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MALAWI CLIMATE CHANGE VULNERABILITY ASSESSMENT

SEPTEMBER 2013

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ARCC

African and Latin American Resilience to Climate Change Project

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African and Latin American Resilience to Climate Change (ARCC)

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ACRONYMS AND ABBREVIATIONS

ARCC	African and Latin American Resilience to Climate Change
ASF	African Swine Fever
ASWAp	Agriculture Sector-Wide Approach
CADECOM	Catholic Development Commission in Malawi
CCM	Community Climate Model
CISANET	Civil Society Agriculture Network
CMIP	Coupled Model Inter-comparisons Project
COP	Conference of the Parties
CSAG	Climate Systems Analysis Group
DCCMS	Department of Climate Change and Meteorological Services
DHS	Demographic and Health survey
DEO	District Environmental Officer
DISCOVER	Developing Innovative Solutions with Communities to Overcome Vulnerability through Enhanced Resilience
EAD	Department of Environmental Affairs
ECF	East Coast Fever
EMP	Environmental Management Plan
ENSO	El Niño Southern Oscillation
ESP	Environmental Support Project
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FISP	Farm Input Subsidy Program
FMD	Foot and Mouth Disease
FtF	Feed the Future
GBI	Green Belt Initiative
GCM	Global Climate Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GES-DISC	Goddard Earth Sciences Data and Information Services Center
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoM	Government of Malawi
GTZ	German Organisation for Technical Cooperation
Ha	Hectare
IGA	Income-Generating Activity
INC	Initial National Communication
IOD	Indian Ocean Dipole

IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IWRM	Integrated Water Resource Management
KII	Key Informant Interview
LEAD	Leadership for Environment & Development
MEGS	Malawi Economic Growth Strategy
MGDS	Malawi Growth and Development Strategy
MK	Malawi Kwacha
MoECCM	Ministry of the Environment and Climate Change Management
MoNREE	Ministry of Natural Resources, Energy and the Environment
MW	Megawatt
NAC	National Aquaculture Center
NAP	National Adaptation Plan
NAPA	National Adaptation Programmes of Action
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
ND	Newcastle Disease
NEAP	National Environmental Action Plan
NEP	National Environmental Policy
NGO	Nongovernmental Organization
NOAA	National Oceanic and Atmospheric Administration
NSSD	National Strategy for Sustainable Development
OA	Options Analysis
OPV	Open Pollinated Variety
PRA	Participatory Rural Assessment
RCP	Representative Concentration Pathway
SIOD	Subtropical Indian Ocean Dipole
SOER	District State of Environment Report
SOMD	Self-Organizing Map-based Downscaling
SPLU	Starter Pack Logistics Unit
SST	Sea Surface Temperature
TIPLU	Targeted Inputs Programme Logistics Unit
Tmax	Monthly Mean Maximum Temperatures
Tmin	Monthly Mean Minimum Temperatures
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention for Climate Change
USAID	United States Agency for International Development
USD	United States Dollar
VA	Vulnerability Assessment

VCA	Value Chain Analysis
WALA	Wellness and Agriculture for Life Advancement
WFC	World Fish Center
WRB	Water Resources Board
WRI	World Resources Institute
WSSD	World Summit on Sustainable Development
WUA	Water Users Association

EXECUTIVE SUMMARY

The Malawi Vulnerability Assessment (Malawi VA) was an initiative of the United States Agency for International Development's (USAID) African and Latin American Resilience to Climate Change (ARCC) program.[1] Its goal was to understand current and projected climate change impacts in central and southern Malawi, and to explore to what extent national and district government entities, rural communities, and households are equipped to adapt to those impacts. The research was based on the premise that a climate change vulnerability assessment of rural livelihoods will be useful to guide USAID's food security programming and climate change investment decisions. The findings presented in this report are derived from a three-phase analysis effort. Through this effort, the Malawi VA team attempted to unravel a climate change storyline across many themes: agriculture, fisheries, water and natural resources, livelihoods, and (to the extent possible) institutions and policies.

The Malawi VA recognizes two climate change response options: mitigation and adaptation. **Adaptation** was the focus of this study. The analytical framework used to compile the Malawi VA results was based on the common model of **vulnerability** as a function of **exposure, sensitivity**, and **adaptive capacity**. The Malawi VA focused its analysis primarily on exposure, sensitivity, and adaptive strategies (rather than adaptive capacity).

Because of the depth of analysis carried out during the Malawi VA, a further refinement of "**degrees of impact**" provides a framework for a deeper analysis than would otherwise be possible. Using this further refinement, **exposure** aligns to the direct (or "first degree") manifestations of the climate system: temperature, precipitation, winds, and hazards such as flooding and drought. Sensitivity is expressed as second- and third-degree impacts, where the second-degree impacts are the spontaneous adaptation of the biophysical world to the climate changes, and the third-degree impacts are the socioeconomic impacts. (The Malawi VA also looked at adaptive strategies, strategies that populations and agricultural market systems use to address the second-and third-degree impacts.) Thus, the "degrees of impact" framework aligns to the standard model while enabling a systematic exploration of increasing complexity. However, in moving from first-degree to higher degrees of impacts, attribution of change to climate alone becomes increasingly difficult.

The Malawi VA distinguishes **climate variability** (variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events, such as droughts and floods) from **climate change** (shifts in the mean state of the climate or in its variability persisting for extended periods of time [decades or longer]).

Key to building the foundation for the entire Malawi VA was understanding the current and projected manifestations of climate change in the study area of central and southern Malawi. For this, the Malawi VA team is carrying out a climate modeling and downscaling exercise. Understanding communities' vulnerability to climate change was accomplished through in-depth participatory rural assessment exercises carried out in nine representative villages in eight districts, supplemented by almost 50 key informant interviews (KIIs). In addition, the Malawi VA team conducted detailed agricultural studies of six crops identified as being significant for food security and of interest to USAID: maize, sorghum, groundnuts, pigeon peas, cowpeas, and soybeans. These agricultural studies included phenological studies, value chain analyses, and economic analyses. The Malawi VA also carried out studies in the areas of fisheries, water resources, and natural

[1] ARCC is a three-year, USAID-funded program to provide technical, analytical, and project assistance, as well as capacity building, to promote adaptation to climate change in a way that improves the ability of vulnerable populations to respond to climate challenges and safeguards economic growth. The program focuses on promoting the Economic Growth Objective within the USAID Foreign Assistance Framework by promoting adaptation to climate change and integration of adaptation into other economic investments to safeguard and promote sustainable, climate-resilient growth.

resources management. Throughout these analyses, the Malawi VA team recognized the confounding factors of population pressures and poverty, environmental degradation, and the constraints imposed by incomplete or limited institutional capacities and regulatory oversight.

Results from the Malawi VA **climate analysis** underscored the variability of Malawi's climate, which is strongly influenced by at least three powerful external drivers: the El Niño Southern Oscillation (ENSO), an Indo-Pacific phenomenon that modulates circulation; the Indian Ocean Dipole (IOD), an equatorial pattern that affects rainfall; and the Subtropical Indian Ocean Dipole (SIOD), which may be linked to higher than normal rainfall in southern Africa. The uncertainties introduced by these strong external atmospheric drivers, along with uncertainties in future greenhouse gas emissions, contribute to considerable uncertainty in climate projections for the region and greatly restrict the ability to isolate climate change from normal climate variability.

Even so, several climate change trends are already observed and are expected to intensify during the coming decades. The Malawi VA climate modeling results show that a gradual increase in average annual temperature is already occurring and will continue; rural farmers interviewed during the participatory rural assessment exercise confirmed these historical trends. The climate models also showed that the largest increases in temperature were projected to take place during the early summer months—just when planting begins and crops germinate. Farmers reported that rain was more erratic, while the historical climate analysis revealed that rainfall patterns are already shifting, with later rainy season onset in most areas of the country and earlier cessation in all areas. The climate models showed that this trend is expected to continue into the future, with average monthly rainfall expected to decrease during the months of December and January, and increase during the months of February, March, and April. Overall, the rain day frequency is expected to decrease slightly while dry periods (between rain days) are expected to increase. However, reductions in total annual rainfall is not necessarily predicted for all areas—in many areas, heavier rains may make up for the shortfall in rain day frequency.

Heavier rains, less predictable rains, hot spells, and extended dry periods all contribute to making farmers' decisions regarding planting and harvesting more difficult. In response to the changes they have already observed, farmers have been altering the dates for planting their crops and making use of selected seed for shorter cycle crops. Some are clearing land and planting crops closer to streams and lakes. Farmers are increasing their use of conservation agriculture techniques to conserve soil moisture, as well as investing in dry season irrigated vegetable gardens. Many are adopting intercropping and diversifying their crops.

Looking toward an uncertain climate future, the Malawi VA focused on six crops of particular relevance to USAID/Malawi programming: maize, soybeans, sorghum, pigeon peas, cowpeas, and groundnuts. **Maize**, mostly rain fed, is considered the most important food staple in Malawi. Yet since 1990, regularly occurring droughts have significantly compromised maize production throughout the country, resulting in food shortages that now take place every two to three years. The projected impacts on maize due to climate change—and the anticipated periods of extreme heat and droughts—include a high to very high potential for decreased productivity and decreased yield.

Sorghum was an important staple in Malawi prior to the introduction of maize, and is still regularly grown as a source of food and for brewing beer. Recently, sorghum production has been increasingly affected by poor and unpredictable rainfall. However, in the future, sorghum may begin to replace maize due to its drought tolerance, albeit with a moderate potential for reduced productivity due to the increased temperatures predicted by the climate change modeling. Irregular rains also fuel fungal growth in sorghum—a challenge for post-harvest handling.

Malawi is one of the most important **groundnut** producing countries in southern Africa; groundnuts represent a quarter of household-level agricultural income in the country. In addition to a food source, groundnut hulls are valuable as fodder for animals and fuel. Additionally, growing groundnuts helps fix atmospheric nitrogen in soils, enhancing soil fertility. Late onset of rains has already led to the adoption of early maturing varieties, rather than drought resistant varieties. Early maturing varieties cope better with low rainfall, but then the very labor-intensive groundnut harvest period overlaps with that of other crops. Expected future temperature increases and variable precipitation are highly likely to decrease groundnut productivity, while the continued occurrence of late, heavy rains will negatively impact early maturing varieties by promoting aflatoxin, which will in turn limit export market opportunities.

Pigeon peas rank as the third most important legume crop after groundnuts and beans; farm households consume about two-thirds of the pigeon peas produced in Malawi. Pigeon peas can withstand low moisture conditions and do well in areas with low rainfall. As a drought- and temperature-tolerant legume able to tolerate low soil fertility, production will likely increase with climate change, especially in southern Malawi. Pigeon peas' seed yield is expected to decrease slightly due to seeds' sensitivity to drought. The earlier maturing (preferred) varieties tend more toward decreased yields and post-harvest, pest-related losses (primarily from weevils and aphids); new varieties are being developed to counter these disadvantages.

Cowpeas are important in poor rural regions throughout the semi-arid and sub-humid areas of east and southern Africa, and Malawi is no exception. Cowpeas are widely known as the "crop of the poor" because the plant's green pods and leaves are the earliest food available before cereals mature. As such, cowpeas serve as "insurance" against food shortages during the "hungry season." Cowpeas adapt well to climate stresses during reproductive stages, but are not drought resistant. Drought, heat, poor soil fertility, and inappropriate agronomic practices all contribute to low productivity. Projected changes due to climate change are a slight to moderate decrease in productivity due to extended periods of drought.

Soybeans can grow at a range of altitudes and temperatures, and they require little water. Production of soybeans in Malawi has been irregular, mostly driven by external factors (donor pressure and export markets), due to the plant's nitrogen fixing properties and multiple uses: feed for livestock and fish, bio-fuel and industrial oil, and for human consumption. Yet medium-maturing varieties are already being negatively affected by late rains that augment fungal infections. The future for soybean production in Malawi is uncertain, as pressures by donors and export markets to increase production will be countered by high sensitivity to planting conditions (difficult with late onset, or erratic, or heavy rains, especially for medium-maturing varieties), together with drought intolerance in early stages.

Clearly, a robust agriculture sector requires reliable **water** sources. Historically, Malawi has enjoyed an abundance of surface water. In fact, surface water comprises more than 90 percent of total water availability in Malawi, and precipitation is its principal source. This abundance has allowed the country to develop large-scale irrigation systems and an important hydropower industry, both of which contribute significantly to the nation's economy. Hydropower provides the country with almost all of its energy usage. This hydropower comes from just five power plants on the Shire River, fed by Lake Malawi; fluctuations in the level of Lake Malawi directly affect river flow rates.

Already the impacts of climate change on water availability in Malawi are evident. Erratic rains, extended dry periods, and increased evaporation have combined with population growth and increased water demand to turn Malawi's historical water abundance rapidly into water scarcity. In fact, due to low lake levels beginning in 1997, electrical power production is often rationed at the end of dry seasons, typically in October and November. Although climate change may increase wet season surface water yields slightly, this will be more than offset by dry season decreases. Overall, climate change will contribute to a reduction in the total water balance by as much as one-half by 2035.

In the face of climate change, competition for this water will certainly grow worse. It is expected that smallholder farmers currently reliant on rain-fed agriculture will divert water toward supplemental small-scale irrigation, further reducing the water available for large-scale irrigation systems, hydropower, and municipal use. Other non-climate factors will exacerbate the situation, including mining, urbanization, and poor land use practices. Although the country is moving toward a system of integrated water resource management, these nascent efforts are largely based on a first-come, first-served basis and are being applied in a context that lacks the solid institutional capacity needed to deal with the country's growing and significant water scarcity challenges. In addition, these approaches do not yet capture or regulate small-scale users nor consider the likely shortages due to the impacts of climate change.

In addition to Lake Malawi and the Shire River, among the most threatened of Malawi's water sources is the small but economically important **Lake Chilwa**. Lake Chilwa is the source of about one-quarter of the fish production in the country. With a maximum depth of just five meters, the lake is surrounded by wetlands. In the past, seasonal lake-level fluctuations have left the lake partially or completely dry—Lake Chilwa completely dried in 1968 and 1995. Such dryings are expected to increase with climate change; the shallow depth and very low total volume of the lake make for conditions of a very fragile hydrologic system, one especially vulnerable to variability in precipitation and increased evaporation.

Not only in Lake Chilwa, but throughout Malawi, it appears that **fisheries** have and will be increasingly impacted by climate change. In the mid-1990s, significant declines in 12 species of fish were recorded in Malawi. Although the specific nature of the impact of climate change on fisheries is not well studied or understood (owing to shortages of monitoring equipment and support for such research), it appears that impacts on fisheries biology, reproduction, productivity, and habitats may be associated with changes in temperatures, precipitation, and increased runoff into lakes and streams. Winds can change upwelling patterns in the lake and indirectly induce migration of fish to other areas, often further from the shoreline. Intense rains can lead to soil erosion, high rates of runoff, and siltation, creating an environment in which fish cannot fertilize their eggs or protect their nests. Heavy siltation may also hinder fishes' ability to migrate.

Many factors other than climate change also contribute to the decline of fisheries in Malawi: overfishing and a failure to observe laws and regulations designed to support sustainable use of fisheries, changes in land use (particularly conversion of forests to cropland with resulting erosion), expansion of small-scale irrigation through stream diversion, and eutrophication due to agricultural runoff. While fish stocks are directly affected by changes in climate variables, the decrease in the volume of fish catches is much more difficult to attribute to climate because of these confounding human factors.

In other areas of **natural resources**, the impacts of climate change are increasingly being felt and exacerbating the effects of environmental degradation, population pressures, widespread poverty, and unsustainable land use practices. The combination of deforestation with increased rainfall runoff and accelerated erosion are contributing to land degradation on a large scale in Malawi. In addition to non-sustainable agricultural practices, climate change may contribute to reduced soil moisture (e.g., increased evaporation rates). Increased droughts make forests more vulnerable to wildfires. Ungulates (both domestic and wild) are especially vulnerable to climate-related changes in habitat and food supply.

All of the climate manifestations, biophysical impacts and disruptions to crops, water, fisheries, and other natural resources have had a role in influencing the **livelihoods** of rural communities in central and southern Malawi. Once primarily dependent on agriculture, these communities are finding that their agricultural lands, often degraded through poor husbandry and lack of access to fertilizer, are being further degraded due to soil leaching by heavy rains and floods. Floods can bring sandy soils that do not retain moisture. Erratic rainfall constrains crop choices, with maize particularly affected. Increased population puts pressure on arable lands, a shrinking commodity. As a result, many farmers are moving to new areas that may be less suitable, such as previously shared-resource areas like wetlands (*dambos*) and forests, to compensate for decreasing yields and competition for land.

Although nationally agriculture remains the most important sector of Malawi's economy, today, individual farmers are questioning agriculture's future viability as a reliable source of household income. Nearly all households studied during the Malawi VA are searching for alternative ways to increase revenues to compensate for lower yields—and most start their search in the natural reserves closest to home. All across central and southern Malawi, the most significant reported income-generating activity (IGA) is increasingly derived from forest products; in their efforts to cope with the impacts of climate change, most rural households are investing more time and effort in harvesting, producing, and marketing charcoal and firewood. Other alternatives are timber harvesting and hunting, both limited and dwindling options.

Farmers are already changing the timing and patterns of cropping and replacing crop types. Some farmers are starting to replace agricultural plots that are no longer productive with small-scale aquaculture. These small fish farming enterprises contribute to food security as well as income generation. Some are attempting to cope with declining soil fertility by increasing their use of manure and compost. Additionally, some are taking steps to protect and regenerate trees in cultivated fields in order to help replenish soil organic matter through leaf drop and leaf litter. There is also an increasing reliance on casual labor and remittances as strategies to improve livelihoods. Other alternatives are brick making; collecting mushrooms, fruits, and wild honey; and collecting reeds for weaving into mats.

While farmers and rural community members in Malawi have proven to be quite innovative in responding to climate change, more attention is needed to monitor their chosen coping responses and to encourage a genuine transformation from coping to adaptation—especially for the poorest households whose options are severely limited. The truly successful and sustainable adaptation strategies over the longer term are those that contribute to adaptive capacity and resilience to climate variability, and which are not linked to the unsustainable use of natural resources. Further, not all adaptation strategies will be appropriate for everyone, or will be appropriate under all future climate scenarios. It will therefore be critically important to provide Malawians not simply with recommendations but with a range of options. This, in turn, relies on raising awareness of the likely climate change trends and their impacts in Malawi, and on providing the knowledge, skills, training, and resources needed to enable and empower people to select and exercise a diversity of options, as required; in other words, to build **adaptive capacity**.

By focusing on increasing the resilience of the country and its communities, individuals, and natural assets to climate change and climate variability, USAID's adaptation efforts will help protect existing investments, maintain development gains, and contribute to economic security. USAID supports three broad categories (pillars) of adaptation activities:

- **Improving access to science and analysis for adaptation decision making.** Strengthening knowledge about what to expect and what can be done to adapt to climate change.
- **Establishing effective governance systems for adaptation.** Supporting engagement, coordination, participation, and planning processes, including building the capacity of key institutions, necessary for effective, longer-term adaptation.
- **Identifying, promoting, and piloting actions that increase climate resilience.** Implementing adaptation strategies that deliver development gains in a changing climate.

The results of the Malawi VA informed an **options analysis** of potential responses. The options analysis explored approaches to strengthen adaptive capacity and risk management across communities and institutions at all appropriate scales. The options analysis also distinguished longer-term, climate-specific interventions that seek to enable Malawi to deal better with a volatile, uncertain, complex and ambiguous future from shorter-term, "no regrets" options that react to climate variability and change already underway. By focusing on increasing the resilience of the country and its communities, individuals, and natural assets, USAID's climate change adaptation efforts will help protect existing investments, maintain development gains, and contribute to economic security.

1.0 INTRODUCTION

The Government of Malawi (GoM), through its Agriculture Sector Wide Approach (ASWAp; GoM, September 2010), prioritizes investments in three strategic areas: food security and risk management; commercial agriculture, agro-processing, and market development; and sustainable agricultural land and water management. The ASWAp recognizes the potential adverse impacts of climate change on agricultural production and addresses this in collaboration with other ministries. The ASWAp also includes a number of actions to mitigate and adapt to climate change. Concurrently with the ASWAp, the GoM is addressing climate change at the national level through numerous strategies and action plans. For example, Malawi's 2006 National Adaptation Programmes of Action (NAPA; GoM, March 2006) created the momentum to establish the National Climate Change Steering Committee and its Technical Working Group. The GoM has also refocused its efforts to develop its climate change programs further by restructuring and strengthening its institutions and committing to the preparation of a national climate change policy. The Ministry of Environment and Climate Change Management has been created; several of its units, including the Department of Climate Change and Meteorological Services (DCCMS), have new mandates and more relevant and empowered terms of reference. The Department of Environmental Affairs retains its responsibility for implementation of the NAPA and remains the critical hub for climate change coordination. Several donors support elements of the NAPA and have committed resources to strengthening the capacity of critical government entities to conduct analyses, prepare action plans, and implement programs aimed at improving the resilience of local governments and communities.

In this context, the United States Agency for International Development (USAID) identified the need for a food security/agriculture sector-based vulnerability assessment relevant for all donors, which can in addition support analytical needs specific to informing USAID's Feed the Future (FtF) initiative and programming future climate change initiatives. USAID also supports a large livelihoods and food security initiative under its Wellness and Agriculture for Life Advancement (WALA) program. Both the FtF and WALA programs focus on the central and southern regions of Malawi. The African and Latin American Resilience to Climate Change (ARCC)[2] Malawi Climate Change Vulnerability Assessment (Malawi VA) was initiated to:

1. Design and implement an approach for a climate change and climate variability vulnerability assessment and analysis of adaptive strategies for food security, agriculture, and other targeted sectors.
2. Determine climate change vulnerabilities and recommend options and adaptive strategies for USAID that will inform decision making generally in three sectors or subsectors, (e.g., food security, water resources, and fisheries) and a more in-depth analysis of FtF priority components.
3. Contribute to overall USAID mission programming for climate change initiatives.

This assessment was also intended to inform the development and possible preparation of a National Adaptation Plan (NAP) for the GoM that responds to its obligations under the United Nations Framework Convention for Climate Change (UNFCCC).

