981-85 and 1991/92 seasons, when millions of people across the region suffered acute food insecurity and depended on external food relief. During the 1981-85 drought an estimated 100 000 people died and 5.8 million were affected in Mozambique (EM-DAT 2011), the situation having been aggravated by the civil war. Flooding is often attributable to tropical cyclones which frequently make landfall in Mozambique, especially along the central coastal regions but also extending inland, south and north of this area (INGC 2009). The devastating flood of 2000/01 killed approximately 800 people and affected 4.5 million (EM-DAT 2011).

FIGURE 1

Administrative Division of Mozambique



During the period 1960 to 2006, temperatures have risen across Mozambique (INGC 2009). Average rainfall trends generally indicate a slight drying, particularly in summer, but importantly the proportion of rain falling in heavy events has increased (McSweeney *et al.* 2008). Associated with this, the duration of dry spells has increased, particularly in spring, signalling a delay in the end of the dry season (INGC 2009). These trends are reflected in global trends (Easterling *et al.* 2000). A significant increase in the number of disasters in Mozambique (flood, epidemic, tropical cyclone and drought) has been found since the 1980s (INGC 2009).

Global Circulation Models (GCMs) suggest that southern Africa will warm by between 3.1 °C and 3.4 °C, with warming of up to 4.8 °C possible towards the end of the twenty-first century (Christensen *et al.* 2007). The projections show reduced rainfall for much of the region in winter (May to July). In mid- to late summer (December to April), wetting is indicated in the eastern and northern parts of the region. However, there is still considerable uncertainty over rainfall changes in the summer rainfall regions.

Climate change will likely manifest in the short to medium term through increasing intensities of rainfall of shorter duration (especially during late summer), decreasing frequencies of low intensity (soft soaking) rainfall, and longer dry periods between rainfall events (Trenberth *et al.* 2003; New *et al.* 2006; Tadross *et al.* 2005, 2009; Christensen *et al.* 2007), accompanied by continued steady warming. The intensity of tropical storms and their associated rainfall (and possibility of flooding) are likely to increase (Webster *et al.* 2005; Emanuel *et al.* 2008).

The most recent GCM-based model projections of climate change for Mozambique (INGC 2009) show that rainfall could increase moderately to strongly over most of Mozambique, although this remains uncertain. Coastal areas are likely to experience the strongest wetting in summer/autumn. Temperatures will continue to rise by 1.5 °C-3.0 °C by mid-century, and rates of warming, and associated increases in evapotranspiration, are expected to be higher towards the interior. Heat stress events will be more frequent in future (Battisti and Naylor 2009), and it is likely that heat thresholds will be exceeded more regularly, particularly in spring (INGC 2009).

This means that the implications for Mozambique's small-scale and subsistence farmers, who rely almost entirely on rainfall for crops, livestock and other production purposes, need to be thoughtfully assessed and used as a basis for supportive actions and strengthening of their adaptive capacity. A high proportion of Mozambique's population remains highly vulnerable and food insecure, with climate variability and destruction caused by extreme climate

events being partially responsible and aggravating the underlying drivers of vulnerability. The natural resources base remains very fragile, under threat from over-exploitation and unsustainable practices, existing climate-related risks such as recurring droughts and floods, overlaid with emerging and projected future climate change impacts and rising population pressures. Nevertheless, threats and opportunities are likely to be heterogeneous across the country, and local environmental and socio-economic contexts must inform site-specific adaptation options.

Increased food production and improvements in food security remain high on the list of priorities for Mozambique, whilst simultaneously ensuring sustainable management of natural resources led by both government policies and bottom-up (community-based) approaches. More frequent high temperature stress on crops, more rapid loss of soil moisture through changing rainfall patterns and increased evapotranspiration, and heightened risks of droughts and floods all call for urgent attention to adaptation. This report identifies the key impacts and adaptation priorities which are considered feasible within the local biophysical and socio-economic context of arid/semi-arid southern Mozambique. This subregion has been identified as one of the most vulnerable to the impacts of climate change in Mozambique (INGC 2009) and the region (Midgley *et al.* 2011). Focus is, in particular, on the Gaza Province, and specifically the inland arid and semi-arid areas of the province, which, although traversed by the Limpopo River, suffer from profound structural water poverty and very limited livelihood options as a consequence.

CHAPTER 3

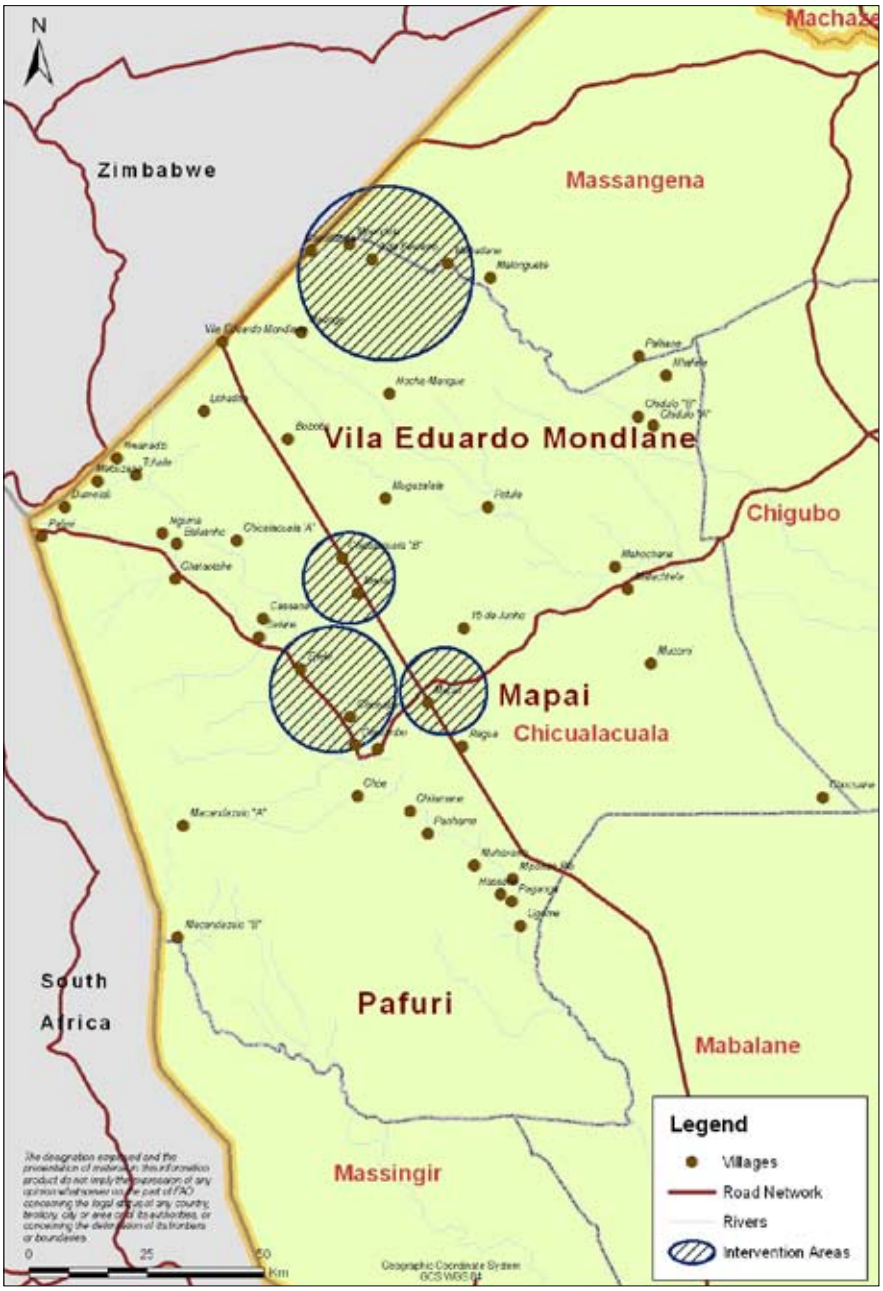
CLIMATE IMPACT ON AGRICULTURE AND NATURAL RESOURCES AT DISTRICT AND COMMUNITY LEVELS

The Limpopo River originates on the southern African plateau in eastern Botswana, northern South Africa and southern Zimbabwe, and enters Mozambique at Pafuri, in the Chicualacuala District of the Gaza Province (Fig. 2). From here it flows south-eastwards and into the Indian Ocean north-east of Maputo. The Limpopo Basin of inland Gaza is typically flat and characterized by low elevations of generally less than 100 metres above sea level (masl) but with a few elevated ridges up to 500 masl. Rainfall is less than 500 mm on average, the rainfall season between December and March is short and erratic, and temperatures are high (annual mean exceeding 24 °C) with extreme summer heat common. The area experiences regular droughts, and occasional destructive floods brought by excessive rainfall.

These climatic hazards have significant impacts on the population, almost all of whom are subsistence farmers with few other sources of food and income, thus relying heavily on the natural forests when crops fail and income from livestock is reduced. The risks of crop failure and variability of production are high owing to erratic rainfall patterns. Croplands are established both along the alluvial soils of the flood plains (to maximize on water availability, but prone to flooding) and at higher elevation on limestone-derived soils (not so flood prone, but with little access to water). Both are subject to high risks but the latter suffer more under drought conditions. Livestock are also affected, with both droughts and floods causing significant mortality and loss of production, e.g. 15 percent of Chicualacuala's cattle herd was lost during the 2000 flood. This district is one of the poorest and most marginalized areas of the south, and indeed of the country.

FIGURE 2

Chicualacuala District and the UN Joint Programme intervention area

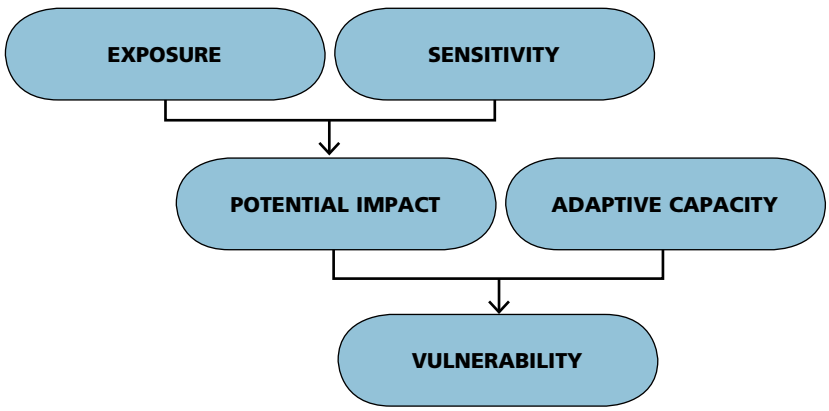


The population of approximately 40 000 people is widely dispersed across the Chicualacuala District (18 155 km^2, 2.1 inhabitants per km^2), clustered in nine localities. Infrastructure and facilities, including agricultural facilities, are poor. However, the Limpopo railway corridor traverses the district, offering some promising opportunities for trade with passing passengers from Maputo or Zimbabwe, or dealers from Maputo. The majority of the population do not have access to modern energy services and rely on fuelwood for their energy requirements. Piped water is essentially unknown; water is collected at communal point sources in containers and transported by various means to the homesteads.

In 2009 and early 2010, a series of baseline studies was conducted to inform a district-level assessment of climate-related risks, impacts, vulnerabilities, and current coping strategies. The studies included livelihoods and vulnerability, climate-related coping strategies, water resources and infrastructure, current land use and land use suitability for agriculture, livestock and agroforestry systems, and the potential for renewable energy technologies. This formed the beginning of the Joint Programme on Environmental Mainstreaming and Adaptation to Climate Change in Mozambique between the United Nations and the GoM (see Chapter 6). To facilitate the assessment and subsequent implementation of adaptation activities, two of the three Administrative Posts, namely Eduardo Mondlane and Mapai were selected for implementation.

FIGURE 3

Vulnerability and its components (based on McCarthy *et al.* 2001)



Vulnerability to climate change in the context of rural agrarian livelihoods is influenced, firstly, by exposure to climatic (and non-climatic) hazards and the underlying sensitivity of the natural resources base to such hazards (Fig. 4). The combination of the two factors gives rise to the potential impact on natural and human systems (McCarthy et al. 2001; IPCC 2007). The ability to respond to these impacts determines how vulnerable individual communities are to climate change. Communities which are highly impacted and possess weak adaptive capacity are usually the most vulnerable. The baseline vulnerability studies (Hachileka 2009; Sacramento **et al**. 2010) took this approach, employing the CRiSTAL tool (www.cristaltool.org) through a livelihoods lens. Participatory methodologies were employed to gather information on community perceptions of exposure to climate hazards, sensitivity to such hazards, and current and possible future coping strategies. In this chapter, the climate impacts on natural resources in Chicualacualan communities, as determined by exposure and sensitivity, will be synthesized. In the following chapter, we will discuss the implications for livelihoods and vulnerability.

3.1 EXPOSURE TO CLIMATIC HAZARDS AND SENSITIVITY OF NATURAL RESOURCE BASE

Exposure includes climate variability within and between years, extreme climate events and long-term climate changes. Impacts on land-based economic activities and associated livelihoods are usually very significant, through direct effects on critical natural resources such as soil and water, and on the growth and economic value of crops and livestock. Over the study area, climate exposure is very difficult to assess scientifically, since the district's three meteorological stations have been inoperable since mid-1970. The communities ranked the main climatic hazards and recent changes as follows (Hachileka 2009; Sacramento *et al.* 2010).

1. Rainfall variability – this hazard was ranked highest by all interviewed communities. Over the previous five years, rainfall patterns have shifted (communities termed this "drought"), with more frequent dry spells and dry seasons, shortening of the rainy season (as shown in Fig. 5), and more unpredictable rainfall.
2. Extreme heat was rated the second most severe climate hazard – temperatures have increased significantly. Higher evaporation and transpiration rates in the growth season have led to more rapid loss of soil moisture soon after it has rained. Heat stress is also affecting labour.
3. Three upland communities rated strong winds as the third climatic hazard. These cause damage to infrastructure, crops and trees. They also contribute to high rates of soil moisture loss.

4. Two lowland communities included human disease pressure in their top three hazards. Common problems include respiratory ailments, eye diseases, diarrhoea and malaria.
5. Inhabitants of the flood plains of the Limpopo and Nuanetzi Rivers are also occasionally exposed to floods (essentially the severe 2000 flood is remembered well, but otherwise rare). This was not, however, a top three hazard in any community.

The hazards identified by the communities and their perceptions of variability and recent changes are broadly in line with scientific evidence for this part of the country (INGC 2009).

Sensitivity depends primarily on the main livelihood activities, the key livelihood resources, and the effect of climate hazards on these activities and resources. In this remote semi-arid region of Mozambique, livelihoods are based on crop and livestock farming, harvesting and processing of forest resources for own use and sale, and occasional labour opportunities.

The high reliance of the people of this district on natural resources warrants close attention to current and potential water resources and land use patterns in the face of climate stress. Most of the area is suited mainly to forest and pasture, with small areas of arable land of low productivity (Maposse *et al.* 2010). Along the river banks lie approximately 200-300 ha of land potentially suitable for irrigated crop production of which only a small proportion is currently prepared and equipped. Livestock production offers good opportunities in this agro-ecological zone. The edible and inedible products (notably charcoal) provided by woodlands and forests complete the picture of food and income generating natural resources, albeit under increasing pressure from exploitation. The natural resources base of the district will be highlighted below, with reference to climate change impacts.

3.2 WATER RESOURCES

The most pressing concern is access to water and water quality, and the district suffers from significant structural water shortages. The primary hydrological resource is the Limpopo River, including seasonal and permanent natural lakes (lagoons) formed in depressions close to the river, and a few smaller seasonal rivers which flow only immediately after heavy rains. The perennial Limpopo River is accessible to only a few lowland communities. Hand-dug wells of considerable depth (ca. 20 m) yield water only close to the river. Thus most of the settlements on the uplands rely exclusively on groundwater extracted using manual pumps from depths of ca. 80-120 m. The existing wheel-driven pumps are not suited to such depths, requiring two strong adults to operate;

women and children, who collect 95 percent of household water, experience great difficulty with this. There is insufficient water for households and public facilities, aggravated by poor water quality and limited water storage facilities. A significant number of households rely on their women and children to walk for an hour or longer to fetch water (Cumba *et al.* 2009).

Watering points for livestock are few and poorly distributed and only herds close to the Limpopo River or other surface water bodies are assured a constant supply. The depth of the water table makes drilling and pumping groundwater expensive and not suitable for crop irrigation in most locations. The lower Limpopo Basin experiences regular droughts and the flow of the river is variable both within and between years. This, coupled with extensive abstraction upstream in South Africa, often reduces flow to a trickle in this part of Mozambique at the end of the dry season. In recent years, which have been drier and hotter than usual, leading to rising rates of evapotranspiration, significant negative impacts on water resources have become evident, particularly in the upland areas. Reductions in crop production and grazing quantity and quality have negatively impacted on food availability and income potential.

Although initial hydrological projections for the Limpopo Basin do not currently indicate reductions in rainfall run-off and flow for the Basin as a whole (INGC 2009), further research on this question is required. In addition, economic development in the Basin based on increased abstraction of an already almost fully committed resource could lead to further reductions in flow when the river reaches Mozambique (Pegram *et al.* 2011). Adaptation options in the lower basin based on the Limpopo water resource would be severely constrained by such a scenario. This has been identified as a potential cause for conflict between the riparian states. The Limpopo Watercourse Commission (LIMCOM) was established in 2003 through a multilateral agreement between the four riparian states, with the purpose of fostering cooperation and the shared management of the Limpopo water resource. This platform will become increasingly important in guiding the equitable allocation of water as climate change and development increases demand by all four countries. Mozambique, as the downstream and least developed partner, is at most risk in this regard.

3.3 FARMLAND: SOIL RESOURCES AND CULTIVATION SYSTEMS

The soil potential ranges widely, and is generally moderately fertile, but requiring adequate moisture to support agricultural production (Maposse *et al.* 2010). The current agroclimatic condition does not support rainfed crop yields

to adequately feed the population. The sandy topsoil and lack of organic matter provides for little water holding capacity. Ploughing is done by animal traction using oxen or occasionally donkeys. Minimum or no till and maintenance of vegetative surface cover in crop fields are not practised and no fertilizers or manure are applied, although cattle are allowed to feed on crop residues. Limited intercropping with maize, legumes and non-legumes is practised but is not well planned, and the proportion of legumes in the fields is low. As a result, soils are often bare and exposed during the long dry season. Thus, soil structure and fertility are progressively reduced. Farmers then abandon the field and clear new lands. Whilst this practice of bush fallowing has generally been sustainable in the past, and fallow lands were rested for 15 years on average, the future will require shorter fallow periods, halting of deforestation for agriculture, and more attention to intensification of perennial croplands.

Climate change is expected to add urgency to the need for better maintenance of fertility and moisture holding capacity, to better support crop growth during times of stress. Under warming conditions, soil fertility loss rates could rise. Equally, high intensity rains cause erosion and leaching of nutrients in structurally poor soils, particularly under conventional agriculture where soils are disturbed (ploughed) and left exposed. Lack of water infiltration could lead to increased waterlogging of fields after heavy rainfall, disrupting farm operations and providing favourable conditions for pests and diseases. Practical and affordable methods of raising nutrient and carbon levels will be an important adaptation response. Both conservation agriculture and various forms of agroforestry, particularly incorporating nitrogen-fixing and fodder species, would answer to this need.

3.4 FARMLAND: FOOD CROPS

The main crops are maize (planted by all although it is not drought tolerant and gives poor yields, 0.5-0.8 t/ha), and the more drought-tolerant sorghum, pearl millet, groundnut, beans, watermelons and pumpkin, and cassava to a smaller degree. These are grown in both the upland and lowland plots. Watermelons are an important food and cash crop for the "hungry" months of February to April. In the lowland plots where residual soil moisture and irrigation are available, a large variety of other vegetable crops are grown. Maize is the preferred staple crop, since the more drought tolerant sorghum and pearl millet are prone to bird damage, and millet is tedious to process. For use in the next season, seeds of the various crops are not selected; all the harvest is placed in the same grain store where a high degree of spoilage is common. Cashew (Anacardium occidentale)

trees have been planted on a small scale but other cultivated fruit trees are scarce (although tree nurseries have in the past supplied) and fruits are used mostly for own consumption. The diversity of crops grown is moderate to high, with upland farmers (rainfed) generally growing about 10 crops, and lowland farmers (with access to irrigation) growing about 20 crops.

Pests and diseases pose severe problems, and include rodents, birds, insects and wild mammals, as well as viral and bacterial diseases e.g. mosaic virus on cassava. Trampling by livestock on planted crops in unfenced lands causes significant destruction. Except for attempts to keep livestock and birds out, few control measures are employed.

Farmers do not usually sell food crops as there is rarely a marketable excess, and transport to market is difficult for most villages. The harvests only provide food for the families for a few months. Some small-scale preservation and processing of maize, cassava and nutritious vegetables leaves are practised. Small-scale irrigation farmers more often have some produce to sell in nearby markets of Mapai and Eduardo Mondlane (the district administrative centre), and rarely distant towns such as Chókwè. For the remainder of the year, the inhabitants purchase food to make up the short-fall, as well as eat, drink, process and sell a wide range of produce from non-cultivated plants, many of them natural indigenous tree species.

Rainfed crop production is significantly at risk under climate change (Kurukulasuriya and Mendelsohn 2008), and particularly maize which is sensitive to the timing and duration of dry spells. A recent modelling study (Lobell *et al.* 2008) found that in southern Africa, maize and wheat show consistently negative impacts of climate change. However in semi-arid regions such as Chicualacuala, even the more drought-resistant rainfed crops will suffer yield losses under the projected climate changes. Additionally, heavy rains causing waterlogging and flooding may also increasingly impact on production. Increasing yield variability and risk of crop failure will worsen food insecurity, with multiple knock-on effects for households.

3.5 PASTURES: LIVESTOCK

Traditionally, cattle are the preferred livestock species and are well suited to the area, particularly the hardy and disease-resistant indigenous breeds such as "Landim" and "Nguni". There are currently (2010 census) about 30 000 head of cattle (multipurpose) in the district, 21 300 goats, 10 100 sheep, as well as pigs, donkeys and chickens. The majority of households own some animals. No planned rangeland management strategies or practices exist and animals

are generally herded by young boys on communal rangelands. Forage biomass and quality is highly seasonal, becoming ever scarcer and less nutritious as the dry season progresses (Maposse *et al.* 2010). Browse and crop residues are also important sources of nutrition. Based on an average rangeland carrying capacity of about 20 hectares per head of cattle, there is good scope for increased stocking rates in many areas and a strengthening of this economic activity. Given sufficient watering points and improved grazing and herd management, it is estimated that cattle numbers could probably be doubled.

The limiting factor for livestock is the inadequate number and poor distribution of watering points and reduced water availability in the dry season. The lack of economically and ecologically optimal pasture management practices and poor access to basic veterinary services other than the annual mandatory cattle vaccination campaign against blackleg/anthrax/foot-and-mouth disease are also limiting. Localized overgrazing exists around current watering points, exacerbated by the recent droughts. No supplementary feeding of animals is practised and suitable technologies are unknown or not deemed feasible due to labour constraints.

Income from livestock and meat is an important source of cash, with goats, sheep and chickens sold locally, but few households eat meat except for the occasional chicken. The majority of cattle marketed in Eduardo Mondlane are transported live by truck or train for resale in Maputo. Low numbers of cattle are slaughtered in Eduardo Mondlane and Mapai under appalling, inhumane and unhygienic conditions, and sold to buyers coming from Maputo by train. There is some milk production and consumption/sale but at very low yields and volumes. Other potential livestock products such as hides are not processed, and waste (from slaughter and manure) is not used productively. Some farmers who own plough oxen hire them out to those who do not, thus earning a valuable additional income.

Climate-related risks to livestock production are primarily related to the impacts of droughts on rangeland condition, grass nutritional value, and water resources. Poor animal conditions increase disease risk, and some diseases (e.g. tick-borne) could become more virulent under the changing temperature and rainfall conditions. Draught animals suffering from malnourishment are not strong enough for ploughing, resulting in poor soil preparation and reduced food production. A lack of stock management during droughts exacerbates the impacts on rangeland condition and impedes rangeland recovery. Although the indigenous breeds of livestock are generally hardy to the prevailing high temperatures, they will also suffer reduced growth rates and loss of reproductive

vigour (reduced calving frequency and weaker calves) under stressful climatic conditions, including excessive heat. Nevertheless, livestock-based livelihoods are less vulnerable compared to crop-based livelihoods in the semi-arid regions of Africa, and a gradual conversion from rainfed crops to livestock could be seen as a good adaptation strategy (Jones and Thornton 2009).

3.6 FORESTS

Chicualacuala is richly endowed with forests, including closed and open deciduous or evergreen forests and riparian forests. The forests currently comprise about 62 percent of the district surface area (IUCN 2010) but are being reduced at an alarming rate due to unsustainable charcoal production (see below). Communities have an in-depth knowledge of the food and non-food resources provided by the forests and use these to supplement their diet and income. Forests are also good sources of fodder and forage for livestock during the dry season. Valuable tree species are commonly spared when land is cleared for agriculture, since they provide shade for crops and livestock, wild fruit, forage, firewood, and improvement of soils. This indigenous form of agroforestry typically values fruit-bearing species such as *Sclerocarya birrea* (marula), *Strychnos madagascarienses* (macuacua, or black spiny monkey orange), *Strychnos spinosa* (massala, or monkey orange), amongst others. These trees are not propagated, cultivated or otherwise managed (Maposse *et al.* 2010), mainly because water for seedlings is scarce.

Forests also provide firewood which almost all households depend on for their energy needs, and construction materials such as wood (poles), rope and grass for thatching. Some of these products are sold to those who cannot harvest their own. Bush meat is occasionally consumed and sold, particularly in times of hunger.

Although the local communities enjoy communal "ownership" of their forests, more formal surveys (delineation of forests), inventories of forest resources, or community-based forest management plans have not existed until recently. Traditionally, access to, and use of, forest products is regulated through community leadership structures, and concessions are also granted in the provincial capital, but only partial control is currently achieved by these means.

The most pressing problem is that of uncontrolled and often illegal charcoal production, with large numbers of local and non-local people involved and benefiting from the huge and lucrative market for charcoal in Maputo and other urban centres. The forests of Chicualacuala have during the 15-year period 1995 to 2010 lost 790 km^2 in area, representing a reduction of land cover from

67 percent to 62 percent. Most of this area was converted to agricultural land, much of it around the town of Mapai. Ecosystem degradation is directly related to areas of increasing population density, and areas around transport corridors (main road and railway).

Now the forests of Chicualacuala face the additional pressure of climate change. Hotter and drier conditions will gradually reduce regeneration and growth rates, causing losses in productivity, although carbon dioxide fertilization could mitigate this to some extent. Some wild fruits tend to desiccate under conditions of drought and heat. The risk of more intense and more frequent wildfires in forests and rangelands will also increase (INGC 2009). A national campaign to reduce wildfires is showing some success, with communities in Chicualacuala taking measure

CHAPTER 4

CLIMATE IMPACT ON LIVELIHOODS, COPING STRATEGIES AND ADAPTIVE CAPACITY

The high potential impact of climate change on the natural resources base of Chicualacuala, as discussed in the previous chapter, will not be easily dealt with by the inhabitants, rendering them highly vulnerable. Vulnerability to climate change is "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC 2007). Whilst people and communities currently possess a suite of coping skills and options suited to local conditions, climate change will present new conditions where normal coping mechanisms are either insufficient or inappropriate, or the climate stressor surpasses the efficacy of known coping mechanisms. We therefore also need to assess communities' abilities and access to resources to develop improved or new options which will confer resilience (termed adaptive capacity). This chapter will address both current coping strategies and underlying adaptive capacity of the Chicualacuala communities.

4.1 COMMUNITY LEVEL COPING STRATEGIES

Populations making a living in arid or semi-arid environments have evolved a wide range of coping strategies to deal with high levels of climatic variability and risk, and shocks such as floods, severe droughts, and diseases. Management of the natural resources base such as water, pasture and forests, and household practices must be adjusted in stressful times. Usually a combination of responses to the impacts of climate hazards is employed.

The baseline climate vulnerability study for Chicualacuala (Hachileka 2009; Sacramento 2010), including an analysis of current coping strategies, was undertaken using the CRiSTAL tool (www.cristaltool.org) and Climate

Vulnerability and Capacity Analysis (CVCA, www.careclimatechange.org/cvca). Many of the current coping strategies relate to rainfall variability and drought, since this is the most important climatic hazard. When lack of rain causes crop failure, people search for and consume wild tubers and fruit, they sell fuelwood/charcoal, livestock and alcoholic drinks for cash, they turn to small business for an alternative income, and they go to greater lengths to secure water for themselves and their livestock. Sometimes, manure is spread on fields to retain soil moisture. During extreme heat, people use fresh grazing areas and fields, adjust their daily routines to avoid the worst heat around midday, make better use of shade for people and livestock, ensure sufficient access to drinking water, and reduce the risk of wildfire. In serious cases of climate stress, some farmers turn to small business, or seek employment in towns.