The Malawi VA consisted of 10 separate sub-components:

1. An initial scoping mission;

[2] ARCC is a three-year, USAID-funded program to provide technical, analytical, and project assistance, as well as capacity building, to promote adaptation to climate change in a way that improves the ability of vulnerable populations to respond to climate challenges and safeguards economic growth. The program focuses on promoting the Economic Growth objective within the USAID Foreign Assistance Framework by promoting adaptation to climate change and integration of adaptation into other economic investments to safeguard and promote sustainable, climate-resilient growth.

2. In-depth participatory rural assessment in nine representative villages;
3. A total of 46 key informant interviews (KIIs);
4. Two stages of climate change modeling;
5. A fisheries study;
6. A natural resources and biodiversity study;
7. A water resource study;
8. Phenological studies of six crops;
9. Six value chain analyses, each conducted in three stages; and
10. Economic studies of six crops.

The results of the assessment will be used as input for an adaptation options analysis.

This document reports on findings resulting from the Malawi VA, findings derived from a three-phase analysis effort. Phase 1 consisted of initial data collection, analysis, and modeling. Phase 2 revised the preliminary findings with additional data collection and modeling, completed the second stage of the value chain analyses by incorporating the results of the phenological[3] studies, and initiated the first stage of results integration. Most important among the Phase 2 efforts are refinements to the preliminary climate change analyses and modeling future climate change projections; these refinements were used to revise the preliminary agricultural value chain and economic assessment results. Phase 3 completed the final stage of the value chain and economic analyses; completed the results integration; and compiled this final, comprehensive report that integrates all of the VA findings in a unified manner.

[3] In this context, phenology refers to the study of plant life cycle events (phenological "stages") and how these are influenced by seasonal and inter-annual variations in climate. Examples include the date of seed germination, the emergence of leaves and flowers, or the appearance of tassels in the case of maize. For the Malawi VA, phenological studies were carried out for six crops.

2.0 THE MALAWI VA STUDY

2.1 GOALS AND RESEARCH QUESTIONS

The goal of the Malawi VA was to understand the current and projected impacts that climate change has and will have on central and southern Malawi and to explore to what extent national and district government entities, rural communities, and households are equipped to adapt to those impacts. The research was fueled by the hypothesis that a climate change vulnerability assessment of rural livelihoods (focusing primarily on agriculture, but also taking into consideration fisheries, water, and natural resources) will be useful to guide USAID's food security programming and climate change investment decisions.

The questions that guided the Malawi VA were the following.

1. **What are the *current and projected* geophysical (first-degree) manifestations of climate change in central and southern Malawi?**
   To what extent and how…

   a. Have and will *temperatures* change?

   b. Have and will the timing and quantity of *precipitation* change?

   c. Which manifestations are attributable to climate change as opposed to climate variability? Can we distinguish and attribute impacts between the two?

2. **What are the *current and projected* biophysical (second-degree) impacts of climate change in central and southern Malawi?**
   To what extent and how do the first-degree climate manifestations above have an impact on…

   a. *Agricultural* production (i.e., though phenology)?

   b. *Water* resources?

   c. *Fish* stocks?

   d. Other *natural resources*?

3. **What are the *current and projected* socioeconomic (third-degree) impacts of and adaptations to climate change in central and southern Malawi?**
   To what extent and how do the changes and impacts above influence…

   a. National and district *governance* (i.e., through public policies and investments)?

   b. Malawian *value chains*[4] and the *production costs* of six main crops?

   c. Malawian *livelihood* choices and community and household *well-being*?

[4] A value chain analysis and production costing naturally includes the phenological stage of production, as the first—and likely most sensitive—of the links of the agricultural chain. While phenology is included in the second-degree biophysical question and analysis (see question 2a), the rest of the chain is intricately and inextricably linked to the human system and therefore best explored under Question 3 on socioeconomic impacts. Although crop growth and yield is explored under second-degree impacts (Question 2a), the cost of production is addressed under third-degree impacts (Question 3b). The impacts of temperature and rainfall changes on roads, transportation, and processing infrastructure do not reflect directly on the biophysical system (they do not alter the phenology or resulting yield of the crops), but on the socioeconomic system (assuring their progression from field to table); as such, these issues are also addressed under the third-degree impacts (Question 3b).

    d. What is the current adaptive capacity of (a) through (c) above in light of future climate change programming? What opportunities do they present?

4. It is intended that the results of the VA will lead into a discussion of **which programming options and investment opportunities are most likely to strengthen resilience to climate change among the target groups?**

    a. Which sectors/subsectors offer the most robust ("no/low risk" or "no regrets") options for action?

    b. If adaptation, which pillar, by sector, provides the most promising investment opportunities, and which actions surface as key in:

        i. Improving access to science and analysis for decision making?

        ii. Establishing effective governance systems for climate resilience?

        iii. Identifying and replicating actions that increase resilience?

2.2 CONCEPTS, TERMINOLOGY, AND FRAMEWORK

2.2.1 CONCEPTS AND TERMINOLOGY

The Malawi VA aimed to identify the main sectors and subsectors that are being (or are likely to be) impacted by climate change, and to inventory and analyze the strategies that different levels (crops, communities, authorities) use (or could use) to respond to those impacts without endangering their well-being or mandate, respectively.

For the purposes of the Malawi VA, it is important that each component apply key terms, such as vulnerability, sensitivity, climate change, climate variability and impacts, mitigation, and adaptation in a consistent manner. The definitions of these terms are provided in Text Box 2.1 (following page).

Consensus holds that climate vulnerability is a function of three factors: **exposure**, **sensitivity**, and **adaptive capacity**. It is also accepted that **climate change** differs from **climate variability**, and that, when and where possible, impacts caused by one or the other, or both, are noted in this report. It is also recognized that there are two different response options to manage climate change: mitigation and adaptation. **Adaptation** is the focus of this study.

2.2.2 ANALYTICAL FRAMEWORK

The model used to compile the Malawi VA results was based on a common one of vulnerability as a function of **exposure, sensitivity**, and **adaptive capacity** (Intergovernmental Panel on Climate Change [IPCC], 2001). Because the Malawi VA focused on exposure, sensitivity, and adaptive strategies (but not adaptive capacity), the results are reported in a framework of **degrees of impact** to facilitate analysis. The vulnerability model and degrees of impact framework (see Table 2.1) are readily aligned: **exposures** are equivalent to first-degree climate impacts; these are the direct manifestations of the climate system (temperatures, precipitation, winds, and hazards such as flooding and drought). Second-degree impacts describe the **sensitivity** and spontaneous adaptation of the *biophysical* (e.g., phenology, crops, water, natural resources) world to the climate changes, and the third-degree impacts describe the socioeconomic impacts.

TEXT BOX 2.1. KEY DEFINITIONS FOR TERMS USED IN THIS REPORT

Weather describes atmospheric conditions at a particular place in terms of air temperature, pressure, humidity, wind speed and precipitation. (USAID, 2007)

> **Climate** is defined as the weather averaged over time (typically, 30 years).

Vulnerability 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. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is **exposed**, its **sensitivity**, and its **adaptive capacity**. (IPCC, 2007)

> Climate vulnerability = f (exposure, sensitivity, and adaptive capacity)
>
> While **exposure** describes above all changes in temperatures and precipitation, **sensitivity** is the degree to which a system is affected, either adversely or beneficially, by climate variability or change (IPCC, 2007). The effects that can be attributed to climate with at least some degree of confidence can be of first, second, or higher order (see Text Box 3.1).

Climate change is a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the properties and that persists for an extended period, typically decades or longer. (USAID, 2007)

> **Climate variability** differs from climate change in that the changes may not persist for an extended period (i.e., inter-annual variability). (USAID, 2007)

Climate impacts are changes triggered by exposure to changes in climate, measured relative to a continuation of present climatic conditions.

> **Climate changes** differ from climate impacts in that they are less immediate, more slow in coming, and relatively more persistent.

Climate mitigation entails technological changes and substitution that reduce resource inputs and emissions per unit of output.

Climate adaptation describes measures that reduce the vulnerability of natural and human systems against actual or expected climate change effects. USAID's climate adaptation program focuses on three pillars:

1. Access to science and analysis for decision making;
2. Effective governance systems for climate resilience; and
3. Identifying and replicating actions that increase climate resilience.

The "degrees of impact" framework aligns to the standard model while enabling a systematic exploration of increasing complexity: moving from first-degree to higher degrees of impacts, attribution of change to climate alone becomes increasingly difficult. For example, although a change in temperature is undeniably climate related, a change in what crops a farmer chooses to plant may reflect economics as much as climate. For the purposes of this report, whenever climate cannot be excluded from the set of drivers, the impact is retained as a "climate impact."

The extent of climate change *exposure* is explored directly by the climate modeling component of the VA, which provides an analysis of the first-degree geophysical impacts (or manifestations).[5] *Sensitivity* and *adaptive capacity* are addressed equally by the sectorial studies (water, natural resources, fisheries, and phenology) focusing on second-degree biophysical and third-degree socioeconomic impacts. It is well accepted that biophysical and human systems are both *sensitive* to climate change and that both, in turn, resort to

[5] Because first-degree impacts (temperatures, precipitation) are part and parcel of the climate system, the term "manifestation" is used.

adaptation when feasible. The Malawi VA, however, was invested more in an exploration of human system adaptation and did not aim to describe the manner in which plants evolve to survive warmer climates. The participatory rural assessments (PRAs), KIIs, and value chain and economic analyses more thoroughly explored third-degree adaptations. Examples are found in Table 2.1 below to illustrate the difference between first and higher degree impacts, changes, and confounding factors. The examples given are in no way exhaustive.

TABLE 2.1. DEGREES OF IMPACT FRAMEWORK

CLIMATE MANIFESTATIONS	BIOPHYSICAL IMPACTS and SOCIOECONOMIC IMPACTS	CONFOUNDING FACTORS *(Other drivers of change)*
Geophysical: • **Temperature** • **Precipitation** • **Wind** • **Extreme events** (e.g., flooding, droughts, heat waves) • **Sea level rise**	**Biophysical impacts:** • Disease, pest vectors, reduced yields (agricultural and fisheries), phenological effects, reduced access to water and natural resources… **Socioeconomic impacts:** • Reduced consumption • Change in livelihood patterns • Disruption to value chains • Infrastructure damage	• **Population pressure** and demographic shifts • **Poverty** • **Regulatory** environment inappropriate; weakly enforced • **Poor natural resource use** – Land use practices – Deforestation – Overfishing

The Malawi VA also looked at adaptive strategies—strategies that populations and agricultural market systems use to address the second and third-degree impacts. It is useful to explore the difference between coping and adaptation strategies. When a climate variable (temperature or precipitation) varies beyond a certain threshold, it may exert a negative influence on biophysical and human systems; that influence is hereby called a *climate impact*. The impact is recognized or measured by *changes* in the biophysical and human systems (such as wilting in the former or reduced consumption in the latter). When the impact or change refers to a human action (i.e., a third-degree impact), it is because most humans and human systems respond either by a coping (more immediate) or by an adaptation (more permanent) strategy. This is explored in depth in Section 5. Because the Malawi VA was not designed to measure adaptive capacity *per se*, this report focuses primarily on adaptive strategies. Section 6 attempts to tease out some adaptive capacity lessons, with adaptive capacity defined as "the ability of a system to adjust to climate change and to moderate potential damage, to take advantage of opportunities or to cope with the consequences" (see Section 6). Adaptive capacity thus goes beyond *adaptation*—adjustments that have been made by entities, assisted or spontaneously—to describe the full potential response to climate change. However, because of the lack of a standard metric to measure capacity, the degrees of impact framework retains the term *adaptation* throughout the other sections of this report (and the capacity is only implied).

2.3 VA COMPONENTS AND METHODOLOGY

The Malawi VA was a multi-dimensional assessment of climate vulnerability focusing mainly on the central and southern regions of the country.[6] The Malawi VA encompasses 10 components, as shown in Table 2.2 on the following page.

[6] This choice was deliberate to capture the current Feed the Future/WALA focus areas prioritized by USAID/Malawi, described in the "sampling" section.

TABLE 2.2. MALAWI VA COMPONENTS

Legend: ■ = Major element; ▒ = Also studied

VA Component	METHODS: Quantitative	METHODS: Qualitative	METHODS: Desk / Lit Review	METHODS: Primary Data Collection	ANALYSIS RESOLUTION: Scalar	ANALYSIS RESOLUTION: Spatial	ANALYSIS RESOLUTION: Temporal	SECTORS: Agriculture	SECTORS: Water Resources	SECTORS: Fisheries	SECTORS: NRM & Biodiversity	SECTORS: Institutions & Policies
Scoping Mission		■	■	■	34 KIIs, National	Lilongwe/Blantyre	Conducted June 2012	▒	▒	▒	▒	▒
Participatory Rural Assmt (PRA)	▒	■		■	9 villages in 8 districts	Central/South	Historical (50-5 years ago), current, 10 years ahead	■	▒	▒	▒	▒
Key Informant Interviews (KII)	▒	■		■	46 KIIs in 8 districts	Central/South	Current and anticipated changes for 2050	▒	▒	▒	▒	▒
Climate Modeling / Downscaling	■		■		22 Met. Stations	Countrywide	Historical (1997-2011) and projected (2020-40 & 2040-60)	▒	▒	▒	▒	
Fisheries Study		■	■	▒	Central/South	Field visits	Current			▒	▒	
NRM/Biodiversity Study		■	■	▒	Central/South	Field visits	Current				▒	
Water Resources Study		■	■	▒	46 KIIs, 3 water bodies	Field visits: Lks Malawi & Chilwa, Lower Shire River	Current and projected to 2010, 2025, 2035		■	■		
Phenology Studies (8 crops)		■	■		6 crops (national)	Countrywide	Current & projected scenarios	■				
Value Chain Analyses (6 crops)		■	■	▒	6 crops (national)	Countrywide	Current & projected scenarios	■				
Economic Analyses (6 crops)	▒	■	■		6 crops (national)	Countrywide	Aligned to climate projected	■				

As can be seen from the table, the Malawi VA combined a mixed-methods (quantitative and qualitative) and multi-scalar (central and southern Malawi, 22 meteorology stations, nine villages in eight districts, and six crops) approach to unravel the climate change story across many themes: agriculture, fisheries, water and natural resources, livelihoods, and (to the extent possible) institutions and policies. Nearly all of the components engaged in at least some primary data collection in Malawi. Although many of the components also provided quantifiable results, the most heavily quantitative component of the Malawi VA is the climate modeling. The 10 interlinked components are categorized into four study types:

- A PRA exercise was carried out in nine target villages selected to represent the diversity of livelihoods in southern and central Malawi, complemented by 46 KIIs with district authorities and partners (both covering eight districts);
- Two phases of downscaled climate modeling were conducted, which will result in an in-depth analysis of recent climate trends nationwide, as well as near- and longer-term climate projections.
- Thematic desk studies: a sector-specific study focusing on agriculture (phenology and value chain and economic analyses for six crops) plus three studies in related sub-sectors (fisheries, water resources, and natural resources/biodiversity). Most of these studies were reinforced with site visits and limited qualitative data collection in-country.
- Incidental, crosscutting desk studies in enabling areas (institutions and policies) were conducted.

The results of the Malawi VA will culminate in an options analysis activity that will engage all major stakeholders to evaluate and prioritize future climate change adaptation options.

The methodology and limitations of each of the 10 components are discussed briefly below. The PRA (and its linked KII), as a cornerstone of the Malawi VA, is described in more detail in Section 2.4.

2.3.1 SCOPING MISSION TO MALAWI

The initial scoping mission was carried out in June 2012. Four core members of the Malawi VA team held initial informal meetings at the University of Malawi, Bunda College, and the Civil Society Agriculture Network (CISANET), and gathered and reviewed documentation. Following the arrival of the USAID Africa Bureau Climate Change Advisor, the scoping team met with key USAID/Malawi staff to discuss the goals of the scoping mission and the wider VA. The team presented an update on what was known about the climate change vulnerability context in Malawi, discussed key knowledge gaps that had been identified, provided an overview of the objectives of the visit, and solicited Mission input. They discussed the current state of climate change adaptation activities in relation to the Mission's general areas of activity and interests (agriculture, food security, health, water, education, and disaster management including response to floods and droughts), and explored the scope of the VA including sectors, biophysical assets, district and regional contexts, and potential partners.

Following the in-brief, the team conducted key informant interviews with 34 agents and institutions, including GoM ministry representatives, multi- and bilateral donors, research institutions, nongovernmental organizations (NGOs), and civil society stakeholders. These interviews, in combination with a review of available documentation, provided a solid foundation of relevant recent and ongoing climate change projects in Malawi on which to build. The informants also helped to identify additional resource persons and institutions to be contacted by the Malawi VA team, along with additional documentation and references.

2.3.2 CLIMATE MODELING

Understanding the present and future geophysical manifestations of climate change in Malawi is key to building the foundation for the entire Malawi VA. For this analysis, the DCCMS provided rainfall records from 22 meteorological stations for the 15-year period of 1997–2011, and daily maximum and minimum temperatures for the 16-year period of 1990–2005.[7] These observed daily climate records were processed using a suite of automated quality assurance procedures developed by the University of Cape Town's Climate Systems Analysis Group (CSAG) to identity and remove any suspect values from the dataset. The climate records were found to be of high quality (~98 percent valid values), with only a few instances of missing or incorrect values or duplication of monthly time series between months within a year or between years. Not only were these data used to present historical trends and to investigate the role of drivers[8] of inter-annual climate variability; they were also used in a technique called "downscaling"[9] for future projections.

Three indices were computed for the 1997–2011 period. The data used to create the sea surface temperature (SST) indices were from the National Oceanic and Atmospheric Administration (NOAA) Optimum Interpolation Sea Surface Temperature V2 data (Reynolds et al., 2002). This monthly data is at a 1° x 1° spatial resolution and available from 1982 to 2011. Although only the 1997–2011 period for this analysis was considered, standardized monthly anomalies were calculated from the monthly data available from 1982–2011. The three indices were calculated as follows.

- Indian Ocean Dipole-SST anomaly difference between the western (50° - 70°E; 10°N - 10°S) and eastern (90° - 110°E; 10° - 0°S) tropical Indian Ocean (Saji et al., 1999).
- Subtropical Indian Ocean Dipole-SST anomaly difference between the western (55° - 65°E; 37° - 27°S) and eastern (90° - 100°E; 18° - 28°S) subtropical Indian Ocean (Behera and Yamagata, 2001).

[7] The analyses were based on available data. While rainfall records were available from all stations for the period 1997-2010, temperature data only up to 2005 were available from DCCMS.

[8] The drivers of climate variability referred to include the Indian Ocean Dipole (IOD), Subtropical Indian Ocean Dipole (SIOD), and El Niño Southern Oscillation (ENSO). The IOD is an irregular oscillation of sea surface temperatures in the Western Indian Ocean. When water temperatures drop, unusually strong winds push warmer waters toward Africa, possibly affecting the climate in Malawi. The SIOD refers to the warming of waters south of Madagascar that is related to above-normal precipitation and moist air across southern and central Africa. The ENSO refers to anomalous Pacific Ocean sea surface temperatures (El Niño refers to the warming and La Niña to the cooling) that are studied to bring drier than normal austral summers to eastern Africa.

- El Niño-Southern Oscillation (ENSO), defined as events where SST anomalies (five-month running mean) in the domain (120° - 170°W; 5°N - 5°S) exceed -0.4 °C (La Niña) or + 0.4 °C (El Niño) for six consecutive months (Trenberth, 1997).

The Global Climate Models used to downscale climate change projections came from the 2012 Coupled Model Inter-comparisons Project Phase 5 (CMIP5 [Taylor, 2012][10]) archive. This archive contains simulations of the historic and future climate yielded by multiple Global Climate Models (GCMs), assume a range of emission scenarios, and are produced by the world's leading climate modeling institutions.

The downscaling process utilized an empirical/statistical technique to approximate local weather conditions from regional-scale atmospheric variables that are provided by the GCMs. The technique, developed by CSAG, used is called Self-Organizing Map-based Downscaling (SOMD). This empirical downscaling technique for Africa provides meteorological station-level response to global climate change forcing.[11] The downscaling of GCM data is accomplished by deriving the normative local response from the atmospheric state on a given day, as defined from historical observed data. The method recognizes that the regional response is both stochastic as well as a function of the large-scale synoptics.[12] As such, it generates a statistical distribution of observed responses to past large-scale observed synoptic states. These distributions are then sampled based on the GCM-generated synoptics in order to produce a time series of GCM downscaled daily values for the variables in question (in this case temperature and rainfall). An advantage of this method is that, rather than use the relatively "unskilled"[13] grid scale GCM precipitation and surface temperature values, large-scale circulation (pressure, wind, and humidity) fields are employed.

From the downscaling results, it was clear that for many variables there were large disagreements between the various projections derived from different GCM models. The disagreements are presented as an "envelope" or range of projections. In this report, the range (envelope of possible values) is reported as the range between the 10th and the 90th percentiles of the ensemble of projections for each month of the year. For the 10 models considered, the result is exclusion of two models, one on each extreme. Thus, the range between the 10th and 90th percentile of the multi-model projections excludes extreme models but does not disregard the reality of uncertainty. All eight remaining model projections were considered as equally likely and hence all projections are included in the calculation of the projection envelopes.

During the first phase of the climate analysis, preliminary projections were computed using the data from the 22 stations. The analysis was carried out in late 2012. However, in order to encompass decadal variability into future projections, a considerably longer time period than that available from the 22 stations was required. Thus, the DCCMS provided an extended time series of data for five[14] meteorological stations, back to 1961. During the second phase of the climate analysis, these additional data were used to drive the trends and near-term projection analyses for 2020-2040 and 2040-2060 time periods. The simulations were run for the historic period using observed greenhouse gas concentrations. Two Representative Concentration Pathways (RCPs) were included in the projections to account for both a relatively low (RCP4.5) and relatively high (RCP8.5) level of anthropogenic emission scenarios. The second phase of the climate analysis was carried out in March-late April 2013, with specific results relevant to the value chain studies (see section 2.3.7 delivered early April).

[10] An overview of various aspects of CMIP5 is available in WCRP, n.d. We acknowledge the World Climate Research Program's Working Group on Coupled Modeling, which is responsible for CMIP, and we thank the climate modeling for producing and making available their model output. For CMIP the U.S. Department of Energy's Program for Climate Model Diagnosis and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portal.

[11] See Hewitson and Crane (2006) for methodological details and Wilby et al. (2004) for a review of this and other statistical downscaling methodologies.

[12] The "synoptic" scale in meteorology (also known as "large scale" or "cyclonic scale") is a horizontal link scale of the order to 1,000 kilometers or more. This corresponds to a horizontal scale typical of mid-latitude depressions. Most high- and low-pressure systems seen on weather maps are synoptic scale systems. (Wikipedia.org.)

[13] GCM "skill" is a measure of the ability of a climate model to represent observed climate characteristics such as monthly total rainfall, or regional circulation patterns.

[14] The five stations were Ngabu, Nkhota Kota, Kia, Mangochi and Bvumbwe. Due to a certain amount of data consistency [or consistent behavior in the data] across the stations, these five stations are viewed as accurately representing the different climatic regions of southern and central Malawi—the Malawi VA study area.

2.3.3 WATER RESOURCES STUDY

The Malawi VA water assessment was based on a thorough secondary literature review supplemented by 17 key informant interviews with individuals representing national and decentralized levels in Malawi, and by field visits to Lake Malawi, Lake Chilwa, and the Lower Shire River. These activities were carried out in September 2012. In addition to primary data collection, the water assessment study explored related data from two global information sets: (1) precipitation data extracted from the National Aeronautics and Space Administration's (NASA's) Goddard Earth Sciences Data and Information Services Center (GES-DISC), and (2) global data sets and projections compiled by World Resource Institute (WRI)'s Aqueduct Water Risk Atlas.

2.3.4 PHENOLOGY STUDIES (SIX CROPS)

For the phenological study, an agronomy expert reviewed six select crops (maize, sorghum, groundnuts, pigeon peas, cowpeas, and soybeans) to assess to what extent climate-related variables alter crop phenology and productivity (e.g., carbon dioxide, radiation, temperature, crop characteristics, water and nutrient availability, weeds, pests, and diseases) and influence crop lifecycles and overall crop productivity. This exercise drew upon existing literature, data, and resources, and (where possible) research findings in countries known to have a similar environmental setting and climate. The phenology study considered common pests and diseases observed in the region affecting these crops, and how climate can influence their occurrence and outbreak potential. The study focused on identifying pests and diseases reported to occur in the agricultural regions of Malawi attacking the specific crops assessed. The phenology allowed the identification and selection of the most prevalent pests/diseases for each of the crops in Malawi. A summary of the potential damage in the plant and the considerations about the impact of environmental/climate conditions were developed for each pest and disease. The phenology study was carried out in February–March 2013.

In addition to the CSAG results (see Section 4), two other climate models contributed to predicting the potential impacts of changes in climate conditions on different phenological stages of the selected crops. These were the climate model created by the United Nations Development Programme (UNDP) for Malawi (McSweeney et al., 2010) and the National Center for Atmospheric Research's (NCAR's) Community Climate Model (CCM3) climate model (Christensen et al., 2007; Govindasamy et al., 2003; Kiehl et al., 1996; Meehl et al., 2007). The determinations of impact on crops, pests, and diseases are based on a mean increase of average annual temperature between 1.2 and 2.5 °C by 2030 and between 1.1 to 3.0 °C by the year 2060. The projections of annual rainfall therein do not indicate significant changes. However, the range of projections from the different models is wide and includes both negative and positive changes (-3 to +32 percent).

2.3.5 FISHERIES STUDY

The fisheries study began with a literature review and an analysis of secondary data. This was subsequently combined with the results from five KIIs conducted in September 2012 by a fisheries expert. The fisheries expert assessed local fisherfolks' perceptions with information provided by national fisheries sector officials. The PRA and household interviews collected during the Malawi VA provided local information as well as regional and national views. In the villages and throughout the KIIs and PRA activities, the Malawi VA team members noted community members' observations about fisheries; their perceptions concerning fish recruitment and stocks; and how climate variability, deforestation, soil erosion, water turbidity, contamination, and economic development were all affecting the fisheries sector.

2.3.6 NATURAL RESOURCE AND BIODIVERSITY STUDY

In September 2012, a natural resource expert conducted multiple field visits in Malawi, meeting with the Forest Department to visit the Sendwe Village Forest and surrounding area of the Lilongwe District; with the extension staff of Total Land Care to visit the Doha District; and with farmers in Chipeni village. Additional meetings were also organized with Department of Forestry, the United Nations Food and Agriculture

Organization (FAO), Crop Development, Land Resources, Agricultural Extension Services, Oxfam, and the United States Forest Service expert working with the Forest Department. These key informant interviews were supplemented with a literature review.

2.3.7 VALUE CHAIN ANALYSES ([VCA] SIX CROPS)

The Malawi VA includes a systematic analysis of potential impacts of climate change on the value chains for six key crops in Malawi: maize, sorghum, groundnuts, pigeon peas, cowpeas, and soybeans. These six crops were chosen in consultation with USAID, as being crops of particular interest for current and future programming.

The first stage of the value chain analysis began with a thorough literature review followed by primary data collected through farmer interviews and focus group discussions (FGDs) conducted in key growing areas of each of the eight selected district. A sample of maize farmers was chosen to inform the analysis and "ground" it in the realities that Central region farmers faced at the time the fieldwork was being conducted. Adding qualitative insight to the analyses were KIIs held with government officials and other participants all along the value-chain (e.g., 19 for maize), such as input suppliers, commercial farmers, and buyers/processors.

Analysts mapped the value chain for each crop inputs through production, to marketing, and post-harvest processing, and compiled data and reviewed on trends in production, geographic location, productivity, marketing, pricing, processing and consumption/demand, where available. The analysis applied the effects of climate at each stage in the value chain (derived partially from Phase 1 of the Malawi VA climate modeling study). The analyses also incorporated data from and early draft of the phenology study (see Section 2.3.5) into the final drafts of each crop-specific study. Stage 2 of the value chain studies incorporated the final phenology study results, while Stage 3 incorporated the revised climate change projections.

2.3.8 ECONOMIC ANALYSES (SIX CROPS)

In the economic analysis, a team of experts calculated the economic impact of climate change on the six studied crops. This required identifying additional processes, inputs, and labor required by seven unique manifestations of climate change as they affect the planting, growing, harvesting and storing of each crop at farm level:

1. Later and/or more uncertain onset of rains;
2. Shorter rainy season;
3. Lower total rain volume over the season;
4. Heavier rain spells in April;
5. Dry spells during the season;
6. Higher relative temperatures; and
7. Lower relative temperatures as compared to a normal year.

The first step was to identify the "baseline" elements in production and cost them to arrive at a cost of production for one hectare (ha) of smallholder crop, including transport costs from field to storage site and basic "on-farm" processing, e.g., shelling and drying. Eleven **economic variables** for producing each crop were considered:

- Change in expenditure due to variety choice,
- Change in expenditure of improved seed to account for climatic impact,
- Change in expenditure on fertilizer, first and second applications,
- Change in expenditure to deal with climate-induced pests,
- Change in expenditure to deal with climate-induced diseases,
- Change in expenditure caused by different planting and harvest periods,

- Change in expenditure on labor due to climate change effects (e.g., weeding, stripping, ridging),
- Change in expenditure due to climate-induced post-harvest costs and storage,
- Change in expenditure on transport due to climate change,
- Change in expenditure on processing costs on farm (drying, shelling) due to climate change, and
- Reduction in selling price due to lower quality caused by climate change.

The results were **narrative statements** of the effect of the seven climate changes on the 11 identified economic cost variables for each crop. The narratives were **developed for two scenarios**: If farmers react to climate change and if farmers do not react to climate change. These scenarios were determined by comparing the implications of a "moderate" climate change relative to "typical" climatic conditions. [15] The narratives drew heavily on the PRAs and value-chain analyses, the climate modeling by University of Cape Town, and the Malawi VA phenology study. They also drew on a range of data secondary sources accessed by a local, senior agronomist.

The second step was to make narrative statements of the effects expected from different types of climate change on the various stages of crop production, relative to the standard yields; costs; and participation of farmers obtained from the Ministry of Agriculture and Food Security. Narratives were developed under two conditions—if farmers react to climate change and if farmers do not react to climate change—and for two scenarios–typical-to-moderate climate change and extreme climate change.

Having identified the effect on the economic cost variables as narrative statements, a senior, local agronomist member of the Malawi VA team then quantified the individual effects. This was essentially an expert-based estimate. Estimates were based on the effect of variables, such as additional pests and weeds caused by the change in climate, relative to the typical climate.[16] This resulted in a calculated change in yield that may be solely attributed to the seven manifestations of climate change. The decline in yield was calculated per hectare of crop, and then aggregated up to a national level. These two variables (calculated decline in yield attributable to climate change and additional costs incurred to react to climate change) were then calculated (for both conditions and scenarios) relative to the benchmark. Through this methodology, the experts attempted to identify the effect on costs and calculated yield change for each of the seven types of climate change, as well as for realistic and plausible combinations of the seven manifestations of climate change in the same season.

2.4 PRA, KIIS, AND SAMPLING FRAME

The cornerstone of the Malawi VA, the PRAs, provided in-depth information covering all of the VA objectives and reflected all of the sectors/sub-sectors as well as the cross-cutting areas of study. While the PRA grounded the findings from the studies and assessments in the daily reality of Malawian communities and households, the parallel KII process placed community perceptions in the wider arena of district-level understanding and programming. The PRA exercise identified and explored the impact of the geophysical manifestations and biophysical impacts on the evolution of coping and adaptation strategies, livelihood patterns, value chains, and general well-being. During the PRA exercise, all issues addressed were explored through the lenses of socio-economic differentiation and an historical context to capture change.

Through the management of a local consulting firm, the Malawi VA team recruited and trained 30 potential researchers (including seven women). The week-long training was held in Blantyre and was facilitated by members of the Malawi VA team. A total of 23 researchers completed the training successfully and were subsequently contracted to join one of three research teams, each tasked to conduct an intensive on-site qualitative case study in three villages, one each consecutive week. One day was organized between the first and second sites in order to share techniques and clarify any technical misunderstandings.

[15] For this study, the definition of "typical" was based on a senior, local agronomist's long-term experience of growing conditions in Malawi.
[16] Determining the typical climate requires longer-term climate data than was available in the CSAG analysis. Thus, for this study, "typical" is based on the agronomist's long-term experience of growing conditions.

During the training session, the researchers were trained in the use of 12 specific PRA tools. These tools were employed to capture the evolving perceptions and daily realities of communities. PRA tools[17] included:

- "Hazard and vulnerability mapping" and "techno-transect walks" to assess the geographies of risk;
- "Zigzag diagrams" to explore the links between food security and rainfall;
- "Field profiles," "livelihood evolution," and "household portfolios" to gain in-depth understanding of potential climate impacts from selected farmers, livelihoods, and households;
- "Seasonal calendars" to fit emerging trends to an annual flow of activity;
- "Wealth ranking" to explore the influence of power and differentiation of risk;
- "Climate Impact" to dissect village life through the specific lens of climate;
- "Key informant interviews" with local weather forecasters, health agents, traders, conflict resolvers, and community organization representatives; and
- "Village history and hope" to align all reported changes through time and to assess community expectations.

Concurrent with the PRA exercise, the Malawi VA team conducted 46 KIIs to ground the community PRA in a wider understanding and exploration of climate impacts in the eight target districts. District-level authorities from environment (general, forestry, and health); agriculture (including irrigation, crops, and fisheries); disaster; meteorology; planning; and health were consulted as well as projects with local offices (Wellness and Agriculture for Life Advancement [WALA], Developing Innovative Solutions with Communities to Overcome Vulnerability through Enhanced Resilience [DISCOVER], Catholic Development Commission in Malawi [CADECOM], Leadership for Environment & Development [LEAD], Concern and World Food Program). KII topics focused on perceptions of how climate change influences each district: How visible the impact may be and what differences have been noted across space, time and sector. The KII process also explored how respondent agencies or communities may have already evolved in response to, or adapted to, the impacts of climate change, and to what extent systems are already in place to provide early warnings to communities about pending change or extreme events.

2.4.1 SAMPLING FRAME FOR THE PRA

The PRA component of the Malawi VA aimed to capture existing perceptions of climate change and adaptation measures that are already used and/or feasible. The assumption was heterogeneity; therefore, this knowledge needed to be gleaned from a set of villages and households that are representative of the diversity of dynamics in Malawi. Shown in Table 2.3 are the criteria that were considered to help guide the sampling strategy and sources of geo-referenced information permitting selection.

[17] The PRA manual is included as Annex A to this report. The PRA Toolkit is available upon request to interested readers.

TABLE 2.3. POTENTIAL SAMPLING CRITERIA

Criteria	Assumptions	Data Availability (geo-referenced)
• Climate change and climate variability (projected and/or observations)	• Households most exposed to climate change and climate variability already will have developed or be considering a greater variety or number of adaptation strategies.	• A UNDP 2008 study (C. McSweeney, et al; UNDP Climate Change Country Profiles: Malawi; October 2008) was the only one found with sub-national climate projections. However, the resolution was insufficient to be useful.
• **Livelihood** strategies and agricultural production • Major threats: Prices (77%), impact of drought/floods on yield (63%) and illness/death of family members (46/41%) are the major threats reported by Malawian households.	• Adaptation varies by **livelihood** type (farmers, fishers, pastoral, hunters); High dependence on singular livelihoods and/or particular crops may increase vulnerability. • Adaptation varies by variety, frequency and intensity of exposure to hazards/threats.	• **Livelihood** zones: Sep2005, VAC profiles; crop production: Total area cropped for 2010 can be found at: http://www.countrystat.org/mwi/cont/pxwebquery/ma/130agr002/en. Specific crops: Some available by EPA from Malawi Atlas of Social Statistics, 2005. • Price/purchasing power: Malawi's PVA, 2006 (GoM and WB) has a TA-level map of poverty headcount; Drought/flood maps from CIESIN (GFDRR), but these appear to include impact, not just exposure/risk.
• Socio-economics and demographics: population density, index of remoteness, prevalence of female-headed households, dependency ratio, literacy	• Socio-economic and demographic factors influence the need, decision and capacity to adapt.	• Most of these variables could be sourced from the Malawi Atlas of Social Statistics, 2005.

Drawing on the combination of data compiled (Table 2.3 above), districts that are found to be relatively more exposed to climate-related impacts included Balaka, Chikwawa, Zomba, Machinga and Nsanje. In a parallel manner, districts that appeared to be relatively more sensitive to those threats included Machinga, Dedza, Thyolo, Mangochi, Ntcheu, and Lilongwe.

Based on a very limited and partial analysis of the above variables, the following staged sampling was proposed (Table 2.4).

TABLE 2.4. PRA SAMPLING FRAME

Element	What is Selected…	Representative of…
Stratum A	District	USAID Feed the Future/WALA Focus Areas
Stratum B	Livelihood Zones (N=9)	All livelihoods existing in the stratum above
Primary sampling unit	Villages (N=9)	District/Livelihood pairs (combination of Strata A and B, "zones;" portraying a particular profile)
Secondary sampling unit	Participants for focus groups and PRA activities	Depends on activity (livelihood group or socio-economic)

Hazard and Vulnerability Mapping in Lupanga Village

STAGE 1: Selection of Districts (Stratum A) and Livelihoods (Stratum B)

The starting point for the sampling strategy was the set of 13 districts targeted by the FtF Program (seven districts) and the WALA Program (eight districts; Machinga and Balaka are included in both). The majority of these districts are in the Southern Region; among the 13 districts, FtF features four from the Central Region and WALA features none.

A subset of areas for the PRA fieldwork would ideally capture each of the nine livelihood systems reportedly present within the 13 districts. Starting with the districts exposed to the widest combination of climate-related threats, districts were excluded when their livelihood systems were found to be among those already chosen within more exposed districts. The result was selection of nine livelihoods within eight districts, "nine zones." The resulting combination of livelihood zones covered in the PRA indicates that the study would capture the diversity of up to 77 percent of Malawi's total (2003) population.

STAGE 2: Choice of Villages

Ideally, within the nine *zones* selected above, villages would have been selected randomly from the ward/village lists extracted from

FIGURE 2.2. NINE SAMPLED COMMUNITIES FOR THE PRA

the most recent Targeted Inputs Programme Logistics Unit/Starter Pack Logistics Unit (TIPLU/SPLU) registers (N=25,540 nationwide). However, after conducting KIIs with many district authorities and partners (and determining that the required lists were not available), one village was chosen and confirmed from each of the following district/livelihood pairs to best represent a particular unique profile or focus, as an opportunity to explore nine heterogeneous case studies, one per zone. Table 2.5 and Figure 2.2 portray the nine communities (villages), their district names in alphabetical order, with livelihood zone they represent and the unique profile sought.

TABLE 2.5. PRA SAMPLE OF NINE VILLAGES

District	Livelihood Zone	Unique profile sought	Village Name
• Balaka	• Middle Shire	• Urban	• LUPANGA
• Dedza	• Kasungu-Lilongwe Plain	• Cropping of tobacco	• THAMBOLAGWA
• Machinga	• Chilwa—Phalombe Plain	• Active WALA activity	• KAWELAMA
• Mangochi[18]	• Southern Lakeshore	• Fishing livelihoods	• LIGULUCHE
• Mangochi	• Phirilongwe Hills	• No intervention	• CHISAMBANOPA
• Mulanje	• Thyolo-Mulanje Tea Estate	• Tea estate dynamics	• MULUPHA
• Nsanje	• Lower Shire	• Recent flooding	• FELO
• Ntcheu	• Rift valley Escarpment	• Cropping of pulses	• CHILUZI
• Zomba	• Shire Highlands	• Irrigation	• NKASALA

STAGE 3: Choice of Respondents/Participants

Within each of the selected villages, it was important to choose participants in a way that took account of the power dynamics among various leaders and traditional institutions. The PRA Toolkit (Annex A) detailed the purposive and random socio-economic sampling required for each tool.

2.5 CONSTRAINTS AND LIMITATIONS

Each of the Malawi VA components had its own inherent set of constraints and limitations; these are discussed in this section.

2.5.1 LIMITATIONS OF THE CLIMATE MODELING

In general, climate modeling is limited by several[19] sources of uncertainty. Natural variability in the climate system itself is by far the most important of these. Because the climate system is quasi-chaotic in nature, this source of uncertainty will never completely disappear. The Malawi VA's climate modeling indicated that this natural variability might be even more important in Malawi than in other locations around the globe. Specifically, although the initial modeling exercise ("Phase 1") used just 15 years of data,[20] a temporal span that is a relatively short sample from which to estimate robust conclusions regarding long-term climate statistics. The results nevertheless gave a good indication of the large variability in rainfall and temperature conditions that Malawi has experienced in the recent past.

[18] Note that two of the nine villages were drawn from Mangochi district.

[19] Other limitations to climate modeling, in general, are the range of future emission scenarios possible, as differences in greenhouse gas emissions can have significant impacts on the climate (the CSAG model reviewed two scenarios); uncertainty in scientific understanding of climate processes (CSAG operates at the forefront of climate science); imperfections in the downscaling tools and methods (CSAG applied the most current, recognized models); and data uncertainties (the observed daily climate records were run through a suite of automated quality assurance procedures developed by CSAG in order to identity and remove any suspect values from the dataset; the climate records are found to be of high quality [~98% valid values], with only a few instances of missing values, incorrect values, or duplication of monthly time series between months within a year or between years).

[20] Ideally, the PRA design, site visits of all sectorial desk studies, and value chain analyses would have waited until the completion of the climate modeling. This would have allowed them to be grounded in the most accurate possible climate analysis. However, in the interest of moving the project quickly forward with at least preliminary intermediate findings, the Malawi VA proceeded with a preliminary modeling exercise using just 15 years of data. The final modeling exercise, with additional data, is currently underway.

The findings established that, given the geographic location of Malawi, it is likely that its northern and southern regions are influenced by different climate drivers. The current literature on African climate and the dominant modes of climate variability tend to focus on specific regions within the continent, like equatorial east Africa (north of 10°S) and subtropical southern Africa (south of 15°S). The region of interest (Malawi) straddles both of these geographic "divides," arguably providing incentive to cluster the stations into northern, central and southern groups.

Due to the limited number of strong Indian Ocean Dipole (IOD) events during 1997–2011, it was difficult to establish any robust patterns for its impact on Malawi rainfall regimes. These data indicated that Malawi's climate could be strongly influenced by El Niño Southern Oscillation (ENSO), thus contributing to uncertainty in climate projections for this region. The addition of the extended series of data provided by five stations in the southern and central parts of the country ("Phase 2") suggested a better relationship with ENSO than did only the data from the 22 stations, but also reinforced that it is the combination of at least three, separate external atmospheric forcings that influence summer weather dynamics.

Another limitation of the Malawi VA climate modeling study is that it produces station-based (i.e., point-based) data for historical and projected variables. The distance from the studied villages and the closest meteorology stations ranged from five to 65 km (see Table 2.6), thereby making any comparisons between the climate modeling and the PRA results very tentative and unreliable. (Because of the complexity associated with interpolation, a gridded, rather than point-based, product was not possible within the timeframe of the Malawi VA.)

TABLE 2.6. DISTANCES FROM PRA VILLAGES TO NEAREST METEOROLOGICAL STATIONS

Village	Closest Met Station	Distance (meters)
Chiluzi	Dedza	60,729
Thambolagwa	Dedza	14,766
Lupanga	Makoka	61,013
Nkasala	Makoka	22,606
Liguluche	Mangochi	5,861
Chisambamnopa	Mangochi	7,698
Mulupha	Mimosa	4,533
Felo	Ngabu	56,394
Kawelama	Ntaja	9,516

2.5.2 LIMITATIONS OF THE PHENOLOGY STUDY

The phenology study was conducted as an input to the value chain analyses. As such, it was based primarily on generic (regional) plant growth characteristics, relevant to the Africa Region, but not necessarily to specific regions within Malawi, although Malawi-specific information was used when available. The phenology study describes generic responses of each plant in each stage of its growth and development. Even using such a regional approach, the study found that scientific and technical literature on some topics was limited; scarce; and sometimes, contradictory. While more information was available for the more commonly studied crops, such as maize and sorghum; for the less commonly studied ones, such as field peas, there was correspondingly less literature available. To overcome this deficiency, the agronomist attempted to complement findings with information reported elsewhere and outside the target region, but still on the African continent. Even then, there were cases where reports or scientific papers provided conflicting information, such as on sources indicating certain pest was negatively influenced by warmer temperatures, while another publication indicated the precise opposite–i.e., that development of the pest was favored by cooler conditions. Thus, the information reviewed was corroborated through triangulation.