It should be noted that although not identified by informants in the vulnerability survey, households that live close to the Limpopo River often own two agricultural fields, one in the uplands and one in the lowlands close to the river. This can also be regarded as a coping strategy to balance the risks of drought and flood (Cumba *et al.* 2009). However, the majority of households who live in the uplands do not have this option, although they usually own more than one field. From a food security point of view, coping mechanisms also include reducing the number of daily meals, eating less expensive or desirable food, and serving smaller portions (Cumba *et al.* 2009).

An additional shock experienced by communities which has an indirect link to climate stress is rising food prices. The major weakness preventing the effective implementation of coping strategies is the lack of financial resources. This arises from the conundrum that the major sources of income (crop and livestock sales) are themselves adversely impacted by climate change (Sacramento *et al.* 2010). Additional support in the form of new or more effective technologies, and technical and institutional support are required.

Some of the key coping strategies, notably the production of charcoal, are leading to rapid ecosystem degradation and loss of goods and services from the natural resources on which this community depends. Charcoal is an effective coping mechanism only in the short term, increasing at times when crops fail and livestock production decreases, thus providing a safety net. Nevertheless, deforestation is simultaneously a contributor, an amplifier and a consequence of changing weather patterns (Sacramento *et al.* 2010). The intensification of charcoal production started in 2003, and was initially encouraged by local government as a measure to reduce food insecurity. This activity increased sharply during the following dry years, as people turned to the forests as a ready

source of income to survive crop and livestock losses and reduced production levels. Proximity to access and transport routes, especially the train stations and the main road to Chokwé and Maputo, coupled with rising demand and prices in the urban centres, are additional driving forces for this acceleration. There is a growing awareness of the problem but seeming lack of alternatives or lack of will on the part of the authorities to control this situation. With climate change, continued forest loss and land degradation will progressively weaken adaptive capacity, leading to a vicious cycle of worsening impacts, loss of livelihood options (for example, harvesting of forest fruits and honey) and increasing poverty, and continued unsustainable forest exploitation.

Although small initiatives exist to incentivise tree planting (e.g. a school tree planting programme) and some nurseries were previously established, tree planting is not a common activity, and very few communities consulted during the baseline studies identified it as a potential climate change adaptation strategy (Sacramento *et al.* 2010). The main reason appears to be a reluctance to invest time and labour in an activity which will not bring them any benefits for at least three to four decades.

Together with exploitation of forest resources, livestock keeping is an important component of coping strategies under drought conditions in all the rural communities of Chicualacuala (FAO 2009a). Although there is great potential to strengthen the livestock industry, this is only sustainable under conditions of climate change with the concomitant development of infrastructure (e.g. watering points to allow for rotational grazing, slaughterhouse), livestock health services, and sustainable rangeland management practices. In the absence of such development, increasing animal numbers as an adaptation could lead to longer term environmental degradation and erosion of productive natural capital.

4.2 ADAPTIVE CAPACITY

The Government of Mozambique (led by MICOA)/FAO adaptation intervention (refer to Chapter 6) is one of the major elements specifically aimed at strengthening adaptive capacity at community level.

Adaptive actions occur across wide-ranging social scales, from the individual/household and community levels to district, provincial and national levels, and beyond. They relate to risk perception and management, and are informed by complex interrelationships between physical (e.g. technology and infrastructure, natural resources which support adaptation), financial, human (e.g. health, education/skills) and social (e.g. cohesion/exclusion, institutions) factors - often termed "capital". Social and economic inequality and poverty are important

underlying drivers of low adaptive capacity, as are poor governance and weak institutions.

With regard to risk perception and management, crop and livelihood diversification is already an integral part of the coping strategies of the rural farming population of the Chicualacuala District. It could be said that the obstinacy with which the farmers plant maize year after year, despite the very poor yield and high risk of failure of this crop, is balanced by the farming of a fairly wide range of other crops most of which are more drought- and heat-tolerant than maize. This offers some protection against farming risk, including climate-related risk, and a lower likelihood of suffering complete crop loss. This practice also raises dietary diversity and counteracts malnutrition (Republic of Mozambique 2010). Similar arguments can be put forward in favour of mixed farming (crops and livestock), which provides resilience during a crisis since livestock can be sold for cash to buy food when crops have not produced well or failed. Most of the farmers of Chicualacuala own at least a few cattle and/or small stock, and chickens. Those who do not own livestock or own only very few animals are more sensitive to climate shocks and are more likely to turn to forests for their "safety net".

Access to land and productive assets is an important determinant of adaptive capacity. In the Chicualacuala District all families have access to land in one form or the other. However, the average size of agricultural fields per family is small: in the lowlands 69 percent of families have less than or equal to 2 ha; in the uplands this figure is 81 percent (Cumba *et al.* 2009). The households do, generally, own a number of productive assets (e.g. farm implements), and 77 percent have five or more assets, and almost all households own at least one productive asset (Cumba *et al.* 2009).

Furthermore, vulnerability is also influenced by adaptive capacity based on various types of resources at hand ("capital") including financial, infrastructure, social and human capital.

The main financial resources on which the communities of the Chicualacuala District depend are generated through the sale of crops, sale of livestock and sale of forest products including charcoal, fruits and firewood. Importantly, these sources of finance are directly negatively influenced by drought and other climatic hazards since they depend on climate-sensitive natural resources such as water, rangeland, farmland and forests. Climate variability and climate change could place increasing pressure on crop yields and pasture resources and may lead to increased grain prices and decreased livestock prices in times of drought, resulting in reduced household income and increased poverty. Diversification

of financial resources and income generating activities is central to adapting to changing conditions. The GoM has an established Local Initiative Fund which assists rural communities in financing small enterprises. With the exception of Ndombe village, the studied communities in Chicualacuala are not satisfied with this mechanism and have seen little benefit emanating from it – primarily due to the difficulties encountered in accessing this fund.

The District is serviced by a main unsurfaced road and the Limpopo corridor railway line from Maputo to the border with Zimbabwe. These are important for access to markets for the community as cattle are slaughtered and meat and forest products sold to business people who come by train. Poor road infrastructure into the interior may reduce market access for communities living away from the main road and railway, thereby limiting their capacity to rapidly sell their livestock when a drought starts or buy food when their livestock or crop production fall short. For instance, the Mahatlane community has to travel about 60 km to the nearest market in Chicualacuala town.

Other physical resources owned by the communities in the Chicualacuala District are draft oxen and farming implements such as ploughs, hoes and wheelbarrows. Those who own such goods are in a better position than those who do not, with the latter having to rent these goods from the former. Wells and boreholes also constitute physical infrastructure – differential access to such infrastructure benefits some above others, with the former sometimes converting this advantage into a business opportunity. Individual and households who are disadvantaged in respect of access to infrastructure are likely to be more severely impacted by climate change impacts which will elevate the value of these resources.

The main human resources mentioned by the communities as important for their livelihoods are health, education, farming skills and extension services (farm and veterinary). The reduced availability of food brought about by climate-related crises and rising temperatures leads to impaired nutrition and reduced human disease resistance. This, together with health problems ascribed to high temperatures, inadequate access to safe drinking water and poor sanitation, all exacerbated by the impact of HIV/AIDS, impacts on people's ability to farm, tend livestock, and perform other essential activities. During the 2000 floods, a cholera epidemic ravaged the affected regions, including Chicualacuala. The majority of the communities have only a first aid officer and access to a rudimentary health post, who cannot respond to the many health problems faced by the communities. With increasing hazards such as droughts and extreme heat, improved farming and livestock management skills and extension support,

including small-scale irrigation and basic livestock health strategies, will become increasingly important for adapting to climate change impacts.

Social capital for adaptation includes manifestations of social cohesion, such as the family unit, and the establishment and functional level of community associations, including farmers' associations and churches. Where these are strong, it is likely that households and villages are able to collectively support one another in times of stress. A particular form of social stress in Chicualacuala is the high proportion of working-age males who migrate in search of alternative employment, often only returning after extended periods, or not at all. While the remittances that are sent home are undoubtedly of critical value to their families and serve to keep the lid on rampant food insecurity, other emotional and social stresses are introduced by this practice (for both men, women and children). Climate change may lead to increasing levels of, and reliance on, migration.

Traditional resource management systems are important as most of the natural resources are communally held, with the head of household (family basis) and the community leaders (village basis) having control over the use of these resources for the benefit of all. All forms of leadership, including traditional leaders, leadership of farmers' associations, and of churches, will require capacity building as the increasing scarcity of natural resources and access to productive lands may soon lead to conflicts between community members.

The active presence of Non-Governmental Organizations (NGOs) and Civil Society Organizations (CSOs) can increase adaptive capacity, since they assist the community in the provision of social services. There are very few NGOs and CSOs operating in the areas of agriculture, livestock management and water supply in Chicualacuala, with those that are present working mainly in the fields of child health and nutrition and HIV/AIDS.

4.3 GENDER AND ADAPTIVE CAPACITY

Across Africa and indeed worldwide, the recognition that men and women experience differential vulnerabilities, and what this means for effective climate change adaptation interventions, has gained momentum (FAO 2009b; UNDP 2009; World Bank FAO and IFAD 2009). There is a growing recognition that women may be more susceptible to climate impacts than men for various reasons (Petrie 2010). They are responsible for 80 percent of food production in sub-Saharan Africa and are responsible for household food security (while men are responsible for livestock and cash crop farming) (Brody *et al.* 2008). Yet, in most parts of the region, statutory/customary laws restrict women's access to property (lack of property and land rights), and they usually lack access to

finance, agricultural extension services and technologies. Nonetheless, women are already adapting, including adapting their farming practices (Babugura 2010; Ribeiro and Chaúque 2010). Empowering female farmers to engage in more modern efficient and high yielding agricultural production would free up valuable time and produce a cash income which could be used towards other family priorities. Experience has shown that women are central to permanently improving the lives of their families and communities, and therefore must play a pivotal role in community-based adaptation initiatives.

Despite efforts to address this, women in Mozambique typically have less access to, and control over, these resources than men, and they rarely have an equal say in decision-making at household, community or national levels. It is, thus, likely that women have lower adaptive capacities to climate change. Studies done by the Heinrich Böll Foundation in the Mapai region (Ribeiro and Chaúque 2010) reveal that women and men are differentially impacted by climate changes due to the current power relations and their differentiated roles in these communities (Table 1). Women have access to, but not control over, natural resources and other property rights. Additionally, women do most of the reproductive and part of the productive work, while men are only responsible for productive work.

Migration is one of the major coping strategies to climate related hazards in the five communities studied in the Chicualacuala District (Ribeiro and Chaúque 2010). A high proportion of working-age men migrate to either South Africa or larger cities in Mozambique such as Chokwé, Maputo and Xai-Xai, leaving women in charge of the household for long periods of time. Migration has revised the gendered scenery of division of labour in the communities. It was noted that about 50 percent or more of the interviewed families are female-headed households at least for part of the year (sometimes the men come back home only once a year). In female-headed households, the day-to-day decisions have to be made by women. However, major decisions such as finding a new place to live, or new lands to cultivate, are made by men. Nevertheless, the National Women's Organization (OMM) has recently gained a better position in the decision-making structures of the villages, especially in Mapai and Eduardo Mondlane.

Women tend to require more time to recover from economic losses brought about by shocks, and gender barriers make the task of reconstruction more difficult (INGC 2009). Their work load is increased, exacerbated by the absence of men. They also have to deal with the emotional and social repercussions emanating from death, disease and scarcity of water and food during and after

disasters. With a view to coping and adaptation to climate change, women need to become more involved in the management of natural resources and decision-making around farming, selling and use of income.

Table 1

Activities, differential roles of women and men, and access to and control of resources in the Chicualacuala District. Abridged from Sacramento *et al.* (2010), based on Ribeiro and Chaúque (2010).

Activity	Men's role	Women's role	Access and control
Crop production and selling: subsistence agriculture using basic techniques such as slash and burn, small axe and plough.	Men usually participate in all activities; sometimes they only help women to plough and harvest.	Women are in charge of agricultural activities and are helped by children and men.	Both men and women have access to land for cultivation. However, men have control over land - they decide where to cultivate and what to do with the excess production. A woman only controls land if she is the chief or if there are no men in the family or community.
Livestock production and selling: this increases under drought conditions when crop farming fails.	Men are exclusively in charge of this activity. They (often boys) take the herds to the rangelands and to the drinking points in the morning and bring them back in the afternoon.	Women have no role in this activity.	Men have complete access to and control over this activity. Due to the fact that cattle are an expression of wealth, men are in charge of all activities and the inheritance process is from father to sons only. For cultural reasons there is resistance to selling of cattle.

Activity	Men's role	Women's role	Access and control
Small business: this activity has increased significantly in the last few years as a result of decreasing incomes from crop production. It is done both within and outside the community, and is often funded by the Government's local development fund for small businesses. Trading includes manufactured products, traditional alcoholic drinks, farm products and small livestock.	Men travel to the main village (Mapai and Eduardo Mondlane) to buy products that they sell in the community. This is usually done on the two days when the passenger train arrives from Maputo.	Women are in charge of selling farm products but due to reductions in productivity this source of income is dwindling. They have turned to the commercialization of traditional alcoholic drinks, which is quite profitable.	Both men and women have access to this activity, but men control the activities and the profits. Since many of the households are female-headed for extended periods while men work elsewhere, women have started to take more control over this activity.
Migration: this activity has increased drastically in the last years due to the loss of agricultural productivity.	Only men migrate to South Africa or cities in Mozambique, like Xai-Xai and Maputo, to search for jobs or other sources of income.	No role in this activity.	Only men have access and control over this activity. They decide when and where to go and also when to return. Some just disappear. The use of the profits is decided by men, but when they are abroad women control the use of remittances.
Charcoal: production of charcoal has recently become a major source of income but at the current levels of forest degradation it is not sustainable.	Men are exclusively in charge of this activity (production and selling).	No role in this activity, but sometimes women help with selling close to the villages and in the local markets.	Only men have access and control over this activity. They decide where to produce, which species to use and where to sell.

Activity	Men's role	Women's role	Access and control
Fuelwood, water and wild fruits and tubers: fuelwood is the main source of energy in the communities, while fruits have gained in importance recently due to low crop production, and are an integral part of coping under conditions of drought and hunger.	No role in this activity, in some cases young boys help their mothers to collect.	Women are exclusively in charge of this activity.	Women have access and control over this activity. They usually harvest close to the houses but according to most of them the distances travelled in search of these resources are increasing due the rising demand.