Additionally, and perhaps most importantly, the conclusions on the impacts are relative to vulnerability to climate change within optimal growth ranges; other factors such as vicinity to bodies of waters, canopy protection, and water retention in the soils were not part of this study. Yet it is precisely these factors that allow the phenology study to be of value as an input to the value chain analyses, even though they limit the value as a standalone work product.

2.5.3 LIMITATIONS OF THE PRA AND KII

At the time of the initial stages of conducting the Malawi VA, few researchers in Malawi had been exposed to or had recently applied qualitative research tools; even fewer were keen to spend entire weeks sleeping in rural villages. As a result, the local research team members were inevitably inexperienced with this type of research, but they were fast learners and were willing to invest themselves as required. As with any research study in physically difficult circumstances, there were challenges during implementation. The most crucial field challenges were logistical, including difficulty accessing electricity to enable the iPads, phones, and laptops to be utilized, and the late arrival of the teams to the villages due to difficult transportation. Village selection/politics also came to play as, in one case, the team arrived, but found that the Group Village Headman wanted the team to research his village, not the selected one, partly due to his poor relationship with the headman of the selected village. (The pre-selected village was eventually studied, but the situation incurred serious delays.) The PRA research was conducted in the period prior to planting, so in most of the communities, people went to their fields early in the morning, returning late morning to prepare food for the day. This meant that the teams could not conduct those activities involving farmers prior to 11:00 a.m., except when the team accompanied farmers to their fields for research tasks. In the end, however, nearly all the activities in all cases were completed. Familiarity with tools and time available to carefully triangulate using a series of matrices generally required at least two additional days per village.

2.5.4 LIMITATIONS OF THE VALUE CHAIN ANALYSES

The value chain analyses are being carried out in three stages. The methodological challenges during the first stage were primarily related to the availability of some key informants, due to the relatively narrow time window available for their completion. However, this is not felt to substantially affect the study outcomes. The second stage of the value chain analyses incorporated the findings from the phenology study, described above. The third stage incorporated the results of the refined climate analysis, also described above. The only challenge to accomplishing the latter stage was timely receipt of the refined climate analysis data; this was accomplished through close coordination with CSAG which provided the results necessary for refinement of the value chain analyses ahead of the full analysis and final report delivery.

2.5.5 LIMITATIONS OF THE ECONOMIC ANALYSES

The economic analyses have several important caveats. These are:

1. The analyses were "static" in that they did not account changes over time in farming practice or of the dynamics in the markets.
2. The analyses were "simple" in that they did not use an econometric analysis to pinpoint the precise impacts of climate change.
3. The analyses required judgment calls by an expert agronomist; no third party validation was undertaken, nor supporting field research gathered.
4. In some cases, the only available data sources for use as reference points were out-of-date or generically applied.

Thus, the resulting economic analyses of the six crops provide only a basic sense of the economic costs of climate change on production. However, even with a more quantitative analysis, it is important to note that current climate modeling would not predict which of the combinations of climate manifestations are more likely to occur, or at what frequency they would occur. Thus, regardless of the level of economic analysis employed, uncertainty in the climate future will always introduce considerable uncertainty in the resulting estimates of increased costs of production.

3.0 CONTEXT

Any assessment of climate vulnerability must be set in the context of relevant disciplines; a careful exploration of the most aggravating, or confounding, factors that confuse attribution; and a clear understanding of the status of the enabling environment in place to guide climate change adaptation. Section 3.1 briefly describes the key sectors of agriculture, fisheries and natural resources. Section 3.2 highlights the main confounding factors (population and poverty). Section 3.3 explores the state of the enabling environment in Malawi (institutions and policies).

3.1 KEY SECTORS

3.1.1 AGRICULTURE AND FISHING

3.1.1.1 BACKGROUND

Agriculture is the most important sector of Malawi's economy, contributing about 90 percent of export earnings and around 40 percent of GDP, in addition to employing about 80 percent of the workforce. The total land area in Malawi is 9.4 million ha, and 56 percent of that has potential for agriculture. The agriculture sector is "dualistic," comprising smallholders and estates. Estate lands are mainly held under freehold or leasehold tenure; the main crops are tobacco, tea, sugar, and coffee. Tobacco is Malawi's largest export cash crop, accounting for over half of export earnings, followed by tea and sugar (Purchase from Africans for Africa. n.d.; FAO, n.d.; and World Bank, 2012).

However, most agriculture in Malawi is subsistence, rain-fed agriculture. More than 90 percent of the rural population is composed of smallholder farmers with customary land tenure. They cultivate small and fragmented landholdings covering approximately 2.4 million ha, and achieve low yields. Average landholding size has fallen from 1.5 ha in 1968 to around 0.8 ha since 2010 (IFAD, n.d.). In poor growing seasons large segments of the population experience widespread food shortages. Many households with large families and small plots suffer chronic food insecurity and malnutrition.

Despite the availability of better technologies, the productivity of most crops appears not to have significantly improved during the past 40 years; this may be largely a result of declining soil fertility (IFAD, op. cit.) Other factors decreasing productivity include poor access to financial services (for inputs) and markets (for distribution), as well as small landholdings. (Farmers also face the challenge of significant post-harvest losses, estimated to be around 40 percent of production [IFAD, op. cit.]) The use of climate-tolerant varieties, together with fertilizers (where appropriate), improved crop husbandry, and irrigation could improve yields.

Livestock ownership is very low by regional standards. Although livestock were not studied as part of the Malawi VA, it is notable that performance of the livestock sector is affected by low productivity of the cropping sector; as cropping extends into grazing areas, the number of ruminant livestock decreases. Per capita meat consumption and animal protein intake are low, contributing to poor nutrition among children.

TABLE 3.1. AREA PLANTED TO STUDIED CROPS

Crop	**Area Planted** (Ha) (Source: FAO, 2009)
Maize	1,663,000
Groundnuts	294,000
Pigeon peas	182,000
Cowpeas	88,000
Soybeans	89,000
Sorghum	75,000

3.1.1.2 KEY CROPS

Six crops were selected as the focus of the Malawi VA. These include, in order of lowest to highest resistance to climate,[21] maize, groundnuts, pigeon peas, cowpeas, soybeans, and sorghum. Area harvested to each of these crops is featured in Table 3.1. Interestingly, the crops fall into a resistance order almost exactly opposite to the areas planted. A few details on each crop, specific to Malawi, are provided below.

- **Maize** is the most important food staple food in Malawi. Consumption reaches 133 kg per capita and accounts for up to 60 percent (Minot, 2010) of the caloric intake of households. Nearly 97 percent of farmers grow maize, with close to 80 percent of cultivated land invested in maize. Despite this, maize has the highest variation of yield in the Southeast Africa region. Influenced strongly by the GoM's inputs program, Malawi produces around three million tons of maize, which is above the estimated self-sufficiency level of 2.3 million tons.

- Malawi is one of the most important **groundnut**-producing countries in southern Africa, and groundnuts represent one-quarter of household-level agricultural income in the country (Imani Consultants, 2010). Groundnut hulls are also valuable as fodder for animals and fuel; growing groundnuts helps to fix atmospheric nitrogen in soils, enhancing soil fertility.

- **Pigeon peas** rank as the third most important legume crop after groundnuts and beans. Malawian households consume 65 percent of their pigeon pea production. Malawi is one of five African countries where smallholders are most intensified for dual consumption and export (123,000 ha) (Sabena et al., 2010).

- **Cowpeas** are widely known as the "crop of the poor," as their green pods and leaves are the earliest food available before cereals mature. To smallholder farmers, cowpeas represents an "insurance" against food shortages during the "hungry season."

- **Soybeans** are an important source of protein and oil for Malawian households. Soybean production is also promoted by donors due it to nitrogen fixing properties and multiple uses, including feed for fish and for human consumption; and by export markets as feed for livestock, and for use as a bio-fuel and an industrial oil.

- **Sorghum** was the primary staple in Malawi before maize was introduced, and is still regularly grown by local farmers as a source of food and for brewing beer.

3.1.1.3 IRRIGATION

Historically, irrigation development across Malawi has been spearheaded predominantly by the GoM. The first large-scale irrigation scheme was established in late 1940s at Limpasa in Nkhata Bay, and remains a Government scheme until today. Since that time, the GoM has continued constructing irrigation schemes in eight districts across the country. In recent years, a few irrigation schemes have been developed by the Government with irrigated crops that include vegetables but still targeting smallholder farmers. It is difficult to determine the exact area under public irrigation, but it is estimated that some 20,000 ha have been developed by the GoM with some form of practiced irrigation (World Bank, 2011). The development of these schemes has targeted smallholder farmers and irrigation of food security crops, predominantly rice. The operation and maintenance of the irrigation schemes has also remained largely under the responsibility of the GoM rather than of beneficiary communities. In recent years, attempts have been made for beneficiary communities to take over the running of these schemes, through transfer of irrigation management to Water Users Associations (WUAs). To date, only a few schemes have been handed over to beneficiary communities, with the help of the GoM and NGOs for capacity building. The government has not yet targeted commercial farmers in providing irrigation services.

[21] This ranking was a result of the phenology study in which the number of stages that climate influences and the number of stages that diseases/pests influence for each crop was summed.

Total irrigation potential has been estimated to range from 200,000 ha to 500,000[22] ha. The GoM has recently expressed a commitment to expanding sustainable small-scale irrigation under self-help initiatives and transfer of existing government schemes to smallholder management, as reflected in the National Irrigation Policy and Development Strategy, 2000 and the Irrigation Act of 2001. At present, around 28,000[23] ha are cultivated under formal or semi-formal irrigation (comprising 6,500 ha under self-help smallholder schemes, 3,200 ha under government-run smallholder schemes, and 18,000 ha under commercial estates). A further 62,000 ha are under simple traditional irrigation using residual moisture and supplementary irrigation on stream-bank gardens (*dimba*) and wetlands (*dambos*).

The problems of operation and maintenance of public irrigation have crippled the public irrigation sector performance. The Government resources are being heavily competed in priority and critical areas of rain-fed agriculture, health services, and education, leaving the irrigation sector without adequate resources for comprehensive operation and maintenance. In a country with a single rainy season and land scarcity, land with access to relatively reliable water throughout the year plays a critical role in food security and the development of the commercial agricultural sector (Peters, 2004).

Furthermore, the WUAs are not adequately empowered to take responsibility for their irrigation and related non-irrigation services. They do not enjoy full legal status and are thereby handicapped in their ability to mobilize resources or take full advantage of the technical and administrative management services required to sustain vibrant irrigation schemes. The **Malawi's Greenbelt Initiative** faces serious challenges to realizing its ambitions of having one million ha under irrigation.

On the side of the private sector, investors have championed large-scale irrigation in Malawi since the colonial days, with tea farming in Mulanje and Thyolo leading in irrigation development. It now boasts more than 23,200 ha of equipped irrigated fields. The largest equipped irrigation scheme in Malawi is the Illovo Group's Nchalo Sugar Estate (J. Goodman, Ex-Agris, personal communication, 2012). This scheme was initially established in 1965.

3.1.1.4 FISHERIES

The global importance of Malawi's biodiversity is often cited with respect to fisheries. Malawi has one of the largest number and most diverse communities of freshwater fish in the world, with 800 species of fish, of which 90 percent are endemic (USAID/Malawi, 2005). Over 15 percent of the global total freshwater fish species are found in Lake Malawi.

Fishing contributes about four percent to Malawi's Gross Domestic Product (GDP) and accounts for 60–70 percent of Malawians' animal protein intake. It is also the preferred source of protein for most Malawians. An estimated 1.6 million Malawians derive at least some income from fishing, fish processing, marketing and trading, boat and gear-making, and allied industries (Brummet and Noble, 1995; Andrew et al., 2003).

During the period 1976-1990, fish catches averaged about 60,000 tons per year. Since that time they have declined to an average of 49,000 metric tons in 1993-2003 (World Fish Center, 2007). Catches are lowest (and their prices highest) in May and June (during the cold months); prices are lowest from August to March (during the breeding season). Fish farming/aquaculture is low but growing; currently, 3,000 fish farmers with 7,000 ponds produce 570 tons/year.

Lake Malawi and Upper Shire (Lake Malombe) provide the most commercially viable industrial catches and form the historical basis of artisanal livelihoods. The southeast arm of Lake Malawi provides the richest opportunities for ecological production/species due to nutrient upwelling. Lake Chilwa provides at least 25 percent of total fish production in Malawi.

[22] The Government of Malawi's "Malawi Sector Performance Report 2011: Irrigation, Water and Sanitation" (2012) claims a much higher figure at 400,000–1,000,000 ha suitable for irrigation.
[23] These figures are found in Bishop-Sambrook (2007) and are triangulated with those in the World Bank (2011) report.

In 2009, 132 national economies were examined for their vulnerability to climate change using environmental, fisheries, dietary and economic factors (Allison et al., 2009). Countries determined to be most at risk were not necessarily those that are expected to experience the greatest direct environmental impacts on their fisheries. Rather, the most vulnerable countries were those where fish are crucial for diet, income, and trade, combined with a lack of capacity to adapt to problems caused by climate change. Four countries in Africa (Malawi, Guinea, Senegal, and Uganda), four Asian countries, and two South American countries were identified as having the most economically vulnerable fisheries in the world.

3.1.2 NATURAL RESOURCES

3.1.2.1 WATER RESOURCES

Historically, Malawi has enjoyed an abundance of surface water. This abundance has allowed the country to develop significant large irrigation systems and an important hydropower industry, both of which contribute significantly to the nation's economy. To date, this development has been undertaken with minimal concern for water allocation and conservation, or for addressing water pollution issues.

The Shire River, fed by outflow from Lake Malawi, is the most critical source for renewable surface water in Malawi. Small, inland Lake Chilwa is shared by Malawi and Mozambique, and is the source of at least one-quarter of the fish production in Malawi (Wetlands International, n.d.). In 1998, the Lake Chilwa basin was home to an estimated 916,447 people (Njaya, 2001, p. 7). As the most critical hydrologic systems in Malawi, Lake Malawi and the Shire River system are receiving significant attention and investment from the GoM and the World Bank. Among many other activities, the World Bank-funded Shire River Basin Management Program is planning to raise the Liwonde barrage, which controls the outflow of Lake Malawi, by 20–40 cm to allow for increased water management options and to create additional bulk water storage capacity within the Lake Malawi reservoir. Surrounded by wetlands and with a maximum depth of just five meters, Lake Chilwa is a very fragile hydrologic system, especially vulnerable to the impacts of climate change. But it does not, with the current exception of assistance from the Government of Norway, benefit from the level of donor attention or investment enjoyed by the other two systems.

Water demand across the country is dominated by arable agriculture (71 percent) and by domestic needs (19 percent). Given a majority of demand from competing agricultural uses, the development of effective Integrated Water Resource Management (IWRM) is critical. In addition, hydropower provides 96 percent of Malawi's energy needs (Government of Malawi, "Malawi State of the Environment and Outlook Report," 2010), from just five power plants on the Shire River. Hydropower currently produces 283 megawatts (MW) of energy, while the demand for power is already 347 MW and rising. The Shire River accounts for 96 percent of national energy production and provides the majority of irrigation water for the southern part of the country.


Kapichira DAM

3.1.2.2 OTHER NATURAL RESOURCES

A majority (84 percent) of the population of Malawi depends on natural resource-based livelihoods, including fisheries, agriculture, and forestry (Government of Malawi Ministry of Environment and Climate Change Management, 2011).

Wildlife is a valuable tourism resource as it can contribute significantly to incomes and employment. The sector, however, faces a number of challenges including poaching, poor supporting infrastructure, and low community participation in wildlife conservation. The GoM is poised to continue to conserve and manage wildlife in both protected areas and natural habitats through, among other strategies, strengthening institutional capacity to manage protected areas and ecosystems.

As a measure of biodiversity health, biome protection[24] for Malawi was determined to be protecting 97 percent of its designated biomes, the 21st most protective country in Sub-Saharan Africa. Current forested area in Malawi totals 2.6 million ha. In Southern Malawi, households derive an average of 30 percent of their income from exploiting "common" forests (Fisher, 2004, pp. 135-154; Fisher, and Shively, 2005, pp. 1115-1128). Households that are especially lacking in land, education, and goat holdings are more reliant on "low return" forest activities, such as sales of "forest-based" crafts (bamboo baskets and mats, grass brooms, and wood-fired pots), roof thatching and brick-burning, sales of firewood and bamboo, and traditional medicines.

The natural resources sector registered progress in a number of areas including compliance with the Environmental Management Plans (EMPs) of development projects and programs; setting of standards on pollution control and waste management; increased public awareness on environment and natural resources management; and improved protection of river catchment areas; and increased customary land area planted with trees from 77,810 ha in 2005 with 194,524,672 trees to 187,791 ha with about 275 million trees planted in 2010 (Department of Forestry 2010).

In order to address deforestation, the Forestry Department has been working to establish fuel wood and pole plantations throughout the country. With World Bank assistance, the Wood Energy Project has helped to plant more than 20,000 ha. The private sector has also established more than 35,000 ha of plantations, mainly on tobacco and tea estates (USAID/Malawi, 2005). The Forestry Department continues to focus on reforestation, although survival rates are apparently quite low; it is, for the most part, a costly and inadequate response to the challenges. The plantations are only able to provide a small fraction of wood consumed for household energy and other uses. Generally, governance is weak and provides inadequate support for sustainable production of charcoal.

3.2 CONFOUNDING FACTORS

3.2.1 DEMOGRAPHICS

The World Bank reports that total fertility rate for Malawi has been declining from 7.6 in 1984 to 6.7 in 1992, to 6.3 in 2000, and to 6.0 in 2004 (World Bank, 2009). These fertility rates are still ranked among the highest in the eastern and southern Africa region. The population density is 158 persons km^2 (2010), up from 105 in 1998, making Malawi one of the most densely populated countries in the world (Trading Economics, n.d.). Various sources predict significant population growth over the coming decades (Table 3.2).

TABLE 3.2. POPULATION PROJECTIONS (MILLIONS)

YEAR	Population (Source: WB, 2007)	Population (Source: GoM NSO)
2010	14.9	14.6
2020	20.7	20.1
2030	28.1	
2040	37.7	*2030 not*
2050	49.5	*available*

Population studies emphasize that the combination of high population growth rates with continued high but declining fertility rates, a young age structure, and rampant poverty are likely to contribute to increased urbanization, adding and concentrating demands to already over-subscribed water resources (Palamuleni, 2007, pp. 16-28; GoM Department of Population and Development, n.d.). Those who remain in rural settings, and depend on agriculture and natural resources for their livelihoods and on wood and charcoal for household energy, will continue to exploit already stressed natural systems. Lack of available, affordable alternatives, both for livelihoods and for energy, will only further aggravate the negative impact of climate change on these already stresses systems.

[24] Biome protection measures the degree to which a country achieves the target of protecting at least 10 percent of each terrestrial biome within its borders, and represents a weighted average of protection by biome. Weights are determined by the size of the biome (larger biomes receive greater weight).

A 2012 report by the GoM showed that the country's population is growing most rapidly in the northern and central districts (Population Reference Bureau, 2012), while a recent population study predicts the highest predicted growth in the central region of the country (Palamuleni, 2007).

The border between Malawi and Mozambique is fluid with significant cross-border trade of goods and labor in both directions. During conduct of the Malawi VA field work, key informants in Dedza expressed concern that population pressures in Malawi could be exacerbated by Mozambicans who have remained in the country since fleeing civil strife due to the Mozambican civil war of the 1980s, or who have migrated since for economic reasons.

3.2.2 POVERTY

Malawi is one of the poorest countries in the world, with 74 percent of the population living on less than U.S. $1.25 per day.[25] Rates of maternal, infant, and child mortality are amongst the highest in the world, while 10 percent of the working-age population suffers from HIV (for 2011 statistics, see United Nations Children's Fund, n.d.). In Malawi, poverty rates are higher in remote areas; in general, poverty incidence is greater in rural areas with less favored land. These findings confirm that "the extreme poor in more marginal areas are especially vulnerable, and until migration provides alternative opportunities, the challenge is to improve the stability and resilience of livelihoods in these regions." (World Bank, 2008, p. 49)

The World Bank reports that, from 2005–2010, Malawi benefited from uninterrupted economic growth (averaging about 7 percent), strengthened by sound economic policies and donor support. Since 2010, Malawi's economy has weakened. Growth has slowed from its height of 9.7 percent in 2008 to about 5 percent in 2011. Imbalances in the foreign exchange market and fuel and electricity supply shortages continue to make the business environment less favorable, while the cost of living continues to increase. Inflation, below 10 percent in 2010, had risen to nearly 15 percent by January 2012 (World Bank, 2013).

Both market-oriented and climatic change-related factors have deepened poverty among most agricultural dependent households. As in most developing countries, poverty reduction efforts in Malawi have been drastically affected. This has resulted in food shortages, hunger, malnutrition and lower income levels across much of the population (Action Aid, 2006). Worse still, market-oriented factors such as increasing numbers of middlemen, increasing input prices, and lack of credit have impeded pro-poor agricultural enterprises (GoM, 2006).

Malawi sought food aid in 1994/1995 and 2001/2002 due to shortfalls in food production and high food prices (Food and Agriculture Organisation, 2011 Malawi has experienced severe food shortfalls and wavering income potential due to low soil productivity, fragmented land, high food and agricultural input prices, lack of agribusiness capital, and climatic-related factors over the past decade (GoM, 2006). It is reported that, in Malawi, more than one million households become food and income insecure every year (FEWSNET, 2011). Worse still, most of these households do not have income or do not have access to credit to purchase food on the market.

3.3 ENABLING ENVIRONMENT

A formal analysis of the state of the enabling environment needed to guide climate change adaptation was not included in the Malawi VA. Through the sector studies, however, there emerged findings relevant to some of the primary institutions and policies that play a role in climate change adaptation. These are described in this section. Much of the discussion in this section also reflects the position of the GoM as stated in their *Second National Communication to the UNFCCC* (October 2011).

[25] 2005 statistics reported by United Nations (2010).