CHAPTER 5

THE CASE FOR CLIMATE CHANGE ADAPTATION IN THE DEVELOPMENT CONTEXT

The overall impact of climate change on agrarian livelihoods is a complex outcome of multiple stress and vulnerability. The population of the semi-arid Gaza Province of Mozambique is highly exposed to climate variability and increases in variability brought about by climate change. They are also highly sensitive to this situation, owing to their high reliance on rainfed agriculture in a harsh climate and serious structural water deficits. Although there exists some adaptive capacity, coping strategies are reliant on climate-sensitive natural resources which are rapidly degrading, and people have recourse to very few alternative livelihoods. Thus, vulnerability is very high, and the impacts of climate change are expected to be severe and support for adaptation essential.

In Mozambique, and similar developing countries, the potential impacts of climate change on agriculture and rural livelihoods can be ameliorated through climate compatible development (CDKN 2010). Adaptation should be integrated into national and local development goals and plans, guided by the baseline condition and particular needs and abilities of the local population. The close links between poverty and vulnerability to climate risk and climate change in Mozambique are widely acknowledged, highlighted by the devastating impact of droughts (e.g. 1982/83) experienced in the south during the civil war when coping capacity and relief responses were severely weakened.

The GoM development priorities (as articulated in its key policy documents) emphasise the need to reduce the impacts of climate disasters on people and infrastructure, and to promote a culture of risk reduction and prevention, whilst also achieving economic and social development, employment, food security and sustainable use of natural resources. To this end, Mozambique (as an LDC) submitted its National Adaptation Programme of Action (NAPA) on climate

change under the UNFCCC (MICOA 2007). The NAPA identifies urgent and immediate needs with regard to climate change impacts and adaptation priorities. The most vulnerable regions, sectors and communities to the adverse effects of climate change (floods, droughts and tropical cyclones) and to poverty were consulted and prioritized.

The NAPA identifies four proposed adaptation initiatives aimed at reducing vulnerability to extreme climatic events. They are:

1. Strengthening of an Early Warning System
2. Strengthening capacities of agricultural producers to cope with climate change
3. Reduction of climate change impacts in coastal zones
4. Management of water resources under climate change.

The area of disaster preparedness and management has been prioritized in the near term, and since the shock of the 2000 floods Mozambique has made significant progress and is now better able to anticipate the occurrence of most natural disasters and take action to reduce their impact on the country. The INGC was established in 1999 with a clear mandate for coordinating disaster management (prevention, mitigation and response) for the country as a whole, and for specific areas of particularly high risk, such as the arid and semi-arid areas. Priority interventions in the area of food security and nutrition are guided by the SETSAN baseline (SETSAN 2006) followed up by biannual vulnerability assessments (2008, 2010).

Within the context of semi-arid southern Mozambique, and the communities of the Gaza Province and specifically the Chicualacuala District, the second and fourth priority adaptation areas identified in the NAPA are clearly of utmost importance. Despite this recognition, very little has so far been done or planned to help this region and its people. There is an urgent need to mobilize funding and devise adaptation support programmes in order to deliver meaningful progress on the objectives encapsulated in the NAPA, within the broader national development agenda.

CHAPTER 6

THE "JOINT PROGRAMME" AND THE GOVERNMENT OF MOZAMBIQUE / FAO ADAPTATION INTERVENTION

6.1 JOINT PROGRAMME ON ENVIRONMENTAL MAINSTREAMING AND ADAPTATION TO CLIMATE CHANGE IN MOZAMBIQUE

Given the considerable vulnerability outlined above and in line with Mozambique's endeavours to achieve economic and social development under conditions of high climate-related risks, the Spanish funded Millennium Development Goals Achievement Fund (MDG F) is providing financial support (total of US$7 million) for a Joint Programme on Environmental Mainstreaming and Adaptation to Climate Change (the JP henceforth). The JP aims to achieve five significant outputs through the implementation of specific activities targeted at decreasing poverty by reducing pressure on natural resources which are at risk of climatic hazards, and promoting their sustainable use. The focus is on one of the most high risk regions of Mozambique, namely the Limpopo River Basin and specifically the District of Chicualacuala in the Gaza Province. This District was chosen at the recommendation of the GoM, based on the fact that Chicualacuala was at the start of the programme not benefiting from any other development interventions and very few NGOs and CSOs were active there. It should, however, be noted that many aspects of the first component of the JP, notably risk mapping, training and strengthening capacity, and contributions towards policy development, are targeted at larger areas of the Gaza Province. The programme period is 2008-2011. A one year, no-cost extension has been approved by the MDG F.

On behalf of the GoM, MICOA is the main coordinating ministry and works closely with FAO, the lead agency of the UN partners in this JP. The JP is fully aligned to the NAPA. The NAPA has four priority options (refer above) of which the second, in particular (strengthening capacities of agricultural producers to cope with climate change), and to some degree the fourth (management of water resources under climate change) are addressed through two primary approaches (UN Joint Programme 2008):

1. The mainstreaming of environmental and climate change concerns into existing government policies and planning, through substantive capacity building for stakeholders at various levels (provincial, district, community). This involves sensitization and empowerment of government, civil society, communities and other stakeholders on environmental and climate change issues, strengthening government capacity to implement environmental and climate change policies, and ensuring that development plans at all levels are climate proofed.
2. The implementation of activities on the ground that specifically provide selected communities in the district with the necessary tools to become more resilient to the impact of climate change and extreme weather events, and to adopt alternative sustainable and reduced risk livelihood options as sources of income generation. This includes enhancement of existing climate-related coping strategies, and the dissemination of technical knowledge and implementation of technologies in the areas of water resources management, agriculture (crops and livestock), agroforestry, forest resource management, and some alternative income-generating technologies.

This programme was jointly conceptualized by MICOA and the UN and is implemented by the United Nations in Mozambique, working closely with GoM partners, under the umbrella of the UN Development Assistance Framework (UNDAF) for Mozambique and the "Delivering as One UN" Initiative. The government partners are the Ministry for Coordination of Environmental Affairs (MICOA – coordination and lead ministry counterpart to FAO), Ministry of Agriculture (MINAG), National Disaster Management Institute (INGC), National Meteorology Institute (INAM), and the Governments of the Gaza Province and Chicualacuala District. The six participating UN agencies are the Food and Agriculture Organization (FAO – coordinating and lead agency), United Nations Environment Programme (UNEP), United Nations Human Settlements Programme (UN-HABITAT), United Nations Industrial Development Organization (UNIDO), United Nations Development

Programme (UNDP), and World Food Programme (WFP). The Programme Management Committee includes members of each UN agency and its national government counterparts, plus the district and provincial authorities. Other implementing partners have been co-opted for specific aspects of delivery, including the Ministries of Energy (for support on renewable energy initiatives), Public Works, and Planning and Rural Development, the National Small Farmers' Union (UNAC), the Agricultural Research Institute of Mozambique (IIAM), the International Union for Conservation of Nature (IUCN), and the Social Communication Institute of Mozambique (ICS). Civil society partners and local associations and community leaders were also consulted during programme design and are involved in implementation.

Much has been achieved for the first component of the JP (Environmental Mainstreaming), including the incorporation of climate change issues into national and provincial/district plans. At the district level UNDP and UNEP, working with provincial and district planning teams, succeeded in mainstreaming climate change into the Chicualacuala District Strategic Development Plan (PEDD), using the vulnerability assessment study based on the CRiSTAL tool. Also at district level, UN-HABITAT, with the District Government and MICOA (DPCA-G and DINAPOT) support, produced a District Land Use Plan which contains a section on the effect of climate on resource use. At the national level, support provided by WFP has led to the inclusion of climate change in the the National Strategy for Food Security and Nutrition, (ESAN II) and the yearly contingency plans of the INGC. Other activities have included the production of district level climate risk maps (WFP, INGC), and activities which, based on the experience gained in Chicualacuala have been replicated in other districts on the Limpopo River Basin. Additionally, the JP has produced advocacy materials, provided training programmes on climate change and disasters for various stakeholder groups, promoted knowledge sharing (field days and community exchange visits), and contributed significantly to the improvement of national and local disaster preparedness plans and associated early warning systems. Information on these activities can be found elsewhere in the JP programme documentation.

The vulnerability assessment undertaken for environmental mainstreaming also has synergy with the second component of the Programme (Adaptation to Climate Change) which is the focus of this report. In particular, a concerted effort is made here to analyse and draw the lessons learned on those activities for which the FAO is the lead agency and partner, but always working in collaboration with MICOA and other government partners at all levels.

6.2 ADAPTATION TO CLIMATE CHANGE: JOINT FAO INTERVENTIONS

The adaptation to climate change component, coordinated by MICOA and largely implemented by FAO, has two overarching outcomes: enhancing resilience to climate change, and diversifying livelihood options. This intervention was implemented in one of the more remote districts (Chicualacuala), which suffers from poor infrastructure, a small and widely dispersed population, and high vulnerability to climate shocks. As a result, it is difficult to attract development partners and agencies and national development experts to work in this area.

The climate change projections outlined in Chapter 1 indicate that adaptation interventions in this district must be guided not only by the direction and magnitude of expected changes in temperature and rainfall, but also by consideration of seasonality and the overall agricultural context. It is of great concern for an agrarian-based region that the spring season (September to November) is projected to experience the strongest warming, just before the start of the rainy season, particularly in the Limpopo River valley. The scenario for rainfed farming is thus one of rapid soil moisture loss during spring, at a time when farmers conventionally prepare their lands for planting, and start planting some crops in anticipation of the first rains. It is also the time when rangelands are at a low with respect to quantity and quality of grazing, and the risk of wildfire is high. However, if future projections of an earlier start to the rainy season are robust, the impacts could be mitigated. In this part of southern Mozambique, the rainy season is projected to end earlier; the result would be a shorter rainfall season (INGC 2009), with implications for crop cycles (crops not reaching maturity) and rangeland productivity.

During the later parts of the growth season, towards the end of summer, heavier rainfall is projected, which can lead to flooding, crop inundation and pest and disease outbreaks. Harvest activities would be impaired, with a heightened risk of spoilage. Other important adaptation objectives should include dealing with increased risk of drought, and increased rainfall variability. Overall, interventions should address the need to conserve soil moisture or add moisture (irrigation), but with sufficient drainage to cope with periodic heavy rainfall. Agronomic practices will be required which ensure harvesting throughout the year, and diversification of livelihoods.

The JP is working actively in nine communities in both upland and lowland areas of the district which require differential adaptation approaches (Andrew Mattick, per. comm.). The rainfed upland areas are severely limited by lack of water, and interventions concentrate on support to low-risk,

subsistence activities: improving household food security through agroforestry and conservation agriculture, promoting better community management of forest resources, opening boreholes to deliver water for people and livestock, livestock health management and husbandry. The lowland areas, by virtue of access to water for irrigation, can produce surplus crops for sale, processing, and residues given to livestock. Both crop and livestock-based production needs to be strengthened and profitable but sustainable alternative options found so that people can reduce their dependency on charcoal production as a source of income. Livelihoods diversification is central to dealing with risk and building climate resilience, including the preservation of forest ecosystem services for generations to come.

All interventions are accompanied by an appropriate training programme and distribution of information materials amongst beneficiaries and other stakeholders. These serve to raise awareness and form part of an overarching dissemination and communications strategy. It is also important that there is good cooperation between the JP and district counterparts, particularly the Department for Economic Activities (SDAE) which is responsible for agriculture, livestock and forestry. Table 2 provides a summary of the primary interventions involving the FAO, UN and national institutional partners; the relevant government partners are involved throughout.

Table 2

Summary of climate change adaptation interventions being implemented in the Chicualacuala District jointly by the Government of Mozambique, FAO and UN partners agencies.

Subsector	Activity	Location / target	Implementing partner(s)
Water supply from aquifers	Multipurpose integrated water supply systems (solar pumps) for drinking water (people and livestock) and crop irrigation	9 sites/villages	UN-HABITAT, UNIDO, FAO
Crop production	Small-scale irrigation schemes improved and extended	Madulo, Ndombe, Mapuvule, Chissapa	DPA, SDAE, FAO

Subsector	Activity	Location / target	Implementing partner(s)
	Conservation agriculture introduced	4 communities	IIAM, SDAE,FAO,
	Animal traction for land preparation and transport promoted (training)	Madulo, Hoch Ribué, Mahatlane	DPA (SPP), SDAE (SDP) FAO
Livestock production	Livestock treatment corridors established	9 sites/villages	DPA (SPP) FAO
	Agroveterinary shop established	Eduardo Mondlane town	DPA (SPP), Govt. Dist., FAO
	Grazing management and animal husbandry improved	All communities	IIAM, FAO
Forest management	Community-based natural forest management (CBNFM) established	3 communities	SPFFB, SDAE, FAO
Agroforestry	Agroforestry practices introduced	Madulo, Ndombe, Mahatlane (tree nurseries); 7 communities benefiting	SPFFB, SDAE, FAO, UNDP, IIAM
Diversification	Integrated fish/ small animal farming introduced	Ndombe, Mapuvule, Chissapa (all lowland)	SDAE, UNEP, FAO
	Beekeeping introduced	3 communities	SDAE, FAO
Agroprocessing	Agroprocessing and marketing activities developed	4 communities	SDAE, FAO
	New slaughterhouse built	Mapai town	DNSV, DPA (SPP), FAO, UNIDO

Subsector	Activity	Location / target	Implementing partner(s)
Field-based adaptive research and training	CERUM established (multiple use resource centre)	Eduardo Mondlane town	INGC, UN-HABITAT, FAO, UNIDO
Meteorological data and communications	New automated meteorological station installed	Eduardo Mondlane town	INAM, FAO, UNEP, UNDP
Communication*	Radio communications radius extended (new radio tower)	Eduardo Mondlane town	UNDP, ICS, INAM, UNIDO
*Renewable energy sources – biogas	Biogas generation and composting using animal waste	Mepuza (village) and Mapai (slaughterhouse)	ME, UNIDO, FAO

*FAO not directly involved but of interest in the broader context

6.3 HIGHLIGHTS OF THE FAO-LED AND JOINT ADAPTATION INTERVENTIONS

The following sections summarize each intervention, ending with an overall assessment of its suitability for replication and scaling-up, which will be picked up again critically in the last chapter on "lessons learned".

6.3.1 Multipurpose integrated water resource management systems

Solar water pumping systems have been installed in seven communities (Ndombe, Madulo (2), Mepuza, Mapai, Chicualacuala B and Bragança). At five of these sites the JP drilled a borehole where none existed previously. The project aims to have nine of these systems completed by programme end. The systems provide drinking water for people and animals as well as water for irrigation. The boreholes (UN-HABITAT, FAO) are sufficiently deep (80-120 m) to access a constant supply of potable water, At each site. The JP has installated a submersible pump driven by a bank of solar panels, and installated between one and three plastic storage tanks of 10 000 litre capacity each on raised platforms (UNIDO,,FAO). Connections are established to taps (UNIDO) for collection by households and community facilities, 10 m-long concrete livestock drinking troughs (FAO, UNEP, UNIDO) or crop irrigation systems (FAO), or any combination of these as required in each community.

In Madulo, a village on the uplands situated adjacent to Lake Madulo which is mostly dry, a system has been installed in its entirety by FAO, fed by a 109 m deep borehole, lifting water to one large tank and then to numerous smaller feeder tanks. This system is intended primarily for drip irrigation of food crops. The system in Ndombe, closer to the Limpopo River, will likely be used to extend the area of irrigated croplands. In Mepuza, where a stand of five taps has been installed, the system is already being used by households, the health post and the school. People are also coming from the next village to collect water because it is of higher quality than the water in their village.

There is a critical shortage of water for livestock, and existing points are not well distributed across the rangeland. This leads to localized overgrazing around existing water points and rotational grazing is hampered by this situation.

6.3.2 Small-scale crop irrigation schemes

The District Government (SDAE) is receiving support from FAO to increase production from irrigated land. The potential for irrigated cropping in the project area along the Limpopo River exceeds 200 ha. These are areas close to the river where there is some residual soil moisture, and ponds/lakes/wet depressions are formed in the river bends which are usually perennial and are fed from underground. The river itself sometimes dries up to no more than a trickle at the end of the dry season (probably partially due to upstream abstraction in South Africa). The croplands are not on the river banks but a short distance away and higher up and as such are not at high risk of flooding from the river (although in the year 2000 most of these fields were flooded). However, heavy rainfall combined with poor drainage in some areas can cause waterlogging and even flooding of the fields in the rainy season.

However, in general the main constraint on irrigated cropping is lack of water, exacerbated by the irregularity of the rains. Thus, a key intervention to increase production is to provide water for small-scale irrigation for members of village-level farmers' associations. Early in the project, it was realized that development and improvement of high value irrigated crop farming would only be feasible if the croplands can be protected from the trampling hooves of livestock searching for fodder. Thus, fencing of croplands was essential, and some communities have fenced their lands as part of the JP using wooden posts (self-supplied) under a WFP food for work (FfW) agreement, and barbed wire supplied by FAO.

Improved access to water is being facilitated through the supply of diesel-powered pumps for extraction of water from the river or lagoons, or through

Drip irrigation

the installation of solar water pumps connected to 10 000 litre storage tanks. Irrigation pipes and accessories, seeds, tools, essential agricultural chemicals and technical advice and support are also supplied. In the fields of these three communities, irrigation channels have been constructed and furrow irrigation is practised.

In addition, a smaller area (2.5 ha) has been demarcated in Madulo, in a dry area north of Mapai, not close to the river but on the edge of a mostly dry lake. A drip irrigation system has been installed in a one hectare field, connected to the water supply system (borehole, solar pump, large storage tank, six smaller feeder tanks). A drip system was chosen based on the water scarcity and sandy soil, drip being the most efficient system under such conditions. However, it was very costly (US$10 000 per hectare) and production will have to be good to justify such an investment. The drip system is currently being tested by the 70+ farmers involved, 80 percent of whom are women. Using an alley-cropping arrangement, they are growing a variety of grains and vegetables, fruit trees (pawpaw, cashew, lemon, massala) and pineapple. Forage legumes (leucaena, sesbania and moringa) are also cultivated, for distribution to association members.

In Ndombe in particular, where farming potential is high, vegetable production surpassed expectations in the first production season 2009, producing 54 tons of horticultural produce off 14 ha. Participating families reported that income from sales exceeded their expectations, providing a much needed alternative to charcoal production. Unfortunately, there is a limited market and, as many farmers produced the same crops (especially tomatoes) at the same time, some of the harvest was spoilt. In response, the agroprocessing activities and training are being stepped up (see below) and the community was encouraged to feed excess unmarketable produce to the pigs/ducks adjacent to the fish ponds (see below).

This situation partly arose because the farmers did not heed the advice from SDAE/FAO to plant in a staggered manner. Advice on how to plan planting and harvesting for year-round supply has not been sufficiently adopted since, although spoilage on the same scale has not been repeated. Growing less perishable and easily marketable vegetable crops seems the best response (e.g. onions, carrots, garlic, beans, piri piri, potatoes, cabbage, cucumber, peppers), since market development is a longer-term objective. Thus far, the FAO has distributed much of the required seed, including drought tolerant crops (millet, groundnuts, cow peas), and is also supplying considerable quantities of seed potatoes to five farmer associations. It is hoped and encouraged that the associations will become self-sustaining in this regard.

Based on requests from local communities and local government, and to facilitate the intensive farming of larger areas of each community's fenced croplands and achieve their full potential, FAO has provided a new tractor (to replace the old one), a 5-ton capacity tipping trailer, plough and harrow for the three associations to share (Ndombe, Mapuvule, Chissapa). A nearby non-JP farmers' association (Muzamane) may also join in. Farmers will pay for use of the implements on a financial basis to be decided with the associations. This intervention is essential especially where there are many members and not enough land. Currently most cultivation is done by draft animals which the programme is also promoting, or by hand. However, the fenced land area (93 ha) is beyond the capacity of draft animals, particularly where optimal timing of cultivation operations is essential. The tractor and trailer will greatly increase market access for farmers close to the river who currently transport their excess production in ox carts or by bicycle up a steep escarpment to the town of Mapai from where it goes by train to Maputo.

Overall, more than 175 families are now involved in irrigated crop production across the four farmers' associations (this will increase further as the project continues), with a female representation of between 50 percent and 70 percent.

Farmer association training was provided by FAO/SDAE in all the communities, with the objective of establishing well-functioning and registered associations with access to government finance schemes.

6.3.3 Conservation agriculture

The three principles of conservation agriculture (CA), namely minimal soil disturbance, permanent organic soil cover and crop rotation, are being promoted through the JP (DPA/SDAE/FAO) in four communities. It has been difficult to achieve the adoption of no till/minimum till CA. Farmers are resisting this concept and insist on ploughing their fields, partly because of their investments and income earning potential from draft animals and implements. Early attempts at demonstrating the benefits were not successful since these did not emerge during the dry trial year. Still, a concerted effort needs to be made to convert animal traction ploughs into rippers and to gradually introduce minimum tillage, as no-till planters are unknown in the area and even the district. However, farmers are receptive to using animal manure and mulching, although these are not traditional practices, and some have adopted them, although probably at a suboptimal level. The soil surfaces remain quite exposed; years of being advised to clean-weed their fields will take some time to reverse. Crop rotation is not practised, but there is some intercropping, albeit at a low level and not well planned. Increased and better planned usage of nitrogen-fixing cover crops such as cow peas and pigeon peas, and of intercropping, would be beneficial. In the dry season, cover crops are not an option due to the unavailability of water and the lack of fencing of cropland. Maintaining a cover crop in this arid environment would improve water holding capacity and it should be examined carefully before fully introducing CA.

6.3.4 Animal traction (draft)

From baseline information collected during project formulation it was believed that there existed limited use of animal traction (draft power) for productive purposes in the Chicualacuala District and that this required promotion and training. On-the-ground experience has since shown that there is in fact widespread use of cattle (and donkeys) for animal traction and farmers generally know how to train and use their animals for farm work and transport. One of the biggest constraints has been noted as a lack of carts for transport of people, produce and other goods.

Nevertheless, there is a need for training in some aspects of animal traction (i.e. improved ploughing techniques, proper use of donkeys) and animal welfare,

and training courses for donkey owners were conducted in three villages. Water is a major problem for both humans and livestock, including donkeys. Donkeys are worked most of the day (mainly for transport, occasionally for ploughing when oxen are unavailable) and only allowed to graze after work (Nengomasha and Jones 2010). Grazing is often poor and donkeys have to travel long distances for grazing and browsing, with no feed supplements offered. The training for donkey owners focused on the manufacture and use of breast band harnesses made with locally available materials, the use of head ropes for a simpler and non-intrusive method of restraining them, and on basic health management. Training was provided to cattle farmers in the making of more comfortable neck yokes.

6.3.5 Livestock health

The FAO veterinary technician, in collaboration with the district veterinary services and the national small farmers' NGO, UNAC, has trained and equipped 21 community animal health workers ("promoters") from 13 communities. They are now able to provide basic veterinary services (preventive and curative treatments, mainly to cattle) to livestock farmers and in their respective villages, and have been shown how to keep records. A further 15 promoters have just received training and are awaiting the arrival of their veterinary kits.

Nine livestock treatment corridors have been built. They are being used by the livestock health promoters to treat and vaccinate animals in coordination with the livestock services. In 2010 alone, 24 825 animals (mostly cattle) were treated. A fundamental activity is the regular spraying of cattle against ticks, which can cause fatal diseases such as heart water, red water, and anaplasmosis. They also treat livestock diseases and assist the government veterinarians in conducting the annual vaccination campaign against anthrax, black leg, foot-and-mouth disease (FMD) and lumpy skin disease. FMD is currently a big problem due to the proximity to Gonarhezou National Park in Zimbabwe, where the disease is endemic. Illegal movement of animals across the border into Mozambique, compounded by the breakdown in veterinary service provision (and border controls) in Zimbabwe, have led to a serious deterioration of the situation which used to be under better control. Sites for the construction of a further nine corridors have been selected in coordination with SDAE and the Provincial Livestock Service.

There are indications that the FAO-led livestock health intervention is already having a positive impact on animal health and production and thus income from livestock. Not only mortality is important, but also morbidity which leads to

Vaccination post

poor weight gain or more rapid weight loss in the dry season and poorer calving rates. There is no doubt that mortality and morbidity have decreased, although it is difficult to quantify this. The incidence of tick-borne diseases seems to be reducing as a result of regular spraying of cattle.

Three vaccination campaigns took place against Newcastle disease in chickens during 2010. More than 1 500 families participated in the campaigns and a total of 37 791 chickens were vaccinated. The first campaign was conducted by FAO and the district livestock service. The second and third campaigns were conducted by Save the Children (international NGO) with assistance from FAO, and the former are continuing this activity.

An agroveterinary shop has been established in Eduardo Mondlane in a re-habilitated building, for the sale of agricultural inputs and livestock drugs, and is managed by a private contractor. Furnishings, some agricultural chemicals and an initial stock of veterinary drugs were provided by FAO, but the contractor has bought others as well as seeds and tools and recovers the costs from clients, thus becoming self-sustaining. So far, the main demand from the public has been for horticultural seeds and a small range of veterinary drugs (de-worming remedies, acaricides and antibiotics).

6.3.6 Grazing management and animal husbandry

Livestock keeping is a tradition in Chicualacuala (mainly cattle, goats and chickens) as it provides insurance against crop failure. However, animal and pasture management is poor and FAO is providing assistance to livestock keepers to improve the way they manage their animals and use the pastures. Training workshops have taken place in six communities and over 200 livestock keepers have received guidance in animal housing, nutrition, health and reproduction. Training was given in improved land and pasture management to over 100 government staff and community leaders as part of the participatory land use planning workshop conducted in Mapai.

Under the current approach, cattle graze closer to the villages during the rainy season, moving further away as the dry season progresses, thus suffering serious loss of weight and health by the end of the dry season. FAO is trying to encourage livestock farmers (and herders) to graze the furthest areas with the least access to water first, and move progressively closer to the areas with watering points, closer to the villages, as the dry season progresses. This is difficult because, although the livestock keepers understand the benefits of what SDAE/FAO is proposing, social organization is challenging, compounded by the fact that the herders are generally small boys who are difficult to work with.

6.3.7 Community-based natural forest management (CBNFM)

The livelihood and coping strategies of rural communities depend largely on the exploitation of forest, land, water and livestock resources. In response to prolonged droughts, where dryland farming does not guarantee food security, rural communities have traditionally relied on livestock as a safety net. However, in recent years they have been turning increasingly to the forest for food and a source of income. Charcoal burning is increasing at an alarming rate as it gives a quick cash return and has a ready market in Maputo and other urban centres. A baseline study conducted by the JP (Tánago *et al.* 2009) showed that forest extraction for charcoal and building materials exceeds the sustainable limits. In response, the FAO began helping three pilot communities design and implement a community based forest management plan based on clear demarcation and inventory of the resource (Tánago and Brower 2010).

A total of 47 000 hectares of forest land was initially demarcated within this programme and community forestry management associations were created and trained. All steps of this process were fully participatory and nothing was/is being done without full community and local government agreement. The aim is to firmly establish the management plan as a tool for sustainable forest use.

Charcoal and wood to be transported to urban areas.

Based on promising indicators of impact, FAO/SPFFB assistance has now expanded to a total of 12 villages. Each village has an officially registered community forestry management association, a community based forest management plan in place and trained forest guards working (Andrew Mattick pers. comm.). Further, sustained support will be necessary in these communities to overcome constraints to acceptance and implementation of the management plans, with communities "taking ownership" of "their forests" for long-term sustainability.

Sustainable management of the forests under this system will depend strongly on greater community control and enforcement of community by-laws. This has been addressed through the training and equipping of 24 community forest guards and the implementation of a forest ranger/patrolling system. The guards have been officially recognized by the Provincial Forestry and Wildlife Service and by the District Government.

To reduce pressure on the forest for fuelwood, the programme is also promoting biogas production and energy saving stoves (under UNIDO) and using intensified irrigated crop farming and livestock farming as leverage for improved forest management and reduced reliance on charcoal.

6.3.8 Agroforestry

Various agroforestry systems are appropriate to the area, but they need to be tested on site to assess feasibility under the local circumstances and gain acceptance by farmers (Braatz and Tranberg 2010). Agroforestry will only succeed within fenced-off areas, where trampling and consumption of seedlings by passing livestock can be prevented. The baseline studies identified a wide range of forest tree species used by local communities for non-wood forest products, and provided information on which other species (especially fruit trees) are favoured by the communities.