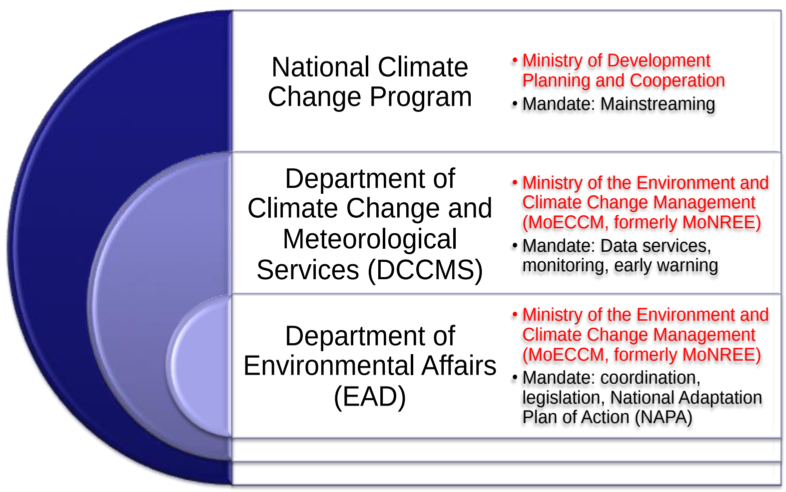
At the time of this write, a national policy framework to address adaptation to climate change had been drafted and was currently under ministerial review. Until such time as the framework is approved, the NAPA remains the key climate change policy document. Formulated in 2006 (under Global Environment Facility [GEF]/UNDP funding), the NAPA identifies priority interventions for adaptation across several sectors: Agriculture, water, energy, fisheries, forestry and product use, wildlife, human health, industrial processes and product use, and waste management. Out of 33 priority areas, 15 are considered as urgent in order to reduce the vulnerability of rural communities to adapt to climate change (GoM, 2006). The NAPA is an important and significant milestone in Malawi's quest to address the adverse impacts of climate change urgently, especially floods and drought, on vulnerable communities, fragile agro-ecosystems, and important sectors of economic growth. The NAPA is, in principle, is being implemented by the GoM in collaboration with its development partners.

TEXT BOX 3.1. KEY CLIMATE ADAPTATION POSITION PAPERS OF THE GOM

- 2002: Initial National Communication (INC)
- 2006: National Adaptation Programmes of Action (NAPA)
- 2011: Second National Communication (SNC)

The preparation of a series of national position documents (see Text Box 3.1) facilitated the building-up of institutional capacity and expertise in various public and private sector organizations in the country. It also led to the building of strong technical teams of national experts that prepared the various thematic area technical reports, and the National Communication (INC) documents. The preparation of these documents increased public awareness among stakeholders on the adverse impacts of climate change on various sectors of economic growth.

FIGURE 3.1. CLIMATE-RELATED INSTITUTIONS, NATIONAL LEVEL



It should be noted that despite the remarkable achievements and progress made in preparing the position documents, few if any of the proposed measures and strategies for adapting to climate change had been funded or implemented prior to the Second National Communication (2011). This appears to include capacity building,[26] where it was proposed to train Malawians in acquiring skills and expertise in computer simulation modeling, research methodologies, and the determination of local emission factors and activity data for estimating greenhouse gases from different

[26] The UNDP led Africa Adaptation Program in Malawi nonetheless finalized a Capacity and Training Needs Assessment for existing Climate Change management structures in 2011 (document not found). Besides mainstreaming climate change in the draft Malawi Growth and Development Strategy II (MDGs II), the program also undertook the Policy Gap Analysis for Climate Change related policies and supported the review of National Meteorological Data Policy. Currently the Program is facilitating the assessment of the Current Hazard Mapping Capacity; Financial Assessment to strengthen capacity and design for dynamic adaptation and mitigation to Climate Change; Review of District Best Practices in Climate change adaptation and mitigation and the Conceptual Analysis on the Applicability of Climate Change, Environment and Natural Resources Sector Wide Approach (CCENRM SWAp). A National Climate Change website for sharing knowledge has also been developed and is functional. The program has also strengthened capacity to manage climate change by sponsoring seven government officials in long-term training (i.e., Climate Change MSc related studies) in the United Kingdom during the 2010/2011 academic year. For 2011/2012 the program also sponsored five government officials that will be undergoing MSc studies in the United Kingdom. During this period the program also trained over 70 meteorology staff in Data Management and, in collaboration with the Ministry of Local government, trained over 105 district staff in climate change adaptation and awareness.

sectors. Capacity building was also proposed for staff in local institutions of higher learning, especially in the fields of crop, soil, and climate modeling; systems analysis; along with participatory research and extension approaches. A thorough update of progress since 2011 is only possible with a systematic institutional review in Malawi (not conducted as part of the Malawi VA). However, during an April 2013 mission of the Malawi VA team, it was evident that the sector had been quite active since the initial Malawi VA scoping mission. A new ministry had been created with climate change in its name (MECCM, see below) and the high level of coordination in the sector appears to have drawn attention from international climate change adaptation efforts, as a good example for others to follow.

The Robert S. Strauss Center developed a database in 2012 of all donor-funded, registered projects in Malawi underway between approximately 2002 and 2015 (Peratsakis, Baker, and Weaver, 2012). The Center classified 2,962 project activities into four categories on a threshold from climate ambiguous (or even negative) to climate-oriented, as follows:

- Ambiguous Development (1 percent of the activities): Activities may have a positive development outcome in the short-term, but its broader climate effects are either negative or unclear.
- General Development (72 percent of the activities): Activities are not explicitly driven by or obviously directly relevant to address climate change threats.
- Capacity Development (21 percent of the activities): Activities do not have a climate-oriented motive, yet do promote climate resilience.
- Climate Oriented (6 percent of the activities): Activities have a clear motive or intent framed by a changing climate, whether past, present, or future.

For all years combined, there were 172 climate-oriented activities, half of which occurred since 2010. Among them, 43 percent were classified as agriculture activities, 28 percent as environment (including lands and natural resources), and 23 percent as vulnerability/disaster risk reduction. Among the climate-oriented activities, 42 percent were funded by Norway, 20 percent by FAO, 15 percent by the Department for International Development, and 9 percent by Irish Aid.

3.3.1 INSTITUTIONS

The current institutional framework based on sectorial divisions underlines a focus on critically important issues related to climate change adaptation (Figure 3.1). The Ministry of Development Planning and Cooperation has a leading role in the implementation of the National Climate Change program and in mainstreaming attention to climate change in sectorial programs and government policies; this ministry chairs the National Climate Change Steering Committee. The DCCMS within the Ministry of Environment and Climate Change Management (MoECCM, formerly Natural Resources, Energy and the Environment [MoNREE][27]) was created with a leading role in providing data on climate change, and the Department of Environmental Affairs (EAD) of the same ministry has played an important role in preparing Malawi's NAPA. This entity chairs the National Climate Change Technical Committee. Multiple departments in the government are involved with various aspects of agricultural development, including land resources, crop production, research, and extension. The Department of Forestry has primary authority and responsibility for the management of forest resources and is focused on the control of illegal production of charcoal, the protection of forest reserves, and promotion of reforestation. There are currently very few champions in government to prioritize interventions that build resiliency of rural populations.

The GoM considers environmental management as an integral component of food and water security, poverty alleviation and socio-economic growth and development as central pillars of national development

[27] The former MoNREE is in the process of becoming MoECCM. It is still referred to as MoNREE on the DCCMS website.

policies and strategies. Addressing climate change forms part of the Government's strategy to spur economic growth and development, thereby reducing poverty and encouraging sustainable development. The EAD is responsible for preparing and implementing environmental policies and relevant legislations. It is also responsible for enforcing the regulations and providing guidance on environmental issues, including climate change. The EAD, in collaboration with the DCCMS, is responsible for coordinating climate change issues in the country. Major policy thrusts include the coordination and proper management of the environment and the natural resource base in collaboration with line ministries and departments, the private sector, NGOs, select communities, and other relevant stakeholders at district, national, regional, and international levels.

In each of the 28 districts, there is a District Environmental Officer (DEO), many of whom served as key informants for the Malawi VA within the eight studied districts. These officers are responsible for coordinating and overseeing environmental issues and the preparation of the district state of environment reports (SOERs).

3.3.2 POLICIES

The GoM placed climate change, natural resources, and environmental management as priorities in its development strategy, the **Malawi Growth and Development Strategy** (MGDS II 2012–2016). In addition, the NAPA focuses on agriculture as the key sector to address the nation's challenges and vulnerabilities. The GoM has also invested in the **Green Belt Initiative (GBI);** this initiative seeks to transform Malawi, through irrigation, from a predominantly consuming and importing country to a producing and exporting country.

The GoM has put in place a series of legislative frameworks to promote and consolidate its environment, climate change and other socio-economic developmental activities. Some of the sectors for which these policies and strategies have been developed include:

- Agriculture (Food and Nutritional Security) Policy, 2005;
- HIV and AIDS in the Agriculture Sector Policy and Strategy, 2003;
- National Land Use Planning and Management Policy, 2005;
- Malawi Irrigation Policy and Development Strategy, 2000;
- Water (Malawi National Water Policy), 2004;
- Forestry (National Forestry Policy of Malawi), 1996; and
- Energy (Malawi Energy Policy), among many others.

Despite the fact that Malawi's agriculture—its engine of economic growth—is rain-fed and highly vulnerable to climate change, especially floods and drought, not much effort has been done to mainstream climate change explicitly in the country's sectorial policies and strategies. However, agricultural, water, and irrigation policies and strategies endeavor to address issues related to climate change, although in most cases not explicitly enough. Thus, the revised or updated versions of these documents need to be systematically reviewed through a climate lens (i.e., climate "proofed"). Climate-proofed strategies and policies explicitly address climate change adaptation, give equal importance to longer-term and slow-onset hazards, and establish flexible mechanisms (including risk financing) that can address uncertainty. Useful guidance has been developed for climate proofing by the German Organisation for Technical Cooperation ([GTZ], now the Deutsche Gesellschaft für Internationale Zusammenarbeit ([GIZ]) (Hahn and Fröde, 2010). The guidance applies four steps that need to be conducted systematically (preparation, analysis, options, and integration), in which process is the key, form follows function, and multiple perspectives are embraced.

Malawi's current environmental policies, strategies, and programs were formulated following the Earth Summit in 1992; as such, all are in response to Agenda 21. Agenda 21 identified poverty, high population, consumption patterns, and technologies as the main drivers for environmental sustainability. Agenda 21 also called for rich nations and international financial institutions to support developing countries to define their national environmental action plans and national strategies for sustainable development. Some of the main policy and strategy documents are briefly described below.

National Environmental Action Plan (NEAP). After signing Agenda 21 in 1992, Malawi prepared the NEAP as an operational tool for the implementation of Agenda 21. The NEAP identified several key environmental concerns that include

1. High soil erosion and low soil fertility;
2. Deforestation and overgrazing;
3. Water resources degradation and depletion;
4. Overfishing;
5. Loss of biodiversity;
6. Human habitat degradation;
7. High population growth;
8. Air pollution; and
9. Climate change.

It is intended that the NEAP be used as a framework for all development plans to ensure an environmentally sustainable development in line with the strategic objectives of Vision 2020, the MGDS, and the Malawi Economic Growth Strategy (MEGS). To operationalize the NEAP, the GoM is implementing the Environmental Support Project (ESP); its overall objective is to integrate environmental concerns into socioeconomic development of the country. Malawi revised the NEAP in 2002 to respond to challenges brought up by the democratization and decentralization processes since 1994.

National Environmental Policy (NEP). The NEP 1996, revised in 2004, provides an overall framework through which sectorial policies are reviewed to assess their consistency with the principles of sound environmental management. The policy emphasizes

1. Empowering local communities in the management of their natural resources to promote social equity;
2. Minimizing the adverse impacts of climate change;
3. Reducing air pollution; and
4. Reducing greenhouse gas emissions through monitoring the impacts of climate change on ecosystems, vegetation, and carbon sinks; reducing gas emissions from the transport sector and the manufacturing industry; and using climate data to help guide land-use and economic decisions.

National Strategy for Sustainable Development (NSSD). In 2004, the GoM prepared and launched the NSSD in response to the requirements of the World Summit on Sustainable Development (WSSD) that was held in Johannesburg, South Africa in 2002. Through the provisions of the WSSD, Malawi has taken a leading role in the implementation of the UNFCCC activities, including the installation of satellite data receiving equipment, public awareness campaigns on climate change issues, and the preparation of the Second National Communication of Malawi document.

Disaster Risk Reduction and Management policy. At the time of this writing, a national Disaster Risk Management Strategy was being developed and a Disaster Preparedness Relief Act was also being reviewed, reportedly in light of climate change. As many climate change events are closely related to disaster risk, it is important that the institutions tasked with the management of disaster risk contribute actively to the development of the climate change policies and strategies, and that the parallel efforts support each other proactively.

3.3.2.1 AGRICULTURAL POLICIES

In response to the severe drought, reduced maize yields, and heightened food insecurity in 2005, the GoM launched a major program to subsidize agricultural inputs. The **Farm Input Subsidy Program (FISP)** was designed to provide assistance to as many as 1.5 million households by distributing coupons to enable them to benefit from a 90-percent subsidy for a package on inputs that included 100kg of fertilizer, and higher yielding hybrid maize seed and legume seed.[28] The cost of the FISP subsidy amounted to $50 million in 2005–2006. The program was successful in boosting production; harvests reached a record 3.4 million tons, with average yields rising to approximately 1.9 tons/ha/year during the period 2006–2010. However, in addition to the high costs, the subsidy for maize has contributed to a shift to plant more land with maize (a crop that is particularly susceptible to the effects of higher temperatures, erratic rainfall, and drought) with correspondingly less area devoted to more drought-resistant crops such as sorghum, millet, and cassava.

The subsidy for fertilizer and seeds has also tended to reduce the attention given to other methods of maintaining or increasing crop yields, such as increasing the application of compost and manure, inter-cropping with leguminous trees and other agroforestry species, and adoption of conservation agriculture and other "climate smart agriculture" practices. Recently, a Ministry of Agriculture and World Bank-led consortium of donors supporting the FISP have restructured the program and have added financing, with the goal of giving more attention to sustainable land management. The program has included a target of 1.5 percent for the level of organic matter in soils in conservation farming areas, and the program will increase support for inter-cropping with legumes and demonstration sites for conservation agriculture and sustainable land management practices designed to improve soil fertility and to increase the efficiency of fertilizer use.

Designed to achieve food security and raise smallholders' income through increased maize and legume production, the FISP is now in its eighth year of implementation. In the 2010/2011 agricultural season, FISP packages included subsidies of fertilizer for maize, of improved maize, and of legume seeds. The program takes up to six percent of the country's GDP and about 60 percent of the budget of the Ministry of Agriculture. This has had successful influence on food security.

In 2012, a study was completed to assess the prospects for agricultural diversification in Malawi. This assessment included an analysis of the production constraints and opportunities for 10 different crops, including maize, legumes, and others (Center for Independent Evaluations, 2012). The assessment focused on constraints such as low yield, low uptake of technologies, and low use of inputs. It also studied lack of credit, high transport costs, and weak links to markets. The study highlighted the opportunities for agricultural diversification that could be pursued through greater use of high yielding varieties, value addition, and contract farming. Apart from a reference to making use of drought tolerant seed, there was minimal attention given to the impact of climate change, land degradation, and unsustainable agricultural practices on current production, or prospects for crop diversification. In addition to making better use of crop modeling under likely climate change scenarios, there is a critical need for decision makers working on agricultural policy and related development programs and investment strategies to take fuller account of the importance of soil erosion, declining soil fertility, inadequate replenishment of soil organic matter, and inattention to increasing the density of trees on cropland. Particular attention must be given to a more concerted effort to capitalize on the potential benefits associated with scaling up conservation agriculture and agroforestry from the standpoint of both more productive and sustainable agricultural production and climate change adaptation and mitigation.

At the regional level, the policy environment for maize is highly unpredictable. This creates uncertainty for value chain stakeholders, and can make it challenging to formalize and develop marketing channels. It also discourages extensive service provision to smallholders. The trading environment is characterized by a lack of harmonization in cross-border trade, standards, and non-tariff barriers, such as domestic regulations. Policies, such as minimum price regulation and export bans, distort trade. This creates an uncertain investment climate, often disincentivizing private sector actors to make significant investments (AECOM, 2012).

[28] FISP, now in its eighth year of implementation, was designed to achieve food security and raise smallholders' income through increased maize and legume production. The program takes up to six percent of the country's GDP and about 60 percent of the budget of the Ministry of Agriculture, and is considered to have had a successful influence on food security. In the 2010/2011 agricultural season, FISP packages included subsidies of fertilizer for maize, of improved maize, and of legume seeds.

4.0 CLIMATE EXPOSURE

This section explores the climate **exposure** or direct ("first degree") manifestations of the climate system: temperature, precipitation, winds, and hazards such as flooding and drought. Section 4.1 begins with a discussion of baseline knowledge (prior to the Malawi VA study). Section 4.2 addresses features and drivers of variability in Malawi's climate: seasonality and inter-annual variability. Section 4.3 provides the findings of the Malawi VA to date, all components combined, to reflect on perceptions, observations or projections in temperature, precipitation, winds and hazards. Annex B provides detailed findings from the PRA analysis that included additional anecdotal evidence for a climate already changing. Detailed graphs and figures from the climate modeling can be found in Annex C.

4.1 CLIMATE BASELINE

The climate of Malawi is greatly influenced by topography and the presence of Lake Malawi, a huge water body (29,600 km^2) that covers nearly two-thirds of the country's length. Malawi's climate is closely associated with its accentuated topography. Africa's Great Rift Valley contains Lake Malawi and stretches from north to south with elevations ranging from 800–1,200 meters. Highland peaks can reach as high as 3,000 meters above sea level. Malawi climates can be classified into three groups:

- Semi-arid (Shire Valley and some parts along the Lakeshore Plain);
- Semi-arid to sub-humid (medium altitude plateaus); and
- Sub-humid (high altitude plateaus and hilly areas).

The geographic focus of the Malawi VA contains parts of each of these three climates.

Generally, Malawi experiences a sub-tropical climate that is characterized by two distinct seasons: A single rainy season historically lasting from November to April, and a dry season extending from May to October. In Malawi, the period from May to August (and often May to October) is considered *winter*, although the warmest months are typically September and October; the rainy season months (November to April) are generally referred to as the *(austral) summer* season.

Given the geographic location of the country, it is likely that separate climate drivers may influence the northern and southern parts of the country. The current literature (Mutai and Ward, 2000; Indeje et al., 2000; Behera et al., 2005; Pohl and Camberlin, 2006; Richard et al., 2000; Reason, 2002; Pohl et al., 2007) on African climate and the dominant modes of climate variability tend to focus on specific regions within the continent, such as equatorial east Africa (approximately north of 10°S) and subtropical southern Africa (south of 15°S). Malawi straddles both these geographic "divides." This fact arguably provides further incentive to cluster the stations into northern, central, and southern groups for the ensuing climate modeling and analysis.

4.1.1 TEMPERATURE

The mean annual minimum and maximum temperatures range from under 12 to over 32 °C (Malawi Meteorological Services, 2006b). The highest temperatures typically occur at the end of October or early November, and the lowest in June or July. The highest mean air temperatures are recorded in the Lower Shire Valley (25–26 °C) and some areas along the Lakeshore Plain (23–25 °C). The lowest mean temperatures (13–15 °C) are recorded over the Nyika, Viphya, Dedza, Mulanje, and Zomba plateaus; Misuku Hills; and the Kirk Range. From May to August, it is relatively cool on most high altitude plateaus and hilly areas, such as the Shire Highlands. During the coldest months of June and July, frost may periodically occur on the high altitude plateaus, especially along *dambos* (a wetland area that can be used for "winter" crop cultivation, but may be too wet in the rainy season for "summer" cultivation) and river valleys. The 1980s recorded some of the highest surface air temperatures in recent years, closely followed by the 2000s, raising fears in many quarters that climate is already changing at a rate that is faster than at any other time in the past. These changing climatic conditions have normally been associated with the effects of the El Niño.

4.1.2 PRECIPITATION

There are two main synoptic rain-bearing systems that are known to bring rainfall to the country: the Inter-Tropical Convergence Zone (ITCZ) and the Congo Air Mass or Zaire Air Boundary. Other factors that equally influence the climate of Malawi include anti-cyclones, easterly waves, and tropical cyclones (occasionally). A deficiency in rainfall may occur if these systems are not active in a season. Rainfall is also strongly influenced by orographic (windward slopes get higher precipitation) and topographic effects.

Historically, rains in Malawi begin in the south around the month of October. The rains peak in the December to January timeframe, and end in March or April. Short, sharp rains, locally called *chizimaluphya*, occur shortly before the rains start in earnest, to signal the start of the rainy season. The mean annual rainfall in Malawi ranges between 725mm in low-lying marginal rainfall areas, such as the Shire Valley and some areas along the Lakeshore Plain, to well over 2,500mm on high altitude plateaus, such as Nyika plateau (Malawi Meteorological Services, 2006a). The rain shadow areas, such as the Shire Valley, the western parts of the Shire Highlands, Lake Chilwa Plain, and the north-western parts of the Viphya and Nyika plateaus, receive the lowest total annual rainfall. High altitude plateaus, such as Mulanje, Thyolo, Nyika, Misuku and Viphya plateaus, and some areas along the Lakeshore Plain, such as the Nkhata Bay lowlands and north Karonga receive the highest total annual rainfall. The rains typically peak in December/January and end in March or, at times, in April. Mean monthly averages of total rainfall range from under 50mm to over 400mm. Humidity ranges from 50 percent to 87 percent for the drier months of September/October and wetter months of January/February, respectively.

4.1.3 WIND

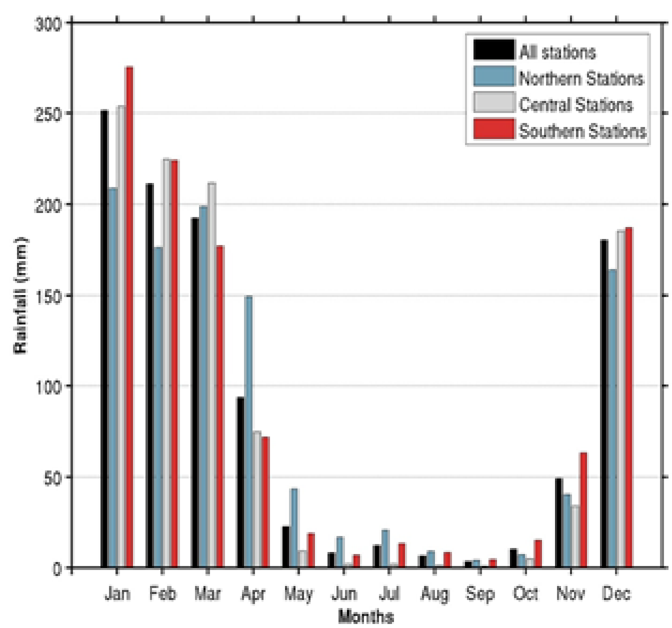
The prevailing wind direction from March to September is southeasterly. As the hot season progresses, pressure decreases from September onwards over Malawi. Airstreams become increasingly northerly; by November, local thunderstorms occur as the air masses converge. The most important factors affecting local wind patterns and associated precipitation are the topographic features of Lake Malawi basin and rift escarpments. This topography reinforces the flow of the southeasterly air streams.