The recommended types of agroforestry most suitable for Chicualacuala are:

- Home orchards: fruit trees planted in back yards and small orchards, particularly in larger towns where people have enclosed yards. Preferred fruit species are the non-indigenous mango, cashew, orange, pawpaw (papaya) and banana, and a number of indigenous species (Maposse *et al.* 2010).
- Trees and live fences used for delineation of property boundaries, as windbreaks around the perimeter of agricultural fields, and as barriers

Tree seedlings

against livestock causing damage (probably only feasible around home gardens). They can also be chosen to provide additional fuelwood, fruit and possibly timber.

- Trees scattered across agricultural lands. It is current practice to retain trees that supply something of value (e.g. fruit, medicinal product) when the field is first cleared and cultivated. Tree seedlings can also be planted into the croplands, especially the preferred non-indigenous fruit species which benefit from irrigation, but a variety of indigenous fruit species and leguminous species (for supplemental forage for livestock during the dry season) are also suitable.
- Multipurpose trees, grass species and legumes for both human and livestock needs are currently lacking. The need for water restricts this option to the four villages along the river which have irrigation systems. Species such as *Gliricidia sepium* (gliricidia), *Leucaena leucocephala* (leucaena), *Moringa oleifera* (moringa) and *Anacardium occidentale* (cashew) are deemed suitable. Indigenous species such as *Afzelia quanzensis* (chanfuta/pod mahogany) and *Strychnos spinosa* (massala/spiny monkey orange) are also suitable. Tree saplings of these species have been produced at the three tree nurseries established by the JP in the district.

Early in the project, FAO in partnership with SDAE helped to establish three tree nurseries (at Madulo – rehabilitated forestry nursery, Ndombe and Mahatlane) to supply not only fruit and fodder trees but also native hardwood species for re-forestation. It appears that the latter was not popular with the communities and they have shown no interest in continuing with this activity unless employed (paid) to do so. The reason is that they see no short-term benefit and the opportunity costs for scarce labour do not favour this activity.

The project has provided training and support to the nursery workers in nursery production. The community-run nurseries have produced some 28 000 saplings of various fruit and fodder tree species of which over 11 000 (39 percent) have been distributed to farmers, schools and health posts and for use in pilot agroforestry demonstration plots. Non-indigenous fruit tree saplings have been purchased elsewhere, including cashew, lemon, mango, orange and tangerine. Saplings have been planted in the irrigated fields of all three communities. It remains to be seen whether the project-supported nurseries can become self-sufficient, this depending on whether people in local communities are willing to purchase fruit or other tree seedlings, and on the business acumen of the trainees.

The UNDP is funding some small on-farm agroforestry trials conducted by IIAM on the use of fruit trees (e.g. mango, cashew) alley cropped with vegetables and/or cereals or legumes, as a potential agroforestry system for the area.

6.3.9 Integrated fish and small animal farming

Fish farming (aquaculture) is not traditionally practised by the Chicualacuala communities and is an unknown technology and economic activity. Nevertheless, it was identified and requested by the GoM as having good potential as an alternative source of food and income, thus helping communities adapt to climate change, and was introduced into the JP during the second programme year. On the recommendation of UNEP and in collaboration with FAO, fish farming is being integrated with small animals (pigs, ducks, rabbits) in farmer associations where small-scale irrigated crop farming is also being developed along the Limpopo River (Ndombe, Mapuvule, Chissapa). The reason for this is not only access to water, but also access to organic waste from crop production (unmarketable excess production and other vegetative waste). Tilapia are being bred, including the Mozambique tilapia (*Oreochromus mossambicus*)

Integrated fish farming

and Redbreast tilapia (*Tilapia rendalli*). A lesson learned thus far is that high variability of crop production can create feed supply issues, where, for example, significant delays in crop production can cause a scarcity of food for the pigs and ducks. Improved crop planning for year-round harvests should overcome this problem.

A critical element is awareness rising around the problem of climate change, farming risk and options for diversification, combined with a training programme around principles and techniques of integrated fish/animal farming (Caixote 2010). The hitherto unknown concept of enclosing and feeding animals (notably pigs) has been adopted and is proving beneficial. The earthen fish ponds and adjacent animal houses were constructed by men and women using local labour and mainly local natural materials, some of them identified by the participants themselves. Diversification is particularly beneficial to women who often have fewer livelihood options close to the homesteads than the men. In two of the communities, the women of the community have taken responsibility for, and are the main beneficiaries of, the fish farming, whilst all members benefit from the animal production; in the third, the farmers' association chose to train everyone but with specialized technical training given to two "promoters", one woman and one man. Many of the women are either widows, single mothers, or women whose husbands work elsewhere for extended periods. These women previously depended heavily on selling fuelwood for their income – this reliance on forest products is expected to decrease following the introduction of integrated fish farming, the women themselves identifying this as beneficial to the forest ecosystem. In all communities, both the women and men will be shown how to process (sun dry, smoke) the excess fish harvest, as part of the training programme. Exchange visits between communities involved in this activity have taken place providing a platform for shared learning.

6.3.10 Beekeeping

The beekeeping (apiculture) activity was started at the request of the provincial governor and district administrator. It was only started half-way through the project but was accommodated and is being introduced by FAO. Honey is a highly sustainable forest product with a ready market and good alternative income earning potential, and with many additional benefits (e.g. nutrition, anti-bacterial properties). Beekeeping is expected to become a valuable tool in climate change adaptation strategies, with good potential for expansion in this predominantly forested district.

Beekeeping

Sixty people (from different families) from three communities have been selected and trained as beekeepers, in three groups of 20 each. Only a few members of each group have had previous exposure to apiculture. Each participant has received five improved hives and other beekeeping equipment including protective clothing, masks and gloves. During the initial training they were shown how to lay strips of beeswax into the hives to attract swarms. So far, about three-four hives out of five have been occupied (60-70 percent). The average yield of honey is about 20 kg with potential of up to 40 kg per hive. The second phase of training, namely honey harvesting and processing, is underway. They will harvest for own consumption and to sell, but are being encouraged to also give their children honey (the problem that children have been stealing the honey will be dealt with through the parents and community leaders).

6.3.11 Agroprocessing and marketing

To help overcome marketing difficulties for farm products where road access is poor and distances long, FAO/SDAE is promoting simple preservation and processing techniques for vegetables, fruit and meat. These include sun drying of vegetables, making of jam and tomato sauce, peanut butter making, and drying of meat to make "biltong". Assistance is also being provided in developing the successful marketing of crop surpluses. About 160 people from four communities have been trained thus far, with women constituting the majority of beneficiaries. Further opportunities for livestock products are under investigation, for example, sausages. The lack of hygienic conditions, energy (for

Agroprocessing

cooling) and water, the high capital costs (specialized equipment) and running expenses, and importantly the very low volumes of milk production and widely dispersed cows, render milk processing an unviable option.

A modern slaughterhouse and meat packaging facility is being built and equipped by FAO on a site close to Mapai, with sufficient capacity to allow for the development of the livestock industry. This will dramatically improve the slaughtering conditions currently experienced. The facility will also include a borehole (FAO) a solar powered groundwater pump (UNIDO), a biodigester (for waste – the electricity will provide lights and hot water for the slaughterhouse), and cold store (powered by solar panels). Eventually, this facility should also be able to accommodate other ruminants and cater to the needs of smallholder farmers and especially female livestock keepers.

6.3.12 CERUM

The JP is assisting INGC in building a Multiple Use Resource Centre (CERUM) where it is planned to test and demonstrate a range of technologies adapted

for use in semi-arid areas affected by climate change and continue to train local farmers. A 6-hectare site on the outskirts of Eduardo Mondlane has been ceded by the district government for this purpose. In a joint effort, the land has been fenced (FAO), the building will be erected (UN-HABITAT), a borehole and solar water pumping system will be installed (UN-HABITAT, UNIDO) and the centre operationalized (INGC). Field-based adaptive research for, amongst others rainfed crop production (e.g. drought tolerant and short cycle crops), grain storage, conservation agriculture, water harvesting, fish farming, livestock farming, alternative industries, and renewable energy, will be focused on identifying and testing technologies suitable for arid areas and as adaptive strategies to climate change. IIAM under the auspices of UNDP has already started some trials on some of these aspects.

CERUM will be staffed, with some initial assistance from the JP, to become fully functional and sustainable. The INGC have pledged to support the centre by providing human resources (technical expertise).

6.3.13 Meteorological data and communications

The meteorological station at Eduardo Mondlane, which has not been operational since the mid-1970s, is being rehabilitated at the request of the GoM. The new automated meteorological station has been purchased jointly by FAO and UNEP and has been installed on the CERUM site. UNDP is paying for rehabilitation of the INAM house/office in Chicualacuala. INAM will place at least one full technician in Chicualacuala to man the station. This will greatly improve the monitoring and forecasting of seasonal agrometeorological conditions and related advice to farmers, and understanding and dealing with intra- and interseasonal climate variability in the region. It will also provide essential real-time information for the early warning system in the district.

The weather station network in Mozambique is critically insufficient (only 27 synoptic weather stations across the country), a situation brought about by the civil war and other causes of damage, including climate disasters. Not only is the station density extremely low, but the distribution and quality of data capture are also unsatisfactory. INAM is working towards improving this situation, aiming to establish one automatic weather station in every district, with funding towards this now committed by development partners. In the Chicualacuala District the three meteorological stations have been inoperable since mid-1970, and forecasts and early warning are currently based on data from coastal stations. The new meteorological station at Eduardo Mondlane will thus serve a critical purpose for this district.

A new solar powered radio tower was installed in Eduardo Mondlane, which has extended radio reception from a radius of 15 km to 80 km. Only another 20-30 km radius is needed to reach Mapai but this will require another tower halfway between Chicualacuala and Mapai. The local radio station has been strengthened through technical training and provision of equipment, and will become an integral part of the district Early Warning System for climate hazards, in addition to providing a weather forecast service for farmers and a platform for agricultural extension and other support to small businesses. Sufficient institutional capacity will be required for interpreting climate data and information products for enhanced risk management in crop and livestock production.

6.3.14 Biogas generation and composting using animal waste

The development of renewal energy in the Chicualacuala District has multiple benefits, including the reduction in deforestation for charcoal burning and fuelwood (for local use), supply of clean energy for irrigation, schools and health clinics, and small business development. Renewable energy technologies identified for Chicualacuala include solar energy (which is already known in the area) and biogas based on animal waste. The application of solar energy for groundwater pumping has been discussed above. Biogas represents an efficient and relatively easy way to generate energy in the form of gas, whilst simultaneously eliminating organic waste, particularly that generated by livestock. The first biogas production unit in Mepuza village is under construction (led by UNIDO in partnership with the Ministry of Energy), with the community having produced bricks locally for the construction of the biodigesters which will be fed with animal manure. This will drive a generator providing electricity for the school, hospital and some small workshops (mechanics, welding, carpentry) in the village. A mobile, demonstration biodigester was purchased and transported to Chicualacuala where it was used to train government technicians and rural communities in the production and use of biogas. A second biodigester will be installed at the site of the new animal slaughterhouse in Mapai, which will use manure and slaughter waste products to produce electricity for lights and hot water at the facility.

CHAPTER 7

LESSONS LEARNED

As highlighted in the previous section, this ongoing UNJP, where, with MICOA coordination, FAO plays a major role in the implementation of the climate change adaptation components and activities, is a complex programme. It cuts across various sectors and subsectors (i.e. crops, livestock, forest, land, water, etc.) in an effort to build the resilience and strengthen capacity for climate change adaptation; climate variability and change is already having a profound impact on food security and livelihoods of rural communities. It is a work-in-progress.

This section will draw upon the key lessons learned on the innovations and successes, shortcomings and constraints. In Mozambique, the main barriers to mainstreaming climate change into development relate to lack of alignment of policies/strategies/plans, lack of institutional coordination, lack of integration (multidisciplinary perspective) and limited human and financial resources (see Sietz *et al.* 2011). The first part of this chapter will address the main challenges experienced in this project around institutional coordination and project planning. The second part will present a critical analysis of the FAO adaptation intervention activities presented in Chapter 5.

7.1 PROJECT FORMULATION, INSTITUTIONAL ARRANGEMENT AND COORDINATION

7.1.1 Programme design and implementation

The JP was originally conceptualized for a larger area of the Limpopo River Basin, including the more accessible and populated reaches of the lower Limpopo where existing UN activities would have provided a useful baseline. At the insistence of the GoM, the final choice eventually fell to Chicualacuala, a very remote district, receiving little or no development assistance from outside agencies. There is general agreement amongst stakeholders at all levels that this was a more appropriate choice given the need for substantial assistance, the very high level of vulnerability to climate change, the inadequate level of infrastructure (notably with very limited telecommunications and no electricity supply), very weak institutional capacity, and very low level of donor or civil society support.

This situation is a major disincentive for both national and outside development partners to work in this district, leading to the situation of "a neglected and forgotten district".

Nevertheless, the logistical, budgetary, staff and coordination implications of the decision to place the project in Chicualacuala were far-reaching. The district is accessible only by unpaved road or a full day's travel by train from the capital city of Maputo. Hence, implementing and monitoring project activities by car, where there are no fuel stations, was demanding. The performance of administrative tasks, and the liaison between project field staff and project managers in town, proved very difficult. It is also difficult to attract multiple tenders from service providers, who either do not have the resources to operate in such remote undeveloped areas, or do not see any profitability in doing so.

Low population density is a feature of Chicualacuala District; however, the 40 000 inhabitants are clustered in small villages and two towns, with sometimes great distances between them. Project staff spend large amounts of time travelling; this has necessitated increased attention to travel efficiencies and logistics (time and fuel).

At the start of programme implementation almost no secondary data existed which could be used towards developing a baseline for the Chicualacuala District and to inform implementation activities. As a result, baseline studies were conducted which required considerable primary data gathering. Some were only concluded well into the programme and this contributed to the significant delays in implementation.

The eventual choice of Chicualacuala, rather than districts closer to Maputo as first envisaged, brought major constraints in the launching and implementation

BOX 1

KEY LESSONS

Programme design should be particularly carefully considered for such undeveloped remote areas, taking into account realistic timelines, logistical arrangements and budgets. Reconnaissance visits to the project sites and active engagement with local stakeholders to gain an understanding of the local conditions is essential. An assessment of available baseline data is crucial, particularly in a neglected area. Thus, sufficient time needs to be allocated to the design phase.

of the programme. This led to significant delays and negatively affected coordination between the agencies involved.

Another important aspect in project design is agreeing on a more realistic timeframe to attain the desired results at the beneficiary level. Implementing a complex programme of this nature in a remote area in a matter of three years is clearly extremely ambitious, and all partners now agree that a timeframe of 7-10 years would be more realistic if lasting benefits are to be achieved.

This programme was designed in a matter of three months. Subsequent to this short design phase, there was no inception phase (this is a problem common to most such projects), which would have allowed for the emergence of many of the logistical and budgetary challenges and the lack of data and information, and would have greatly benefitted this JP. The result was that these lessons were learned during the first programme implementation year, at the end of which there was very little to show on the ground. Thus, a project inception period for about six months would have been very helpful.

As the programme evolved, it was recognized that many components of the programme are more of a pilot nature, rather than development activities which can be rolled out over larger areas with rapid impact. Climate change related development activities are relatively new to both government and UN agencies in Mozambique. A process of trial and error had to be followed, and in some cases "unknown" activities were brought in from other countries/districts and/or organizations and adapted to the very specific district conditions. This trial phase, and feedback from communities to avoid any resistance, could have been better accommodated had there been an inception period before rolling out the activities for implementation.

BOX 2

KEY LESSONS

In arid and semi-arid regions and remote areas, where available data and understanding of what works, and what does not work in the local context, are very limited, sufficient time needs to be allocated to project design and formulation, necessitating an inception phase, in order to prevent costly inefficiencies during implementation.

7.1.2 Programme management and coordination

In Mozambique, as in many other countries in the region, coordination mechanisms between national institutions, and between national and international organizations working at the local level, have been largely inadequate.

In the JP, one person serves as both the Programme Coordinator for the entire programme, and the responsible person for implementing the FAO activities, which is the largest component. Whilst this arrangement has the advantage that the Coordinator has in-depth knowledge of the programme, it has had negative consequences for coordination between MICOA, the GoM and the UN agencies which would have been better served by a coordinator based full time in Mapauto. Due to the remoteness of the district, lack of proper working conditions, and administrative requirements in Maputo, it was decided to base the coordination unit in Chówkè, half way between the district and Maputo, and near the provincial capital Xai-Xai. The original project plan did not cater for field staff, apart from FAO, and as a result, many activities were implemented remotely from Maputo, with staff engaging in only limited and very specific field visits. Since then, two other agencies have been assigned field staff. In effect, the Programme Coordinator is coordinating and managing activities in three areas: the District, Chowkè/Xai-Xai and Maputo, which has brought some inefficiency.

BOX 3

KEY LESSONS

In hindsight, there is general consensus that it would have been more appropriate and efficient in both implementation and coordination to have a Programme Coordinator for the whole JP, with his own separate budget for coordinating the JP activities amongst the UN agencies and national partners; as well as an FAO focal point with a separate budget for coordinating and implementing the activities at the district level. This idea was considered during the mid-year review, but was not considered feasible because of budgetary constraints.

7.1.3 Partner issues: UN and Government

The JP was one of the first pilots for the UN initiative "Delivering as One UN" which aims to provide technical assistance in a more coordinated way,

capitalizing on the strengths, comparative advantages and technical capacities of the different members of the UN family at local level, finding ways to increase the UN system's impact through more coherent programmes, reduced transaction costs for governments, and reduced bureaucratic procedures and lower overhead costs for the UN system. For the JP, this approach included six UN agencies and six national ministries and institutions; this needs to be assessed critically.

Given the cross-sectoral nature of a climate change adaptation programme, bringing in the expertise of multiple UN agencies could be a better arrangement than the usual approach of delegating one agency. There are lessons to be learned from this joint approach, discussed below.

First, the intended increase in efficiency sought by allocating each activity to the most appropriate UN agency, gave rise to significant systematic delays, as the input from one agency depended on the completion of activities by another agency in order to achieve programme results, thus compounding the logistical constraints discussed above. Many activities need the intervention of two or more agencies to be completed. This becomes a real challenge for materials and equipment or subcontracted services (e.g. baseline studies) which must follow complex procurement procedures. A typical example is the following: FAO's drip system must wait for the completion of UNIDO's solar panels, which requires flow data information of the borehole to be dug by a UN-HABITAT subcontractor, who needs the results of a completed study of regional borehole supply potential done by a UN-HABITAT subcontractor.

Second, tedious and complex bureaucratic procurement procedures in Mozambique and within the UN system constitute the most common constraint, leading to systematic delays in programme implementation. Detailed implementation schedules by multiple actors are very inefficient for separate institutions with different sets of procedures and rules, different corporate environments, and stretched procurement committees. In addition, the JP and the government partners have different planning, budgeting and implementation cycles, making it very difficult to implement a joint initiative and to exploit synergies.

Third, government institutional partners have difficulty in dealing with the joint approach, where, for a single result, they must deal with three or four UN partners. Also, they have to align with different agreement formats (e.g. annual work plans or Letters of Agreement) and reporting requirements; e.g. INAM's weather station requires the intervention of UNDP for infrastructure building, FAO and UNEP for weather equipment procurement, UN-HABITAT for transport and daily subsistence allowances, and UNIDO for energy equipment procurement.

BOX 4

KEY LESSONS

The "Delivering as One UN" approach is conceptually accepted as a good way towards harmonization between all agencies. However, it should be designed so that each agency has clearly delineated implementation tasks and responsibilities, without impinging on others. A single procurement process would greatly reduce inefficiencies brought about by each agency conducting its own procurement, particularly when some agencies have to conduct international tenders, while other are obliged to conduct national tenders.

7.1.4 Programme design: top-down versus bottom-up

When programme conceptualization and design are rushed, the essential inputs which should flow from sufficient engagement with local partners and proposed beneficiaries are compromised. Although the JP was jointly planned by the participating UN agencies and government partners at national level, the target group, namely rural communities in the Chicualacuala District, had almost no input into programme design. This resulted in a notable lack of a sense of ownership of some of the project activities by the communities during the first half of the programme, which posed risks to the sustainability of some initiatives. Through some programme adjustments and great effort on the part of JP staff (assisted by community leaders), this has started to reverse, with some communities (especially those which have been in the JP longest) taking increasing ownership and responsibility. The expectation is that, with further effort in the remaining programme time, all target communities and their respective organizations (e.g. farmers' and forestry associations) will regard the activities as theirs, and will be in a position to manage them into the future. The development of a close working relationship with local government is also bearing fruit, with the District Administrator and the Chefe de Poste (Head of Post) of Mapai taking a keen interest in the programme and supporting implementation. Requests from these incumbents for the inclusion of additional adaptive interventions (e.g. beekeeping) appropriate for the District have been heeded.

BOX 5

KEY LESSONS

It is critical that there is full involvement and buy-in of the intended beneficiaries and local government leadership from day one. Project design should allow sufficient time to engage with local communities and stakeholders in order to ensure an understanding of the expected benefits of the programme. This will ensure buy-in and ownership from the start. It is imperative to create such mechanisms before the end of the programme to avoid a collapse, which is all too typical of development activities in remote areas. There is a history of development projects collapsing when projects funded by outside sources end in the district.

7.2 KEY LESSONS LEARNED FROM FAO ADAPTATION INTERVENTIONS AND FUTURE DIRECTIONS

In this section, FAO activities that have been described above will be examined through the lens of climate change, the need for adaptation, successes, challenges, sustainability, and potential for scaling-up. Based on this, some of the key lessons that are emanating from our observations will be highlighted for each group of interventions.

As a whole, the JP shows how successful the combination of "hard" and "soft" approaches can be. Physical infrastructure and equipment are not sufficient by themselves; they must be accompanied by training, information and policy support. This is particularly true in the "new field" of climate change, still relatively unknown to most rural people and not yet part of current knowledge and governance systems.

The combination of conventional development approaches (water sector, agricultural development, environmental training) and innovative approaches for piloting (renewable energy, integrated fish/animal farming, beekeeping, policy development, community-based forest management) has taken this project to a level beyond standard development practice, as befits "business unusual" required for dealing with climate change. It is the combination of the hard and soft approach which will make a significant difference to Mozambique and possibly to other countries in the region, in adapting to climate change.

7.2.1 Improving access to water resources

Access to water resources is one of the most critical factors in developing adaptation responses in water-scarce districts such as Chicualacuala. An assessment of available water potential is also essential for the efficient use of scarce resources, which will become increasingly scarce given the climate scenarios for the region.

Adaptation intervention using water will depend on three water sources in the District. The first involved the exploitation of the groundwater resource (surrounding aquifers) which is currently low, and the implementation of increased pumping of water from this resource has made a significant difference in improving productivity. This option has multiple benefits, but is costly and depends in the long term on sustainable aquifer recharge. The recharge capacity of the aquifer has not yet been assessed thoroughly. Although there is no imminent threat of over-use, a comprehensive hydrological study should be done in future. The success of the intervention largely depends on how this is addressed.

The second involves water from the Limpopo River for small-scale crop irrigation. However, it is uncertain whether this option can be scaled up along other parts of the river basin, based on expectations of increasing abstraction (for power plants, industrial development and irrigation) and continuing pollution in upstream areas and tributaries. This Basin is already under major pressure with regard to available water resource, and climate change (possible rainfall changes, and increased evaporation associated with warming) together with demand from industrial and urban development in the economic heartland of South Africa could reduce the flow reaching Mozambique. Initial studies (Pegram *et al.* 2011) need to be followed up with further in-depth analysis of hydrological and planned developments in the Basin, to inform the sustainability of this adaptation option. In view of this uncertainty, groundwater probably provides a more secure source of water if used sustainably.

The small pilot drip irrigation project has been well received, with tangible benefits already visible. Further development of this technology to replace the water inefficient furrow irrigation currently used, would be very beneficial. However, replication and scaling-up of drip irrigation will require further training of the communities.

A third source, which has not been tapped by the project, is the water harvesting potential provided by the natural depressions where water accumulates for variable periods (known as dambos). Small dams and ponds could be constructed to hold water during the rainy season and to be used for both humans and

livestock during the long dry period when water is critically short in the area (Dejene, pers. comm. 2011). This was not envisioned in the project document of the JP and the potential was identified later as the project unfolded. Livestock development would benefit significantly from the use of these dambos in the face of increasing rainfall uncertainty in this district.

BOX 6

KEY LESSONS

Water is central and critical to climate change adaptation in Chicualacuala and similar areas. The current and future water resource, from all sources, must be scientifically assessed and used sustainability in order to adapt to climate change and support long-term development. Future project formulation and site selection should also assess the water availability potential, as it will significantly influence adaptive capacity to climate change.

7.2.2 Crop farming

As discussed, irrigated cropping provides excellent benefits, although depending on a water resource which may be at risk in the future and only suitable close to the Limpopo River. For the remainder of the District, which has no access to surface water for this purpose, current and future climatic conditions demand much closer attention to improving the soil water holding capacity. The project has, perhaps, focused too intently on the lowlands and the opportunity for immediate impact, so that future focus should also be directed at improving productivity of the uplands. Greater emphasis on the planting of drought-hardy species and mixed cropping should be encouraged.

While improved soil management, especially practices supporting improved soil fertility, conservation and water holding capacity, is essential and an important adaptation option which can easily be scaled up, implementation of comprehensive CA in this region presents many problems. Specialized implements suitable for no till/minimum till are neither available nor known in Mozambique, and did not generate any interest in the community. The implementation of CA based on all three principles will be an ongoing and slow process. At this time, CA with no till/minimum till is not the best option in this area, and work should

focus on one or both of the other principles that have been proven to work and are accepted by the farmers. Mixed cropping, intercropping and maintaining soil cover using manure seems to be accepted and should be further supported. Crop residues from CA plots can be used for both soil cover and livestock feed, and forage grasses could be grown between food crops in CA fields for animal feed supplementation after the food crop harvest.

BOX 7

KEY LESSONS

The study area where small-scale irrigation has been practised has shown considerable increases in crop production. This has also resulted in the piloting of some of the CA principles such as crop rotation, intercropping and maintaining soil cover through mulching using manure. CA is likely to be more widely accepted if the basic principles are broadened to include crop-livestock interactions that would encourage multipurpose trees and grass species that can be used for both human and livestock needs.

7.2.3 Crop-livestock integration

Further demonstrations and training on the benefits of crop-livestock integration (e.g. animal manure) for crop production would be helpful. It may be worthwhile to sample upland farms for crop mixes as a basis of introduction of more diverse drought tolerant dual purpose legumes into the system, first to improve overall farm crop yields, and second to improve quality of crop residues for livestock in the system, be it draft animals, lactating cows or small stock.

The promotion of animal traction (draft) remains a valid and sustainable option in both the lowland and upland plots. During the JP, there was a strong demand for a tractor and ploughing implements from lowland irrigation crop farmers, based on the rapid increase in productivity which can be achieved, and management of much larger cropped areas than can currently be accommodated using animal traction. The project recognizes, however, that this is neither a sustainable option, given the damage caused to soil in the long term, nor is it scalable. It could also disincentive the use of animal traction. The support of animal traction requires much more attention, whilst simultaneously continuing to demonstrate the technology and benefits of no till/minimum till. Nevertheless,

the tractor and tipping trailer are used for transporting produce to markets, since draft-based transportation is hampered by long distances and slopes.

The project has so far not trained farmers in nutrition and feeding of draft animals specifically, although general training in animal feeding has been given. Further, the observed practice of transporting crop residues from irrigated plots, and the need to store some residues (especially from legumes), for the exclusive use of draft animals, has been encouraged through training but not adopted owing to a lack of labour. The preferential feeding of draft animals should over time improve the nutrition and productivity of draft animals. For both oxen and donkeys, guidelines on frequency, duration of work and rest schedules for working animals, in order to improve their outputs, should be included in future training of farmers and other users.

Adoption by communities of agroforestry practices has been patchy and rather slow, and whilst potential benefits are large, they will probably make only a small overall contribution to building resilience. The sustainability and impact will depend on interest in turning nurseries into small businesses, which is not happening. A stronger focus on livestock preferred forage trees, such as Leucaena and Glyricidia, could be developed in irrigated plots, around their edges, and around homesteads, as an integrator between agroforestry and livestock activities. Although they are grown by some, feeding to animals needs to be encouraged.

Noting that crop-livestock interactions permit better exchange of resources (draft power, manure, crop residues), processes useful in adaptation, more adaptation processes should take place on uplands or be associated with the

BOX 8

KEY LESSONS

Crop-livestock integration was not envisaged as an intervention by the project, and was not developed, but it will remain a very important area for scaling-up. It has significant potential for building resilience and developing crop-livestock synergies in a smallholder system operating under rainfed conditions, and where livestock are crucial resources in adaptation. The development of animal traction rather than the conventional mechanized ploughing could also be a more affordable and environmentally sustainable solution to the problem of climate change.

broader agricultural activities ongoing on uplands, to be augmented from increased yields from lowlands made possible by irrigation, and diversification in terms of horticultural crops.