4.2 CLIMATE VARIABILITY

4.2.1 SEASONALITY

Rainfall is markedly seasonal in Malawi. The overall total rainfall received over Malawi shows a high degree of inter- and intra-seasonal variability. It is typically cool and dry from May to August, warm and dry from September to November, and warm and wet from November to April. In some high altitude plateaus, such as the Shire Highlands, drizzles, locally known as *chiperoni*, are quite common during the months of May, June, and July, which are historically the coldest months in Malawi.

FIGURE 4.1. SEASONALITY OF PRECIPITATION, BY REGION



Both warmer- and cooler-than-normal SSTs are considered key drivers of regional inter-annual variability across the globe, and Malawi is no exception. The most important driver of climate variability is arguably the ENSO. Close to the east African coastline, anomalous SST conditions in the Indian Ocean portray teleconnective[29] patterns linked to regional climate. In fact, the northern and southern parts of Malawi may be influenced by separate climate drivers. Phase 2 of the Malawi VA climate study, revealed that there may be a correlation between ENSO years–periods in which sea surface temperatures in the eastern Pacific Ocean are anomalously high–and the number of heavy rain events for Malawi as a whole. However, this was not the case for every single ENSO event and even for some of the very wet or dry years, but it did give an indication of a possible relationship. In addition, neither the Phase 1 nor the Phase 2 analysis established any robust correlation between SST conditions in the Indian Ocean and rainfall in Malawi, although the study did find suggestions of such an influence on meteorological stations located in the southern part of the country.

The seasonal rainfall cycle for all 22 Malawi stations combined (Figure 4.1, source CSAG) demonstrates similarity across the regions, with Southern stations having relatively heavier rainfall than other stations from October through January. Central stations take the lead in February and March; northern stations lead the rest of the year (April through July).

4.2.2 INTER-ANNUAL VARIABILITY

While variations in total rainfall exhibit no discernible cycle, the historical trend brings a series of wet years followed by a number of dry years. Normally, the higher the total rainfall, the lower the inter-annual variability. Lakeshore areas are anomalous because local winds and topographic features tend to produce irregular and unpredictable heavy rainstorms, which contribute to both total rainfall and inter-annual variability.

Inter-annual variability is dictated by teleconnections with major climate forcings such as the ENSO, the IOD, and the Subtropical Indian Ocean Dipole (SIOD). A combination of these forcings plays an important role in summer dynamics of Malawi. There are some interesting differences between northern and southern meteorology stations, as southern rainfall appears to be influenced more by sea surface temperatures in the subtropical Indian Ocean than by ENSO or the tropical IOD.

Standardized rainfall anomalies (deviations from normal) for the November to April period (i.e., summer or "rainy" season) broken down by region from 1997–2011 (Figure 4.2[30]) demonstrate very high inter-annual variability. During this period, the climate analysis highlighted that Malawi experienced considerable variability in the summer rainfall totals. It is interesting to note that not all the stations show the same anomaly signal in some years. For example, even though the summers of 2003/2004 and 2004/2005 are seen as dry periods, the stations in northern Malawi received slightly above average rainfall. In comparison, the 2005/2006 the southern and northern stations displayed completely contrasting signals. The 2004–2006 is of interest, because in terms of annual totals, 2005 was a very dry year across Malawi. However, the northern stations received above normal rainfall the year before. This above normal rainfall in late 2004 resulted in the 2004/2005 period indicating almost near normal summer rainfall in the northern stations. In 2005/2006 the northern stations indicate a very dry summer, while the annual anomalies indicate 2006 was slightly wetter than normal. This suggests that the northern stations were fairly dry in late 2005. This analysis highlights how a mixing of signals may complicate our understanding of the main modes of rainfall variability.

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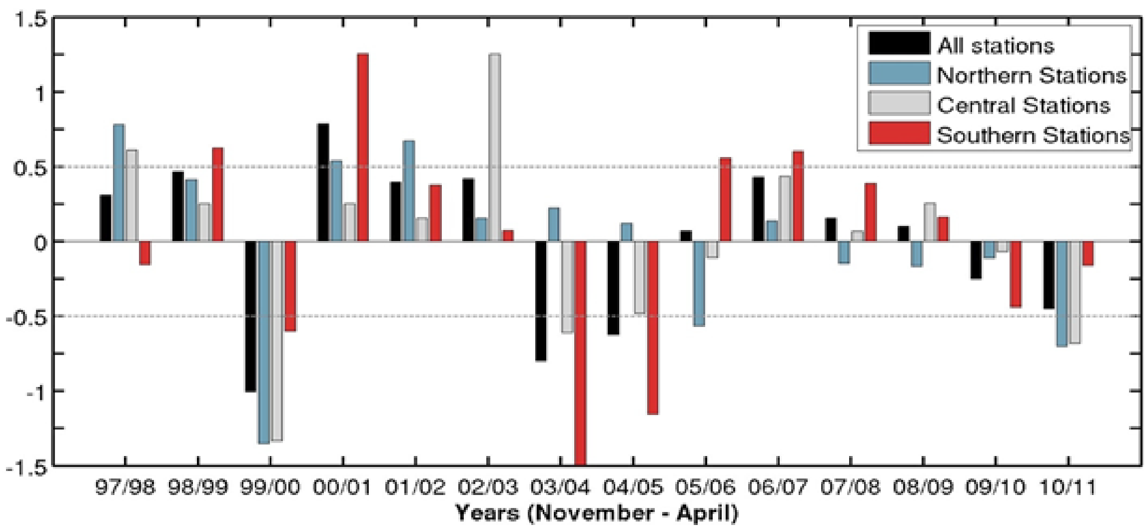
[29] The *American Meteorological Society* defines a "teleconnection" as (i) a linkage between weather changes occurring in widely separated regions of the globe or (ii) a significant positive or negative correlation in the fluctuations of a field at widely separated points. Most commonly applied to variability on monthly and longer timescales, the name refers to the fact that such correlations suggest that information is propagating between the distant points through the atmosphere (American Meteorological Society, 2013).

[30] In Figure 4.2, the Y-axis represents the standardized anomaly (also known as a normalized anomaly), commonly used in precipitation characteristics. It is created by taking the observation, subtracting it from the mean of the data (i.e., producing the anomaly) and then dividing it by the standard deviation of the data. An anomaly of ± 0.5 is the threshold at which the season is designated as very wet (bars going up) or very dry (bars going down).

The wet summers from 2005–2006 occurred around the same time when there were a few consecutive positive phases in the SIOD. It appears that the southern stations follow a similar pattern to the SIOD, with a wet (dry) summer coinciding with a positive (negative) SIOD. The relationship between Malawi rainfall and SST conditions over the southwest Indian Ocean has previously been noted by Jury and Mwafulirwa (2002). This relationship, however, cannot be confirmed with confidence on such a short time series.

It is not possible to define the limits of the natural variability accurately–or isolate an impact to variability as opposed to climate change–due to the relatively short and spatially limited historical record included in the Phase 1 analysis, but also because the climate system is quasi-chaotic in nature. This source of uncertainty will never completely disappear and to this end, planners and decision maker must consider range of possible futures.

FIGURE 4.2. ANOMALIES PER YEAR AND REGION



4.3 CLIMATE IMPACTS (FIRST-DEGREE GEOPHYSICAL)

This section discussed the geophysical manifestations of climate change in Malawi, beginning with the current changes–that is, what has already been perceived or observed or measured–followed by the projected increases expected for the periods 2020-2040 and 2040-2060. For each, descriptions highlight temperatures, precipitation, winds, and hazards.

4.3.1 CURRENT CHANGES

4.3.1.1 CURRENT CHANGES IN TEMPERATURE

The results of the climate modeling exercise confirmed an increase in temperatures from the official trends typically published by the Malawi Met Services. The climate modeling determined a range of 1997–2011 temperatures to be as follows:

- Observed annual minimum daily temperatures nationwide range from 13–21 °C;
- Observed annual maximum daily temperatures nationwide range from 23–33 °C; and
- Observed annual extreme daily maximum temperatures range from 27–39.5 °C.

The climate modeling exercise portrays a clear increase over the annual temperature averages already happening. All stations showed a relatively sharp increase in temperature, both maximum and minimum, over the years of available data. Furthermore, changes in maximum temperature were found during the months of November and December, with smaller changes also found in the late summer months of January and

February. The increase in temperature was found to be even more apparent by analyzing the number of days during the summer months that exceed a given threshold. Here, nearly all trends in the changes in the number of days exceeding 32 °C are statistically significant at the 95 percent confidence level.

These findings are confirmed by the perceptions of many of the villagers during the PRA who, over the past 10 or so years, have a perceived change in air temperatures. Seven of the nine villages studied reported variability in winter temperatures: Six out of nine perceived the winters as warming up and one of the villages perceived a decrease. Seven of the nine villages also perceived higher temperatures in September/October shortly before the summer rains are expected. All nine villages perceived the austral summer to be hotter than what they considered "normal." Furthermore, nearly one-quarter (24 percent) of the 46 key informants interviewed highlighted warming temperatures as one of the most visible impacts of climate change in Malawi.

4.3.1.2 CURRENT CHANGES IN PRECIPITATION

The Malawi VA climate modeling exercise revealed that in the recent past, for 1997–2011 period, Malawi was exposed to six very wet and five very dry summers, as defined by a ± 0.5 anomaly. There also appears to have been fewer very dry summers than very wet summers. The driest summer occurred during 1999/2000, and was subsequently followed by the wettest summer (2000/2001). On both these occasions, all station clusters (regions) displayed the same anomaly signs. In 2005/2006, the Northern region had a very dry summer while the Southern region had a very wet summer.

Mean annual precipitation for the current period ranges from about 630mm at Bolero to 1650mm at Nkhata Bay. This is a striking difference from the historical reported range of 725mm to 2500mm (Malawi Meteorological Services, 2006a.).

These changes were also confirmed in the PRA exercise. In recent years, villagers reported that they have perceived change in the rainy season, making agriculture decisions regarding planting more difficult and less reliable. The PRA results clearly highlight the perceived changes in precipitation. All nine villages studied reported three unsettling dynamics that are becoming the harbingers of climate change across the world:

- An unclear start to many/most seasons;
- Heavier rains in certain years or condensed periods of any given year (especially at the end of the season, and different for each village); and
- Extended dry periods (different years stated for each).

Eight of the nine villages also reported late onset of the rains and six reported an earlier cessation from what they consider "normal." It is interesting to note that the years noted for the differences were rarely the same between villages (thereby confirming the diversity of microclimates and livelihoods they were chosen to represent). Furthermore, 15 percent of the 46 key informants interviewed highlighted reduced or erratic precipitation as one of the most visible impacts of climate change in Malawi.

As is inevitably in agricultural communities that depend on rain-fed cropping, the rains were a major issue of discussion. Some of those interviewed described the new erratic nature of the rains:

"Rains are playing games with us as they are no longer predictable." Community member, Chisambamnopa *"The climate has lost its memory."* Community member, Chisambamnopa	*"The rains have been crooked and tricky."* Community member, Kawelama *"We are not sure which rains are the planting rains and even the meteorological department seem not to know what they are saying unlike in the past."* Community members, Felo

4.3.1.3 CURRENT CHANGES IN WIND

Although of less significance than temperatures and rainfall to rural communities, there have also been perceived changes[31] in local wind patterns. Eight of the nine PRA villages reported more intense winds and seven out of nine villages reported an apparent change in direction of winds. Furthermore, 13 percent of the 46 key informants interviewed highlighted changes in wind patterns as one of the most visible impacts of climate change in Malawi. (The Malawi VA climate modeling did not include winds.)

4.3.1.4 CURRENT CHANGES IN HAZARDS

Although dry spells and heavier precipitation have, to some respect, both been discussed above under precipitation, both drought and flooding merit more attention. (The Malawi VA climate projections did not include an exploration of impacts on flood and drought events.)

Droughts were reported by communities. Despite an unclear distinction between dry spells, prolonged dry spells and droughts, communities referred to a mixture characterized by significant damage to crops, which is what differentiates them from the "normal" dry spells that occur mid-season, often in January of February. Recent "droughts" were reported as follows. In 2007–2008 there was drought in Felo. In 2009, there was drought in Kawelama. The 2010–2011 season was also very bad in Felo, with reports that only millet and sorghum survived; in Lupanga, the nearest river dried up in 2011. The 2011–2012 growing season was reportedly a "drought" in Chisambamnopa, Liguluche and Kawelama.

> *"Since 1990 we have been experiencing droughts. It doesn't take two or three years without experiencing droughts in this area. We don't really know the cause but I think it is due to the destruction of trees in the upland areas."* Community member, Felo

The drying of rivers and *dambo* areas were also reported as consequences of reduced rainfall:

> *"Madzimbayera* dambos *never dried up during droughts, but now it dries up*." Community member, Chiluzi
>
> *"In the* dambo *areas it was wet all year round unlike these days where it dries up so quickly soon after the rains stop"* Community member, Lupanga

The PRA results also determined that a majority of villages studied (five out of nine) reported greater exposure to the flooding of their river beds, *dambos* as well as the water logging of their fields. Two villages, however, reported lower exposure to flooding than in the recent past. These two villages, Kawelama and Liguluche, are closest to two of Malawi's main lakes, Chilwa and Malawi, respectively.

Interestingly, 44 percent of the 46 key informants interviewed highlighted changes in hazard profiles (especially flooding, but also mudslides, erosion, pollution, and wildfires) as one of the most visible impacts of climate change in Malawi.

4.3.2 PROJECTED CLIMATE CHANGE

The Malawi VA climate study provided a quantitative analysis of projected climate for the country for the periods 2020-2040 and 2040-2060. The results of the climate projections for these periods provide an indication of how changes are likely to occur in the more distant future and it is possible that these changes will begin to manifest themselves in the nearer term. This section provides the overall projections for climate in Malawi for the 2020-2040 and 2040-2060 periods. The thresholds of 36 °C and 20mm were determined in close collaboration with the Malawi DCCMS to be generic thresholds applied currently in Malawi. A temperature reaching 36 °C was considered "very hot" and rainfall of at least 20mm for two days in a row signaled the seasonal onset.

[31] The climate change modeling portion of the Malawi VA did not include a wind modeling component.

4.3.2.1 PROJECTED CHANGES IN TEMPERATURE

For Malawi as a whole, the climate analysis resulted in a very consistent signal showing that the greatest increases in mean and extreme temperatures are projected to occur in October and November. Specifically,

- For the period **2020-2040**, monthly mean T_{max} calculations showed the lowest increases in maximum temperature likely to take place during January and February, with changes of between of 0.6 °C to 1.15°C and 0.75 °C to 1.5 °C for the two emission scenarios.[32] The largest increases were seen in the hottest months (October and November), with ranges of between 0.8 and 2 °C.

- For the period **2040-2060**, the early summer months of October and November were projected to be warmer, with an increase of between 1.75 °C to 2.5 °C. In addition, more days of extreme temperatures are projected. As for the 2020-2040 period, the climate analysis projected that the strongest warming would occur during October and November, but the increases were higher than those projected for 2020-2040. In addition, the analysis gave indications that the heat spells would be of longer duration during these periods.

4.3.2.2 PROJECTED CHANGES IN PRECIPITATION

For the 2020-2040 period, projections for Malawi as a whole are largely consistent for all 22 stations and show a general likelihood of later seasonal onset. Many regions may also experience an enhancement of rainfall during the months of December through February, followed by an early cessation. The pattern was more obvious in the high emission scenario. For the **2040-2060** period, projections were also consistent, with a general decrease in monthly rainfall in the early parts of the rainy season compared to those found from the historical climate analysis. In addition to drier conditions during November, as projected for the 2020-2040 period, drier conditions were also projected for December during the 2040-2060 period. There is also still some evidence of less rainfall in April, suggesting that an early cessation will continue to occur after the 2020-2040 period. However, it must be noted that the models did not show as much agreement across all stations.

Regionally, there were some important differences. In the north, for the 2020-2040 period, changes in rain day frequency were found to be broadly consistent with monthly mean rainfall, although the magnitude of the changes are small (fewer than two days per month) and model agreement is low. Nevertheless, at some stations there was a fairly consistent indication of a small decrease in rain days and a projected decrease in November rainfall at nearly all stations. For the 2040-2060 period, the dry period was projected to extend into December, as well. Both periods showed a rainfall increase in February and March.

Lakeshore. There are indications of reduced early and late summer rainfall shown in the 2020-2040 projections. Nkhata Bay was the only station in the region that did not show the clear decrease in rainfall at the end of the rainy season. There was even some indication that it may get wetter during March-April under the high emission scenario. Nkhata Bay also differed from the other stations in that it did not show a decrease in the number of wet days or heavy rainfall events in April under the high emission scenario. For the 2040-2060 period, the stations along the shore of the lake show a similar pattern—the month of November is still projected to become drier, but for the 2040-2060 period, so is December. The mid-summer months of January and February are projected to be wetter, while March has mixed model results. There is still a tendency for the late summer months (i.e., April) to become drier, but this is not as clear at some stations as that projected for the period 2020-2040.

South. For the period 2020-2040, projections for Ngabu, for example, show a relatively clear tendency toward reduced rainfall in November, a mixed signal in December and January, increases in February and March, and decreases in April. The changes in rainfall are also reflected in the number of wet days per month, with a decrease in monthly rainfall matching a decrease in the number of rain events, and vice-versa. The

[32] The two scenarios are RCP4.5 (emissions stabilizing before 2100) and RCP8.5 (high emissions scenario).

projections are similar for the period 2040-2060. For that period, February was projected to be the only month with a likely increase in total monthly rainfall.

5.0 CLIMATE CHANGE SENSITIVITES AND IMPACTS

This section describes impacts and adaptations (spontaneous or assisted) in Malawi that result from changes in the climate system. As noted previously, because of the depth of analysis carried out during the Malawi VA, a "**degrees of impact**" refinement was used to provide a framework for a deeper analysis than would have otherwise been possible. In this framework, **exposure** aligns to the direct (or "first degree") manifestations of the climate system: temperature, precipitation, winds, and hazards such as flooding and drought. These were described in the previous section. **Sensitivity**, then, is expressed in terms of second- and third-degree impacts, where the second-degree impacts are the spontaneous adaptation of the biophysical world to climate changes, and the third-degree impacts are the socioeconomic impacts. The first part of this section focuses on the second-degree impacts, and the second part focuses on the third-degree impacts.

Many of these sensitivities and impacts are evolutions and shifts that have already been observed or perceived for the higher degree impacts classified as biophysical (second degree) and socio-economic (third degree). Others (the economic impacts on the cost of production) are those that are anticipated under future climate scenarios. Results from all pertinent and available studies conducted within the Malawi VA are highlighted. It is noted that not all impacts are driven uniquely or even predominantly—many are climate change impacts aggravated by other behaviors (such as unsustainable resource use or poor land management) or other behaviors are aggravated by climate change. As much as possible in this section, we try to distinguish climate change from other factors. But as one moves from lower to higher degrees of impact, the non-climate factors become more and more difficult to unambiguously disentangle from climate change-related factors.

As Malawian temperatures rise and precipitation becomes less predictable, biophysical and human organisms adapt to survive. Like many other countries and entire continents, Malawi is currently experiencing a state of climate flux, with systems and individuals changing and adapting simultaneously, seeking new equilibria. Many changes occur spontaneously, others may adapt with assistance of varying degrees. If they are still in existence, organisms have identified and employed strategies that enable them to survive, even when they no longer thrive. The scope of this study does not permit a comparison between permutations that will become permanent (i.e., changes or adaptations) and those that are transitory or ephemeral (i.e., impacts); the two are conflated in this analysis. Any inherent dangers of prolonging one or another adaptation strategy, however, will be highlighted whenever appropriate and possible.

5.1 WATER RESOURCES

Due to the confounding factors that are inextricable from an exploration of water demand and access, this section carefully separates water availability at a macro level from water demand. (The latter is discussed at the end of the section.) Today, the impacts of climate change on *water availability* in Malawi are already evident. Erratic rains, extended dry periods, and increased evaporation have combined with population growth and increased water demand to rapidly turn Malawi's historical water abundance into water scarcity.

Surface water remains significantly more abundant than groundwater[33] resources in all sub-basins of Malawi and continues to provide the vast majority of all available water. Many sources concur to report that erratic

[33] Sustainably available groundwater resources are estimated to make up only 2 percent (1,300 Ml/d) of the nationally available total water resource. Source: Water Resources Investment Strategy (Component 1 – Water Resources Assessment) commissioned by Malawi's Ministry of Irrigation and Water Development and co-produced by the Atkins International Ltd, and Wellfield Consulting Services in April 2011 (pp. 136-142).

rainfall has reduced the availability of surface water in Malawi and that the higher reported temperatures over the last 10 years have contributed to its increased rates of evaporation (Table 5.1).

TABLE 5.1. CURRENT IMPACTS, WATER

Element	How does climate impact the element?	Recent impacts observed
Surface water	Precipitation is the principle source of surface water (which makes up over 90 percent of total water availability in Malawi)	Less rain, less water availability
Lakes Malawi and Chilwa	Precipitation and evaporation dominate the hydrological cycles of Lake Malawi	Lake Chilwa completely dried up in 1995 and 1968
Shire River	As surface water declines, less water is available to produce power in the five hydropower stations on the Shire; As precipitation decreases, national water demand rises	Historical precedent of no outflow from Lake Malawi to Shire (1915–1935); Rationing of hydropower from Shire since 1997 (at end of dry seasons)

Historically, Malawi's water bodies have already exhibited a high sensitivity to changes in climate. During recent extreme drought conditions, most sub-basins in the country retained little surface water. The dominance of precipitation and evaporation on Lake Malawi's hydrologic cycle heightens that system's susceptibility. Outflows from Lake Malawi directly impact water flows into the Shire River system, and there is already historical precedent for the flow to stop[34] altogether—from 1915 to 1935, there was no outflow from Lake Malawi into the Shire River system. As the dominant source of renewable water resources in Malawi, the Shire River made available an estimated 31,310 million liters per day during a typical dry season in 2010, out of the national total of 38,700 (GoM Ministry of Irrigation and Water Development, 2011, p. 124). Lake Chilwa completely dried up in 1995, for the second time in recorded history (Njaya, Friday, 2001, p. 15). While typical seasonal lake level fluctuations in Chilwa are 0.8 to 1 meters, in the past, lake level fluctuations of 2 to 3 meters have left the lake partially or completely dry. The shallow depth and very low total volume lead to conditions of a very fragile system, making the lake particularly vulnerable to precipitation variability and evaporation, both of which are likely to increase with climate change.

While climate change has the biophysical (second degree) impact of decreasing water availability, it simultaneously has the socioeconomic (third degree) impact of increasing *water demand* as Malawian farmers and households search for ways to compensate for the water scarcity. While total annual average water demand is estimated at approximately 2,900 Ml/day (2010), this value increases to 3,900 Ml/d during an average dry season, an increase of approximately 35 percent. During average dry season conditions in 2010, the national total demand for water was only 10 percent of the nationally available surface water resource. During an extreme drought event dry season, demand increases to 55 percent (i.e., resources are more constrained but still generally in surplus at a national scale).

Unreliable electricity and fuel supply is a key constraint to development in Malawi. The current installed capacity of about 283 MW is far less than the estimated demand of 334 MW (Government of Malawi Ministry of Natural Resources Energy and Environment, 2010). Only seven percent of the population has access to electricity services (World Bank, 2012). Malawi is not connected to the regional grid, hence faces shortages while it is trying to develop its domestics sources of power. Fuel supply has been erratic in the past two years and worsened in 2012. As a result of low lake levels in the Shire River beginning in 1997, electrical power production has regularly been rationed at the end of dry seasons, typically in October and November (Bootsma and Jorgensen, 2004, p. 262). It is not unusual for pumps remain dry for two weeks in a row. The fuel and electricity shortages are contributing to low economic activity and productivity.

As highlighted in the GoM's 2010 *State of the Environment and Outlook Report*, some of the country's river basins were already experiencing over-abstraction due to numerous water permits and grants issued by the Water

[34] Long before Malawi Lake levels fall to the point where outflow to the Shire River stops again, there will be a significant impact on both hydropower production and availability of water for irrigation.

Resources Board (WRB) (Government of Malawi Ministry of Natural Resources, Energy and Environment, 2010, p. 227). As a measure of Malawi's "water stress," more than 36 percent of the country's area is affected by oversubscription of water resources (Environmental Performance Index, 2010). While this is the tenth-best rating for countries of sub-Saharan Africa, it is far from the ideal of zero percent (or no stress). Water scarcity[35] (overall lack of water representing the weighted ratio of total freshwater withdrawals to renewable water withdrawals) in Malawi registers 100 percent.

Thus, although the influence of current climate change on water availability is certain, the declining water balance (availability minus demand) in Malawi is largely the result of the national demand exceeding the supply. The rising demand for water is driven more by confounding factors than by climate change. Still, climate change will likely worsen water availability.

Three out of nine villages studied in the PRA reported conflicts over water availability for agriculture. In Nkasala village, conflicts were reported over shared use of water for irrigation. In Chiluzi, tobacco farmers upstream were blamed by those further down for drawing off too much water from the streams. Although this reflects more the human system and may include aspects of equitable water access (as opposed to availability), it indicates potential scarcity that is likely to be worsened by reduced precipitation and higher evaporation rates due to climate change.

5.2 NATURAL RESOURCES: FORESTS AND BIODIVERSITY

According to a recent assessment of tropical forests and biodiversity in Malawi, "the environment is being used up or degraded at an alarming rate causing loss of soil fertility, increase in soil erosion; deforestation; water depletion; loss of wildlife; overfishing; increased pollution; and loss of animal, fish and plant species (biodiversity)" (USAID/Malawi, 2005). Although it is commonly noted that key drivers of environmental degradation include high population growth, population density, unsustainable agricultural practices and widespread poverty, the impacts of climate change are increasingly being felt and are exacerbating these effects. (See Table 5.2.) To date, however, there is very little evidence to measure the impact of climate change on natural resources; no study was found to evaluate, for example, whether temperatures have changed enough to trigger movement of species into different zones or whether the primary trees are vulnerable to increased temperature.

Soil loss was recently estimated to average 20 tons/ha/year, and contributes to a reduction in crop yields of more than four percent per year (Yaron et al., 2011). A combination of deforestation, increased rainfall runoff, and accelerated sheet erosion are already contributing to land degradation on a large scale in Malawi. Additional land degradation is associated with continuous cropping without sufficient attention to soil and water conservation measures. Agricultural land that is without any protective tree cover or erosion control measures and subjected to more intense rainfall and higher temperatures is prone to further degradation and a reduction in soil fertility and moisture holding capacity. That same situation is now more exposed to flooding.

[35] The water scarcity indicator is derived from national-level data from FAO's AQUASTAT. The indicator represents the overuse of water derived by subtracting the recommended use fraction (0.4) from the ratio of total freshwater withdrawals (including surface and both renewable and fossil ground water) to total renewable water resources (not including desalinated or treated waste water). This proportion is then multiplied by a weight that is the ratio of freshwater withdrawal to total withdrawals (freshwater, desalinated water and treated wastewater).

TABLE 5.2. CURRENT IMPACTS, NATURAL RESOURCES

Element	How does climate impact the element?	Recent Impacts observed
Biodiversity, including wildlife	Ungulates are especially vulnerable to climate change related changes in habitat and food supply (Wildlife Study/Lengwe National Park)	*Further study needed to determine impacts of heat and climate change relates stresses on wildlife*
Forest resources and associated products	Climate change impacts on crop yields contribute to encroachment on forest reserves (along with population pressure, demand for wood fuels); increased droughts make forests more vulnerable to wildfires	*Further study needed to assess climate change impacts on forest pests and diseases*
Soil fertility and soil erosion	In addition to non-sustainable agricultural practices, climate change may contribute to more rapid loss of soil organic matter; reduced moisture holding capacity, loss of soil nutrients	Loss/erosion is estimated to be as high as 20 tons/ha/year, contributing to yield reduction of > 4 percent per year. Farmers are struggling to replenish soil organic matter and nutrients–compounded by impacts of droughts, floods, competing demands for crop residues, inadequate supplies of manure, compost, and high cost of fertilizers

One recent study (Mkanda, Francis X., 1996, pp. 157-164) of the impact of climate change on wildlife in Lengwe National Park noted that ungulates were particularly vulnerable to heat stress and climate-related changes in habitat and food supply. A shortage of resources and attention to the impact of climate change on wildlife and the integrity of protected parks, reserves and ecosystems points to the need for further study to determine the impacts of higher temperatures and other effects of climate change on wildlife populations and habitats.

Although relatively little research has been done to explore the connections among biodiversity; healthy natural ecosystems; forest cover; and the health, nutrition, and well-being of rural populations, USAID did investigate these relationships in a special study completed in 2012. Analysis of data from demographic and health surveys (DHS) and information from remote sensing of forest cover revealed that there are, in fact, positive correlations between ecosystem health and human health. This research on the association between child health and nutrition outcomes and proxies for biodiversity (percent forest cover, proximity to a protected area, and changes in forest cover) indicated that biodiversity was positively correlated with increased dietary diversity, and reduced risk of diarrhea. The study concluded that "preventing and reversing ecosystem degradation and biodiversity loss can both improve human health and provide resilience to climate change impacts" (Johnson, Jacob, and Brown, 2012).

Although it is probable that unsustainable human pressure on Malawi's natural resources is a stronger driver of resource depletion than climate today, there is no study that qualifies this distinction or the interplay of climate and human factors in an uncertain future.

5.3 PHENOLOGY

As temperatures rise and precipitation becomes erratic, and as water becomes less regularly available, agriculture becomes a risky business. The six crops studied (maize, sorghum, groundnuts, pigeon peas, cowpeas, and soybeans) require specific quantities of water and certain temperature ranges at specific stages of their growth. Changes in climate have already been reported to affect crop growth during different stages, as described below. Table 5.3 lists the crops in order of their sensitivity to climate (tallied from the Malawi VA's phenology study) from most to least climate sensitive. Six stages, different for each crop, were evaluated (for both columns of the table). Annex D provides greater detail for all crops.

TABLE 5.3. CURRENT IMPACTS, PHENOLOGY

Crop (ranked by total of stages, both columns)	**Number of stages in which climate is known to negatively influence productivity directly**	**Number of stages in which climate can trigger pests or diseases that negatively impact productivity**
Maize (24)	Temperature: 6; Precipitation: 6	Temperature: 6; Precipitation: 6
Groundnuts (21)	Temperature: 5; Precipitation: 6	Temperature: 5; Precipitation: 5
Pigeon Peas (18)	Temperature: 4; Precipitation: 2	Temperature: 6; Precipitation: 6
Cowpeas (14)	Temperature: 5; Precipitation: 1	Temperature: 4; Precipitation: 4
Soybeans (14)	Temperature: 2; Precipitation: 0	Temperature: 6; Precipitation: 6 (cooler/lower only)
Sorghum (13)	Temperature: 5; Precipitation: 1	Temperature: 1; Precipitation: 6

Note: The number of stages varies by plant. Annex D provides detailed phonological results for all six crops.

Maize. Maize yields decrease with higher temperatures (Lobell et al., 2008 and 2010; C. Ringler, 2010). Sensitivity to heat is intensified in drought conditions, and maize growing in sites with mild temperatures can be negatively affected by warming in the absence of sufficient levels of moisture in the soil (Lobell et al., 2011). Whatever the driver of reduced soil fertility (e.g., continuous cropping, insufficient measures to replenish nutrients and organic matter in the soil), the reduced moisture-holding capacity of the soil is also increasingly aggravated by high rates of rainfall runoff and low levels of soil organic matter.

Maize

From 1985–2005, maize yields in Malawi averaged approximately 1.3 tons per ha. In 2003/2004, crop production was adversely affected by the late onset of rains and a prolonged dry spell that occurred at a critical stage in crop development, particularly in the southern region (USAID/Malawi, 2005). During the 2004/2005 growing season, drought had a devastating effect on maize yields, and the national average yield fell 40 percent below the long term average, to 0.76 tons/ha. In November 2005, five million Malawians (or 38 percent of the population) were in need of food aid.[36]

Maize was cropped in all of the nine studied villages visited during the PRAs. One village, Nkasala, highlighted another climate variable, winds (*mwera*), that come with heavy rains and "break the maize." Also in Nkasala, the *Mangoni* winds (heavy winds from the north) were blamed for bringing pests like stalk borers (*Kapuchi*) that also destroy the maize.

The issue of changes between local ("traditional") varieties of maize and "improved varieties" such as Open Pollinated Varieties (OPVs) and hybrid maize varieties is complex. Because they are mostly shorter maturing, and can therefore yield a successful harvest even when the season is shortened by late onset or early cessation of rains, improved varieties of maize have long been promoted by the GoM, by the private sector (seed companies), and by NGOs. However, improved varieties also have some disadvantages. They do not perform as well compared to traditional varieties without the application of fertilizer. Improved varieties are also more susceptible to dry spells, as commonly occur in January and February, even in a normal season. Although they can survive a normal two-week dry spell, yields are affected by prolonged dry spells, particularly at the crucial tasselling stage. Traditional varieties are better able to cope with more prolonged moisture shortage, though they too will start to lose yield if the period is very prolonged. A further problem with improved varieties is that they are more susceptible to pest damage in storage, as the grains are less dense and easier to "bore."

Groundnuts. The combination of heat with longer periods of drought has the potential to impact plant development in both vegetative and reproductive phenological stages of groundnuts. The negative impacts of

[36] Other sources cited in Garrity et al. (2010, pp. 197-214).

elevated temperature and reduced water on groundnuts concurs with other reports (Vara Prasad et al. 2003) where it is indicated that this crop can suffer significant reduction in yield due to abiotic and biotic stresses and soil infertility. In Kawelama village, groundnuts were reported planted on the least fertile fields due to their perceived nitrogen fixing influence. Groundnuts were reportedly cropped in at least three of the nine studied villages in the PRA, where most farmers confirmed their sensitivity to higher temperatures. Four of the nine villages visited (Chiluzi, Liguluche, Mulupha and Nkasala) reported reduced cropping of groundnuts due to their reported moisture-sensitivity.

Pigeon Peas

Pigeon peas. Pigeon peas withstand low moisture conditions and perform well in areas with low levels of rainfall, such as in Blantyre, Machinga, and Shire Valley districts. Earlier maturing varieties are reportedly more vulnerable to lower yields, especially due to post-harvest pest-related losses, which may increase with climate change. Pigeon peas were reportedly cropped in at least three of the nine studied villages (Kawelama, Mulupha and Nkasala). There has been however a reduction in the cropping of pigeon peas due to reported moisture-sensitivity.

Cowpeas. Cowpea is a highly nutritious crop with significant levels of resilience to climate change. Cowpeas are more sensitive to temperatures than to precipitation. The crop's agricultural distribution, however, is more restricted than soybeans; cowpeas are mainly cultivated in the low- to middle-altitude and dry areas. High temperatures, drought and poor soil fertility all deter cowpea productivity in Malawi. Cowpea is widely known as the "crop of the poor" because its green pods and leaves are the earliest food available before cereals mature, so serving as "insurance" against food shortages during the "hungry season." Cowpea cultivation areas are frequently inappropriate for the production of other crops such as beans or groundnuts, and cowpea yields in these farmer-managed fields are low, averaging only 388 kg/ha in Malawi. Different abiotic and biotic stresses keep productivity low. The most significant are drought, heat, poor soil fertility, inappropriate agronomic practices, fungal, viral, and bacterial diseases, and parasitic weeds (*Striga* and *Alectra*). Cowpea has been reported as particularly susceptible to infestation by several insects with devastating effects on plants in the field and seeds in storage.

Soybeans. Interestingly, while soybeans are among the most climate-tolerant of the six studied crops (Table 5.3), they are as sensitive to climate-affected pests and diseases as is maize. The phenological study suggested that soybeans have the potential to counter climate constraints, as they appear to have good levels of drought tolerance. In addition, they can grow in relatively high elevations where excessive heat is less likely to occur, so that mountain regions can benefit from cultivating this crop. From an agronomic standpoint, soybeans are a widely spread crop; because of the plant's high protein content, it is being promoted to fight malnutrition in Central Malawi. Chiluzi (Rift Valley Escarpment Livelihood Zone, Ntcheu District) was the only PRA village visited in which soybeans were reportedly cultivated and appreciated for its nitrogen-fixing quality on less-fertile soils.

Sorghum. Sorghum is more sensitive to temperatures than to precipitation. However, the opposite is true for sensitivity of sorghum pests and disease, which are triggered more readily by precipitation. In Malawi, sorghum production is limited by a number of factors such as the lack of better cultivars, inadequate crop production practices, drought, pests, and diseases. In particular, recent production has been affected by poor and unpredictable rainfall in the growing areas (Machinga, Shire highlands, Salima, and Karonga lowlands). Sorghum was reportedly cropped in three out of the nine studied villages in the PRA.

In general, the increased prevalence of pests attributed to high temperatures and late onset of rains is an impact of climate change in Malawi that is not being addressed. The most commonly grown crops are not sufficiently pest resistant, yet pest control through chemical means is beyond the affordability of most households.

5.4 COST OF PRODUCTION (SIX CROPS)

To take the value chain analysis one step further, the Malawi VA carried out an assessment of potential changes in the production costs of each crop that led to some useful findings. The economic cost of climate change on smallholder production of each of the six crops was estimated by identifying the additional processes, inputs, labor and other resources required to account for different manifestations of climate change during the planting, growing and harvest season. (See Section 2.3.8 and Figure 5.1.)

FIGURE 5.1. SEVEN CLIMATE SCENARIOS

Typical climate	Late rainfall onset	Short season	Lower total volume	Heavy spells in April	Dry spells in the season	Hot temperature	Low temperature
Low temperature							
Hot temperature							No
Dry spells in the season						Yes	No
Heavy spells in April					No	No	Yes
Lower total volume				Yes	Yes	Yes	Yes
Short season			Yes	Yes	Yes	Yes	No
Late rainfall onset		Yes	Yes	Yes	Yes	Yes	No

The result was a rudimentary economic analysis, intended to give a sense of the approximate economic cost of climate change. One important caveat is that given the high degree of natural climate variability in the country (Section 4), there is no way to predict which combinations of climate scenarios are more likely to occur and at what frequency.

Table 5.4 shows the results for both a **moderate change in climate** relative to the benchmark climate, and for an **extreme change in climate** relative to the benchmark.

TABLE 5.4. INCREASED COST OF PRODUCTION* (FROM BASELINE)

Crop	Single Climate Factor		Combined Climate Factors	
	Moderate Climate Scenario	Extreme Climate Scenario	Moderate Climate Scenario	Extreme Climate Scenario
Maize	• Increase (without fertilizer) • Moderate increase (with fertilizer)	• Increase (without fertilizer) • Significant increase (with fertilizer)	• Significant increase (without fertilizer) • Very significant increase (with fertilizer)	• Very significant increase (without fertilizer) • Extreme increase (with fertilizer)
Groundnuts	• Increase	• Moderate increase	• Moderate increase	• Very significant increase
Pigeon Peas	• Moderate increase	• Significant increase	• Significant increase	• Very significant increase
Cowpeas	• Moderate increase	• Moderate increase	• Moderate increase	• Significant increase
Soybeans	• Increase	• Significant increase	• Significant increase	• Extreme increase
Sorghum	• Increase	• Moderate increase	• Increase	• Moderate increase

* Increase: 10-20%, Moderate increase: 21-40%, Significant increase: 40-60%;
Very significant increase: 60%-100%; Extreme increase: > 100%

Table 5.4 shows estimated ranges in increased cost of production for each of the seven manifestations of climate change based on one ha of crop under moderate and extreme climate scenarios, assuming no reaction from farmers or the GoM. In this case, the greatest cost increases occur when all five climate events combine—late onset, lower rainfall, extended dry periods, early cessation and high temperatures. In this case, all crops but sorghum have a significant, very significant, or extreme increases in their costs of production. Under a **moderate climate scenario**, the highest costs occur for each crop as follows.

Maize. The late onset of rains. The additional cost is due to the need for replanting, along with the need for additional weeding, ridging, drying/shelling, and pesticides (in storage). It is also noted that longer dry spells during the rainy season raise the cost of production almost as much as late onset, primarily because extremely long dry periods occurring early in the growing season require a complete re-planting of the seeds, thereby doubling the cost of seeds and of ridging.

Groundnuts. The late onset of rains. The main cost, in this case, comes from having to replant (approximately half of) seeds that did not germinate due to lack of moisture. Additional work on the tier ridges is another significant cost component.

Pigeon Peas and Cowpeas. The late onset of rains. The main cost comes from having to replant approximately half the seed to replace seeds that did not germinate due to lack of moisture. Additional work on the tier ridges is another significant cost component.

Soybeans. Late, heavy rains. In March and April, the crop is drying such that it is negatively affected by heavy rains which augment fungal infections. In addition, heavy rains in April lead to purple seed stain, which increases grading effort and cost.

Sorghum. Late, heavy rains. The main cost comes from the additional labor required for harvesting to avoid problems of rotting or fungal infections. Post-harvest handling problems and losses are more pronounced in the highlands where rainfall later in the season is more common.

Under an **extreme climate scenario**, the highest costs occur for each crop as follows.

Maize. Late onset of rains, followed by longer dry spells during the rainy season; both for the same reasons as under the moderate climate scenario.

Groundnuts. The late onset of rains. The main cost is the need to replant more seeds, together with the need for additional weeding, tier ridging, pesticides, drying and shelling.

Pigeon Peas and Cowpeas. The late onset of rains. This is due to the need for replanting even more seeds than under the moderate scenario, together with the need for additional weeding, ridging, pesticides (in the case of pigeon peas), threshing (in the case of cowpeas) and drying/shelling.

Soybeans. Late onset of the rainy season, due to the need for replanting of more seeds, together with additional weeding and tier ridging. Lower total volume of rain also substantially raises the cost of production.

Sorghum. Late, heavy rains. This is due to additional labor for harvesting, threshing and drying, and pesticides.

As can be seen from this summary, each crop is affected differently, and to a different degree, by changes in weather patterns due to climate change. Some crops may withstand a late rainy season onset better than others, for example, with moderately reduced yield in some cases and greatly reduced yield in others. For sorghum, the largest cost increases were associated not with a late rainy season onset, but rather with late, heavy rains. But even sorghum suffered from an increased cost of production with a late rainy season onset, albeit not as much as it did under late, heavy rains.

The answer to climate change will not be for farmers to plant a specific crop during a specific time period, but rather to build the adaptive capacity that farmers will need to allow them to face a very uncertain climate future. Agricultural diversification and intensification (e.g., agroforestry, permaculture, water harvesting, conservation agriculture, and soil fertility management) will be important in enhancing resiliency.

5.5 FISH STOCKS

The exact nature of the impact of climate change on fisheries is not well-studied or understood, owing to shortages of monitoring equipment and support for such research. It appears that significant impacts on fisheries biology, reproduction, productivity and habitats of some fish species may be associated with changes in temperatures, precipitation and runoff into the lakes and linked flooding and drought as well as changes in wind patterns affecting Lake Malawi. See Table 5.5.

TABLE 5.5. CURRENT IMPACTS, FISH STOCKS

Element	How does climate impact the element?	Recent impacts observed
Ecosystem/ Breeding habitats	**Rising temperatures** may cause some species of fish to migrate to deeper colder waters. There, they adapt (crowding out local species and creating an unbalanced ecosystem) or die. **Winds** can change upwelling patterns in the lake and may indirectly foster migration of fish to other areas, further from the shoreline (Source: PRA interviews with fisherfolk).	Fish stocks (and inevitably, catches) decline
Fertilization and nest protection	Heavy siltation due to intense **rainfall and high rates of runoff and soil erosion** creates a murky environment in which fish cannot fertilize their eggs or protect their nests.	Same as above
Migration patterns	**Intense rainfall and high rates of runoff** cause soil erosion and increase siltation, which hinders fish migration to the larger lakes; erratic rainfall resulting in lower agricultural yields often triggers small-scale stream diversion for irrigation, thereby also interrupting migration patterns	Reduced fish recruitment[37]

In Lake Malawi, evidence suggests that both warming and eutrophication[38] that influence fish stocks (Vollmer et al., 2005). There is no evidence to date to determine whether this is due to rising water temperatures, lower and warmer inflows into the lake or limited overturning. At shallow lakes such as Lake Chilwa, surface area and water levels fluctuate with regional rainfall. Fish catches, fishing activity and livelihoods have begun to mirror these observed fluctuations (Jamu, 2011; Jul-Larsen et al., 2003).