7.2.4 Livestock farming and processing

The development of a vibrant livestock industry in this district presents excellent opportunities for climate change adaptation, since it will continue to provide livelihood options in the face of climate change and is both sustainable (if managed correctly) and scalable. Livestock are hardy to the expected future conditions, provided they have access to water, sufficient and nutritious grazing, and animal health services. The issue of water has been addressed above and can be remedied. The introduction of grazing and herd management (animal husbandry) is an important future direction (see below in this section) and the necessary interventions are available and scalable. The livestock health component of the programme is already showing positive impacts and requires further support.

Market demand exists and is growing in the towns, and the railway provides a ready means of transport to outside markets. The construction and equipping of a modern slaughterhouse and meat packaging facility will provide immense benefits to the district and pave the way towards the further development of the livestock industry. The facility is a model intervention for such a region, since it will be entirely self-sufficient in terms of energy and water requirements, will create stable employment opportunities, and has the potential to turn Mapai into a major livestock centre for the province. In addition to meat, the facility could in future be expanded to cater for other ruminants, and include meat processing capability, for example, sausages.

It should be noted that the facility is entirely designed for cattle. As small ruminants raising is considered an important adaptation practice, especially for women and young adults, the facility should make provision for a few slaughter slabs to cater for small ruminants to encourage owners to aim at producing quality small stock that might benefit from higher prices from formal transactions around the slaughter facility. Although hides and skins may not be used now the new slaughtering and processing may bring opportunities to put these products into better use. It needs to be explored.

An approach to improving the rangelands near homesteads would be to improve the quality of the grazing material in the rangelands. A strategy to improve rangelands is to use hardy grasses and forage legumes that are drought tolerant, seed bearing and perennial (Agyemang, pers. comm. 2011). Under-

sowing rangelands with forage legumes and grasses will have potential to improve feed quality. After initial establishment, reproduction and distribution through animal faeces will establish these species across the rangeland. Such seeds of hardy forage legume and grasses for under-sowing in semi-arid regions are available at African institutions (Agyemang, pers. comm. 2011).

The livestock population in the District could potentially double in the coming decades from the current numbers, given the extensive rangeland that is available in the District. This provides a very important adaptation option to the rural population who are highly dependent on livestock (Jones and Thornton 2009). The potential impact on livestock greenhouse gas emissions as seen from national and global perspectives, is negligibly small.

BOX 9

KEY LESSONS

The introduction of the slaughterhouse could catalyse the modernization of the livestock sector and provide opportunities for marketing and livelihood diversification. This is a potentially appropriate adaptation response in areas endowed with livestock resources.

7.2.5 Community-based natural forest management

Community-based forestry management plans were developed in coordination with three communities. This document forms the basis of improved forest resources management, including the sustainable harvest of the major species. Management plans are being used by the community forestry management committees, of which there are now 12. The forest guards police their respective areas.

Unsustainable harvesting and deforestation for charcoal production presents one of the most serious problems, which if it continues in this manner, will critically undermine current coping options and future adaptive capacity to climate change. This activity is essential for livelihoods and if managed and regulated optimally by local communities, sustainable utilization of the forests will provide great resilience in the longer term. Workable models can be replicated and scaled up to other communities, districts, and other parts of the country

and region, where similar problems exist. Pilot projects should be launched to test more efficient kiln construction, and to integrate this with the proven community-based forest management model. This would reduce wood volumes used for this purpose, whilst still supplying the growing demand from the urban centres. More selective harvesting methods based on forest ecological dynamics and species value, would also be highly beneficial for sustained benefits.

BOX 10

KEY LESSONS

Urgent attention to managing and regulating the harvesting of forest resources, combined with the strengthening of alternative income generation from sources other than charcoal, is vital to climate change adaptation. The development of community forest management plans and the introduction of by-laws serve as a strong basis to maintain the ecological stability of the forests. This could be an example for up-scaling in other areas.

7.2.6 Diversification

Integrated fish and animal farming has potentially significant value as a climate change adaptation, and it was a useful exercise to test it in Chicualacuala. However, in this district, the approach has not been entirely successful: whilst the pigs are thriving, ducks and rabbits are not suitable, and fish production is well below its potential. The latter is partially attributable to lack of feed, the algae which depend on animal manure inputs and supplemental feed, which is not being given by all communities. Also, diesel-powered pumps are required to pump water into the ponds for replenishment (gravity not being an option here), and this reduces the perceived cost-benefit. This model requires re-examination and adjusting, perhaps based on fewer components e.g. combination of irrigated crop farming and pig farming (with suitable associated nutrition practices), which have both been successful in these communities. It requires a reduction in the persons managing the units (maximum five) which at the moment is too high and not efficient. If the fish farming must continue it should be detached from the piggery so that proper feeding of the fish is implemented with the right amount of fish fingerlings kept in each pond to attain the expected weights at catch. Full integrated fish and small stock may be considered when beneficiaries have good experience and skills in piggery and fish farming.

The introduction of beekeeping has multiple benefits (food, income, nutrition and health), few risks, has been well adopted, and generally shows good potential for expansion and scaling-up. It is based on a widely available and sustainable forest resource (provided the forests can be sustainably managed). Although this activity was not envisioned in the original project formulation, it has taken off very well, with promising results. Women, in particular, are taking an active part and are benefiting. Beekeeping could be converted into a microbusiness income generating activity. It should be further supported and scaled up.

The programme has sought to introduce interventions which have potential for broad-based increased income generation and gradual reduction of the heavy reliance on natural resources such as charcoal. However, early in the programme the focus was on increased food security and not on developing the value chain, with negative impacts arising from unexpected high yields of irrigated vegetables and a lack of commercial outlets. The development of microbusiness skills and market development require further support in the medium to longer term. Information is required for successful commercialization; this can be facilitated through increasing penetration of telecommunications (radio, cell phone), extension support and other communication channels.

BOX 11

KEY LESSONS

Diversification of the livelihood basis using livestock and forest resources will play an important part in adapting to climate change in this district and other similar areas. Beekeeping and integrated fish and small animal farming were activities not envisioned in the project document but have been initiated based on local requests. Such flexibility will be important in incorporating changes in climate change adaptation programmes, which will help build resilience. Furthermore, the development of value chains, particularly small enterprises, based on the resource endowment of the district, will be an important means to adapting to climate change.

7.2.7 Renewable energy to support agricultural development

The development of solar power and biogas to drive agricultural adaptation interventions, and to make better use of local waste, is an excellent and highly sustainable option under climate change. Biogas has the potential to become highly successful, but various technical elements needed for success must be

carefully considered. A regular and sufficient supply of manure or other animal waste is required for a biogas digester. This is feasible at the slaughterhouse, or where livestock are corralled in sufficient numbers for ready collection and feeding of manure to the digester. In Chicualacuala, livestock are very widely dispersed and the manure thus unavailable; they will have to be brought to community corrals attached to the biogas facility every night. Secondly, distribution of the bioenergy to individual homes and other buildings could become a barrier, where these are widely dispersed (as in many villages in the District). It can be an appropriate option for nearby schools, health clinics and public facilities.

BOX 12

KEY LESSONS

The use of renewable energy from the sun and organic waste, and its use for increasing production and value add should be supported at all times as a climate change adaptation. The technical considerations and barriers must be assessed before deciding on feasibility, particularly relating to biogas. The by-products of biogas can also be used for improving soil fertility, which is a serious constraint in the project area.

7.2.8 Climate information, communications, and technology development

The purchase and installation of a meteorological station, and extension of the radio-communications facility, was essential for the support of a developing agricultural sector and will play a significant role in climate change adaptation and strengthening resilience of crop and livestock farmers. The provision of seasonal and short-term forecasts, interpretation and dissemination of related analysis and recommendations, and effective district-level early warning of climate disasters, will help farmers to manage their activities more optimally. It is expensive and will thus require committed national and international support. This project is contributing towards this end by making an initial investment.

The CERUM also still needs to prove itself but has major potential. Significantly more thought and planning must go into making this a success.

This facility will provide a resource and platform for continued "trial and error" (pilot) testing and longer-term demonstration projects of new and improved activities for climate proofing. Beneficiaries should be given the opportunity to continue learning by doing, and being thus empowered to implement projects and introduce adaptive technologies, a process which should become a life-long driver of development, increased climate resilience and adaptation.

Both these interventions by institutional partners (INAM and INGC), with the support of FAO, form part of their longer-term development plans, show particular potential to contribute to long-term sustainability. Both were included in the programme at the institution's direct request, thanks to sufficient flexibility in the funder's guidelines.

BOX 13

KEY LESSONS

The right climate-related information at the right time is an essential element of any farming operation, equally for subsistence and small-scale farmers in vulnerable marginal areas. This will become even more important under climate change and will make a significant contribution to developing climate resilience.

7.3 SCALING-UP

This paper has documented the experiences, successes and challenges of FAO within the JP, and drawn lessons learned for use by policy-makers and climate change adaptation practitioners. The communities in the study site, the Chicualacuala District, are highly vulnerable to climate change and possess few options with which to build climate resilience. The JP has identified some adaptive interventions that have clearly had a positive impact on the improvement of productivity, broadening of the livelihood basis, and building of community resilience to climate change.

Adaptation to climate change is a long-term process and it may take time to change the behaviour and practices to which communities are accustomed, in order to ensure future sustainability. The lowland farmers' emphasis on tractors and mechanization, as opposed to conventional animal traction, is an

example that points to the need to continue working with the communities. A paradigm shift will be required, and this is a task which cannot be accomplished in two or three years. Continuation of engagement with the communities and re-inforcement of messages and changes in practices are required. This must be seen as a long-term effort which will demand considered future programme designs and government involvement at all levels.

7.3.1 Social cohesion and gender

From the experience of the JP, adaptation interventions are not solely of a technical nature, and there are other important factors that underlie adaptive capacity, notably social cohesion and gender issues.

In communal systems, strong social cohesion can multiply benefits, whereas lack of social cohesion can doom an activity to failure. Some of the FAO interventions were negatively influenced by community conflicts, and sometimes poor organization thwarted the conversion of opportunities into shared benefits. The JP experience has been that active target group participation and sense of ownership by community members and their leaders play an important role in the success of initiatives, but may take time. Given sufficient time, changing attitudes will lead to sustainable changes in resource use practices and a greater sense of responsibility towards current and future generations. Linked to this, JP-led exchange visits between farmer associations as a way to convince newly approached communities of the feasibility of new techniques or methods, have been particularly successful, and should be continued.

The effectiveness and sustainability of climate change adaptation is dependent on the differential vulnerabilities and capacities to adapt between men and women. The JP planning documents reflected this, although it did not become a major focus as the project progresses. While the programme has introduced a few activities benefiting primarily women (fish farming integrated with small livestock production, agroprocessing), gender specific activities in this part of

BOX 14

KEY LESSONS

Social cohesion and gender dynamics play a very important role in the ability of communities to adapt to climate change. Successful scaling-up of promising adaptation interventions must take this into account.

Mozambique are not perceived to be a priority. The stronger focus has been on more equal gender participation in programme related activities. From discussions with female and male beneficiaries it emerged that women initially strongly resist change, but once adopted and convinced of the benefits, they become vibrant multiplier agents and mentors.

7.3.2 Key interventions for scaling-up

Based on the experience of the JP, adaptation interventions that are highly recommended for scaling-up are based on the existing natural resource base of the district, namely water, crops, livestock and forests.

Small-scale irrigation is an important adaptation option which can be scaled up to other areas, but should not be mainly dependent on the Limpopo River due to the uncertainty surrounding the future of this resource (Pegram *et al.* 2011). Rather, the groundwater resource (within the boundaries of re-charge capacity), and water collected in small dams could be used. It can draw on currently accepted principles of conservation agriculture, namely crop rotation and intercropping, and maintaining soil cover through mulching. This approach can be broadened to also benefit livestock and form the basis for crop-livestock integrated farming based on draft power. This is particularly important for building resilience in semi-arid smallholder systems.

The greater use of livestock resources can be scaled up, including diversification of the species used, which would benefit women. This can be combined with agro-ecologically friendly approaches to dryland crop farming, agroforestry, and synergies with small-scale crop irrigation. The modernization of livestock practices, for example through the introduction of proper slaughterhouses, will encourage marketing, the development of value chains and thus livelihood diversification and resilience.

Community-based forest resources management and regulation, based on associations and community forest management plans and by-laws, shows much potential scaling-up to other areas. It will provide long-term benefits in the face of climate change. In addition, forests offer a basis for livelihood diversification, for example beekeeping, which are well suited for scaling-up.

Livelihood diversification based on livestock resources offer scalable opportunities which the JP experience found to be successful, for example, the integration of small animal farming with other farming activities. This also offers further opportunities for developing value chains and thus builds resilience.

Supportive technologies which can make a significant contribution include renewable energy and district-level climate information and communications, and a local centre (CERUM) for development of climate-adaptive technologies.

Solar-powered pumps and biogas represent technologies which are win-win: energy is provided for productive purposes and development of alternative livelihood activities, whilst not contributing further to the causes of climate change. The more efficient use of locally available resources, in the form of hitherto unused waste products from both crops and livestock, should form a part of any adaptation strategy and can be scaled to other areas. Locally relevant information and research services should underpin all efforts towards long-term adaptation support to rural communities.

7.4 CONCLUSION

A large segment of the rural population of southern Mozambique is highly vulnerable to climate change and variability. The Government of Mozambique and its development partners should urgently look into ways of investing and implementing programmes in support of locally contextualized development that simultaneously serves to build climate resilience. As highlighted in this publication the FAO adaptation intervention of the UNJP provides useful lessons for follow-up programmes at a larger scale. To ensure success and sustainability, a project such as the JP should be strongly informed by careful and considered project design and formulation, sufficiently long design and inception phases, a phased approach to implementation with feedback loops built in to accommodate learning, and full involvement of the communities and intended beneficiaries from the start.

Failure to urgently start actions towards building climate resilience in southern Mozambique could have dire economic and social consequences for the region and undermine the progress made in improving food security and poverty of the last decade. The mechanisms for follow-up action could be many and should be approached flexibly and cautiously, taking into account the natural resources base, vulnerability and adaptive capacity of the population.

The UNJP experiment with "Delivering as One UN" is still a viable way for implementation of climate change adaptation programmes/projects at country level. As pointed out in this publication, the programme has some constraints and limitations in its coordination and delivery. The authors are nevertheless convinced that the approach is conceptually sound and worth continuing, particularly in the area of climate change. It should continue to be used in future climate change adaptation programmes. The national government also has a very important role to play in this, by creating an enabling environment that will help others to participate effectively in this effort.

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