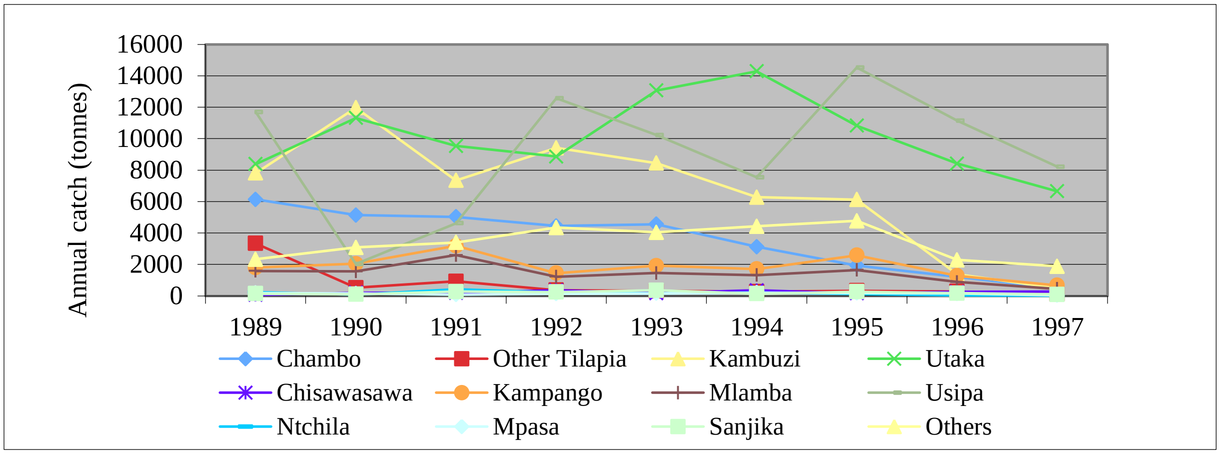
While fish stocks are directly affected by changes in climate variables, the volume of fish catches is much more difficult to attribute to climate because of a multitude of confounding human factors. Fisheries resources in Malawi are already threatened by overfishing and a failure to observe laws and regulations designed to support sustainable use of fisheries. Additional threats are related to changes in land use, particularly conversion of forests to cropland, expansion of small-scale irrigation through stream diversion and agricultural development in close proximity to rivers and water bodies. Climate change is having a negative impact on crop yields, thereby contributing to land use changes that indirectly have a negative impact on fisheries. Nonetheless, it is important to take note of the significant declines in 12 species of catches in Malawi since the early 1990s. Evidence from dated data (Figure 5.1) shows that fish catches are on the verge of decline and most Malawian water bodies are already over-fished and increasingly impacted by wetland degradation (World Fish Center, 2007; Ambali and Kabwazi, 1999; Banda and Tomasson, 1996).

The PRA had purposefully selected one community that was a fishing village in order to better understand fisheries dynamics. To the surprise of all concerned, that village, Liguluche, can no longer be considered a dominant fishing village. Although fishing is still common in Liguluche, it has been reduced to one that is known only for small "*usipe*" fish due to the unavailability of larger fish (i.e., *Kapenta*, *Ncheni*, and *Chambo)*.

[37] Fish recruitment refers to the number of new fish that enter a population or type of settlement in a given period.

[38] Eutrophication refers to the abundant accumulation of nutrients that support a dense growth of algae and other organisms, the decay of which depletes the shallow waters of oxygen in warm seasons.

FIGURE 5.2. ANNUAL FISH CATCHES IN MALAWI



Source: Malawi Fisheries Department

6.0 ADAPTIVE CAPACITY

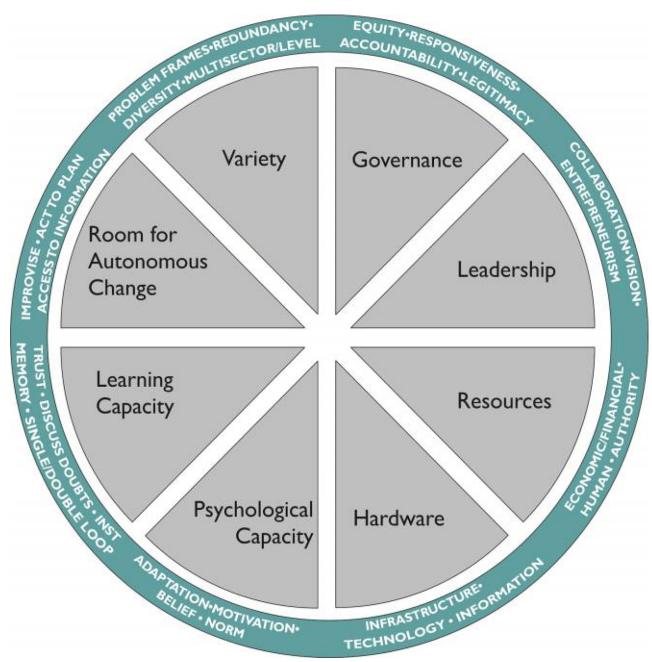
Together with exposure and sensitivity, adaptive capacity is one of the three factors contributing to climate vulnerability. While the Malawi VA focused on the exposure and sensitivity aspects of climate vulnerability, the study also identified adaptive strategies already being undertaken (see Section 8) and, in the process, revealed some insights into the country's potential for adaptive capacity, including for enhancing future adaptive capacity. In this section, we describe some the adaptive capacity potential derived from the related studies conducted under the Malawi VA.

In the context of climate change, adaptive capacity is described as "the ability of a system to adjust to climate change and to moderate potential damage, to take advantage of opportunities, or to cope with the consequences" (MEA, 2006; IPCC 2007). Adaptive capacity goes beyond *adaptation*—adjustments that have been made—to describe the full suite resources that a community can use to support adaptation, such as finances, education, or even existing governance structures. Adaptive capacity goes well beyond the remit of a single farmer, fisherman or household; adaptive capacity at every level of society can be enabled or encumbered by the influence of institutions, government, and social systems.

6.1 FRAMEWORK

Two recognized frameworks explore adaptive capacity specifically to climate change: The "Gupta Wheel", tested worldwide (Gupta et al., 2010); and ACCRA's spheres of local capacity, applied in Africa. The Gupta Adaptive Capacity Wheel identifies six dimensions that must be present in institutions to enable capacity: variety, learning capacity, room for autonomous change, resources, and fair governance. The ACCRA (and CARE) model promotes five "rings" of capacity: asset base, knowledge and information, institutions and entitlements, decision-making and governance and innovation.

FIGURE 6.1. ADAPTIVE CAPACITY, AREAS OF INFLUENCE



Other practitioners have identified a fundamental starting point that neither framework may encompass (Grothmann et al., 2013). Grounded in psychology, these practitioners insist that no capacity can or will be enacted until entities accept that (i) they *can* adapt, (ii) they *want to* adapt, and (iii) they *should* adapt. These are respectively termed "adaptation belief," "adaptation motivation" and "adaptation norm." For the purposes of the Malawi VA, the two frameworks and psychological capacity are merged to produce an "Adaptive Capacity, Areas of Influence" (Figure 6.1) that span local to institutional.

Within the scope of the Malawi VA's component studies, the following sections explore adaptive capacity in Malawi in the context of the eight areas of influence.

6.2 GOVERNANCE

Fair governance implies legitimacy, equity, responsiveness, and accountability; i.e., that the governed—the public—supports public institutions and perceives that rules are fair and applicable to all; that the government accepts and responds to the expressed needs of the public; and that institutions and individuals are held accountable for their actions (or inactions). Although the Malawi VA was not designed to measure any of these elements specifically, some its component studies did bring to light examples of both good and less than ideal governance.

For example, the PRA and KIIs identified instances where communities were actively managing forests and building, protecting and maintaining a sustainable supply of wood for the concerned population. There were, however, other communities where people reported feeling helpless in the face of external private sector agents who apparently, with the knowledge and permission of the relevant authorities, were seeking to exploit resources which had heretofore been considered communal. Another example was provided by a group of women on Lake Chilwa who were fighting to protect the lake and lowlands, but who worried that their goals were not achievable given their lack of funds.

An especially prominent example, which prompts concerns about equity and legitimacy, is the National Fertilizer Inputs Subsidy Program (FISP). The perception exists that the benefits of the program are not equitably distributed and that the program is being used to gain political influence among certain groups of farmers. Others challenge the program's promotion of a single crop—maize—that is not suited to many of the places where it is grown, and will be even less suitable in what is expected to be a highly volatile, ambiguous and uncertain climate future.

6.3 LEADERSHIP

Leadership is about vision, entrepreneurship, and collaboration. Leaders who possess vision, entrepreneurship and a collaborative spirit are quintessential champions for climate change adaptation. Although the Malawi VA was not tasked to conduct an institutional analysis that would have led to the identification of such champions, it became clear, nonetheless, that senior levels of government have been addressing climate change in a variety of ways. Although formerly assigned to the Ministry of Development, Planning & Cooperation (MDPC, formerly MEPD), the mandate for climate change is now shared between that ministry (which chairs the Steering Committee) and the newly created Ministry of the Environment and Climate Change Management (MECCM, which chairs the Technical Steering Committee). Under the new ministry, the Department of Environmental Affairs (EAD) is now responsible for the mandate, coordination and legislation related to climate change while the Department of Climate Change and Meteorological Services (DCCMS) is responsible for data services, monitoring and early warning.

According to national actors, Malawi has gained significant visibility across the region for its reputation and skill in coordinating climate change actions and in the submission of its national communications to the United Nations Framework Convention of Climate Change (UNFCCC).

6.4 RESOURCES

A variety of resources—institutions, human resource, and financial/economic—must exist to enable change for adaptive capacity. Institutions must have the authority under law to act in the public good; individuals provide expertise, knowledge and labor. Financial, economic and other resources must exist at all levels to support the formation and application of policies, and to provide incentives where necessary.

In terms of authority, the National Climate Change Policy is currently under review by MECC after which time it will be presented to the Office of President and Cabinet (OPC). It is uncertain to what extent other strategies/policies (e.g., Forestry, Fisheries, Disaster Management) may be "climate-proofed" or aligned to permit sustainable development in an uncertain climate future.

There are clearly some significant "disconnects" between present and long-term strategies. For example, the Disaster Management Authority (DoDMA) is focused almost entirely on rapid onset hazard *response*, while the impact and management of climate change demands more proactive, long-term planning and action.

Despite Malawi's relatively high population density, human resources are not always adequate. At the national level, among both governmental and non-governmental institutions, few individuals are assigned 100% to climate change issues. Most of those with pertinent roles, not least of which is to deliver messages to communities, have an incomplete understanding of climate change, mitigation and adaptation, and have many other responsibilities that compete for their time. Even among decision makers and senior staff, turnover is reportedly high, making capacity development a challenge.

With regard to financial or economic resources, donors appear increasingly interested in funding appropriate climate change adaptation efforts. Although Japan is winding down their CCA funding (Africa Adaptation Program), UNDP, UNEP, DFID, Norway and the GEF currently appear to have ongoing adaptation funds. Currently there are 19 climate change adaptation activities registered (Strauss Center, 2012) to be ongoing through 2016; the vast majority of these are funded by Norway and are focused on environment, land and natural resources.

At the community and household levels, the PRA exercise identified wealth groups (see Section 6.2). Although the purpose was to explore the influence of power and the differentiation of risk, in addition the identification of these groups result in important findings related to their resources available for adapting to climate change. Specifically, it was found that the:

- The Better-off have diverse income sources and sufficient other resources needed overcome the impacts of climate changes. They make the necessary investments in agriculture (re-planting, buying fertilizer and other key inputs, protecting crops from pests/disease) and maintaining income through additional non-agricultural investments (e.g., sending family members to South Africa, or starting small businesses, including seasonal businesses). Households in this wealth group tend to be more willing to experiment with adaptive strategies.
- The Average struggle to cope with the impacts of climate changes. They have limited financial resources to invest in agriculture or other non-agricultural livelihoods. Their alternatives tend to be limited primarily to casual employment.
- The Poorer are agriculture-dependent and so have experienced significant negative impacts not just from climate change but also from declining land productivity, particularly for vulnerable crops like maize, which is critical to their food supply. The Poorer rely heavily on *ganyu* (casual labor), particularly during the so-called "hungry season;" this can result in neglect of their own fields. Because their resources are so limited, they tend toward coping rather than adapting, and have been complicit in the loss of forest through turning to firewood sales, charcoal production and brick burning as sources of income. This, in turn, just further reduces their options as they are the most affected by the resulting degradation and loss of forest resources.
- At the same time, at the national level, the PRA results also revealed often-contradictory messages coming from various institutions. Changes in the climate have already prompted Malawian agricultural officers to promote irrigation, fish farming, and the planting of hybrid and drought-tolerant crops as means to help farmers compensate for reductions in crop yield. But these changes often also lead to changes in water management (e.g., stream diversion) and/or the expansion of cultivation into areas that may once have been reserved for other ecosystem services (e.g., river banks and *dambos*). At the same time, and responding to similar stresses, environment officers are persuading rural populations to participate in afforestation, bank reinforcement, and the use of vetiver to stabilize ecosystems near water channels, above all so that flooding is attenuated. Clearly, these two very different land-use strategies can conflict.

6.5 "HARDWARE"

The term "hardware" in this context refers to infrastructure, technology and information. These areas were explored only peripherally in various Malawi VA studies, such as the water study (hydropower), the natural resources study (irrigation and charcoal production technology), the fisheries study (nets), the six-crop Value Chain Analysis (seeds, fertilizer, transportation infrastructure, etc.) From the studies, it was found that

- Meteorological and climatological indicators are not being monitored with sufficient geographical coverage, sampling frequency and rigor, nor are the relevant data being maintained in a readily accessible form;
- Local indicators providing early hazard warnings are no longer reliable and DCCMS warnings─when issued at all─do not reach the right individuals in time to adequately inform decisions;
- Cities are not equipped to address the needs of a significant influx of households fleeing rural livelihoods;
- Roads in much of the country are susceptible to flooding (which is likely to increase in the future);
- The hydropower generation infrastructure is weak (but growing under World Bank influence) and soon must contend with growing demand for irrigation (e.g., Greenbelt Initiative) and the associated diversion;
- Renewable energy resources have not been adequately characterized nor have they been exploited to any significant degree;
- Small-scale irrigation infrastructure (i.e. treadle pumps) are in growing demand; and
- Current charcoal production and stoves rely on inefficient technologies.

All of these and more combine to highlight a gap in climate-friendly "hardware."

6.6 PSYCHOLOGICAL CAPACITY

Psychological capacity is a pre-requisite for climate change adaptation. Before one chooses to adapt, s/he must conclude that (i) "I *can* adapt," (ii) "I *want to* adapt" and (iii) "I *should* adapt." These decisions may be made unconsciously, especially when facing a situation such as a failed livelihood outcome. These conclusions and the resulting adaptation actions can also be encouraged by providing knowledge, incentives and opportunities to choose among options. While the Malawi VA did not set out to evaluate psychological capacity, what was apparent on the part of local farmers high willingness to cope or adapt, and to continuously seek options. (Unfortunately, the majority of these quests ended in the forests, with unsustainable exploitation of forest resources).

6.7 LEARNING CAPACITY

Capacity to learn relies on trust, ability to learn from past experiences, openness to changes in underlying assumptions, and openness to uncertainties. It also requires a certain level of institutional memory for the learning to be applied. Given the nature of climate change, discussing uncertainty must be a topic touched upon in every venue—especially among farmers and extension agents.

Based on findings from the PRAs, Malawian farmers learn fast. They don't typically repeat the same mistakes or take failed risks twice. For example, local storage of hybrid maize has, in some cases, proven to be problematic due to damage from moisture or pests. As a result, most farmers growing hybrid maize have either rapidly changed their assumptions about hybrids to protect their stocks or have returned to planting local varieties. This willingness to adapt is of significant benefit to the individual farmer in view of an uncertain climate future. It must be recognized, however, that those with the fewest resources—the very poor—are also the least able to deal with uncertainty and its consequences.

Malawi is one of five pilot countries that implemented a *United Nations: Climate Change (UN CC): Learn Project on Strengthening Human Resources and Skills to Address Climate Change* (2011-2013). The project aims to take a national strategic and long-term approach to climate change learning with the ultimate goal to mainstream climate change learning within existing learning systems. An important first output of the project is the development of a *National Strategy to Strengthen Human Resources and Skills to Advance Green, Low Emission and Climate Resilient Development* through multi-sectoral and multi-stakeholder collaboration. The Strategy seeks to identify, through a country driven process, short and medium term action to strengthen learning and skills development. The National Planning Workshop (March 2012) provided an opportunity to discuss the UN CC:Learn project with concerned government sectors and interested organizations; it sets the stage for the development of adaptive capacity.

6.8 ROOM FOR AUTONOMOUS CHANGE

Autonomous change implies that an entity (institution, farmer, fisherman) has access to information[39], a plan or plans (options), and is enabled/encouraged to innovate when it makes sense to do so. Such actors will need to adjust their behaviors along with the changing climate; every component of society—from smallholder farmers to national governments—must become decision makers providing flexible, adaptive management at all levels.

Unfortunately, information on climate change in Malawi often does not exist or, that which does, is not made widely available. The ongoing GEF/UNDP project on early warning (LDCF; $4 million for four years) aims "to strengthen the climate monitoring capabilities, early warning systems and available information for responding to climate shocks and planning adaptation to climate change in Malawi." This will be achieved by delivering two integrated and complementary outcomes:

1. Enhanced capacity of the Department of Climate Change and Meteorological Services (DCCMS) and Ministry of Irrigation, Agriculture and Water Development (MoIAWD) to monitor and forecast extreme weather and climate change; and
2. Efficient and effective use of hydro-meteorological and environmental information for early warnings and long-term development planning.

One option available to the farming community in Malawi is weather-indexed insurance. These schemes have been gaining credibility as an agent of autonomous change. To date, these have not fared well, primarily due to an inherent flaw: They aggregate conditions over the whole of the country as part of their payout trigger, thereby ignoring regional weather "failures." Reportedly, the system is currently under revision.

Alternative micro-insurance may also be linked to weather (e.g., Harita in Ethiopia). Exchanging their labor on locally chosen natural resource efforts (which simultaneously improve the environment and reduce risk) for weather-based insurance policies, these scheme may allow farmers to absorb the 'costs' and their crops which are protected from erratic weather. As one of the four foci of a current UNDP sustainable land management project currently underway, these elements of making 'room' for change are being explored in Malawi. An important component for sustainability is establishing participation and trust in such a system, requiring that the conditions (e.g., weather data), which triggers payouts be accessible to participants.

Given options and the opportunity to change, Malawians exhibit considerable willingness to explore alternative livelihoods. Some move from lake fishing to river fishing, others transform their agricultural plots into fishponds or plant different varieties or entirely different crops. Many send their sons to South Africa or Mozambique, banking on remittances. Most go into the forests for wood and to produce charcoal. Entire households move to urban centers. Not all of these innovations are sustainable or environmentally benign; given better information or additional options, more might be.

[39] Here, the focus is on *access* to information, rather than its availability, in hardware above.

6.9 VARIETY

Detailed predictions regarding the impact of climate change at the local level with any degree of confidence are impossible now and likely to remain so for the foreseeable future. Thus, the capacity and willingness to pursue a variety of options in response to climate change is critical. Responses to the complex challenges presented by climate change can only be managed within a framework of multiple discourses and a variety of solutions. This implies that there is no single ideological framework, no optimal policy, no game-changing solution that will work everywhere. Variety is required to frame problems, engage actors, explore responses, and promote long-term solutions.

The presence of such variety is implicit in the significant number of actors across multiple ministries (MDPC, MECCM, MIAWD) engaged to explore climate change issues in Malawi. Managing interactions among these actors will likely lead to a transdisciplinary consensus that variety is indeed the best option. Crafty champions will be useful to manage competition among programs and competing interests. Since managing for risk requires managing for a variety of possible outcomes, it may initially appear that resources at many levels are being spread too thinly. Nevertheless, in the face of the significant uncertainties surrounding climate change and its impacts, it is risky to prioritize adaptive strategies prematurely. Some options may appear to be winners under any plausible climate scenario.

6.10 CONCLUSIONS

The development of adaptive capacity in Malawi is nascent and needs serious nurturing. A summary of the eight areas of adaptive capacity is provided in Table 6.1. In general, a more systematic assessment of pertinent Malawian institutions and a more deliberate assessment of country's capacities at many levels would greatly enhance the analysis and serve to produce a clear set of adaptive strategies to consider.

TABLE 6.1. STRENGTHS AND CHALLENGES OF EIGHT AREAS OF INFLUENCE

Sphere of Influence	Strengths	Challenges
Governance (legitimacy, equity, responsiveness, accountability)	Promising potential for community-managed forests and potential for a viable Lake Chilwa Association	Perceptions and challenges surrounding the FISP, including its emphasis on a particularly climate-sensitive crop: maize
Leadership (vision, entrepreneurship, collaboration)	High-level attention to CC; shared mandate steering/technical; Creation of the MinECCM; Cited example of coordination	DCCMS in Blantyre; turnover of key agents
Resources (authority, financial, human)	CC Policy draft underway; donor interest and commitment	Policies developed separately may not be climate-proofed; disenfranchised DoDMA; inflation, poverty
Hardware (infrastructure, technology, information)	Early warning system projects now reinforcing DCCMS information services	Irrigation vs. hydropower (large scale) or fisheries (small scale irrigation)
Psychological Capacity (I can, I want, I should)	Not studied	
Learning Capacity (Trust, single/double learning, discuss doubt)	UN: CC Learn Project / Strategy underway may lay fundamental groundwork for adaptive capacity	FISP
Room for change (access to information, plan, innovation)	Local innovation is strong	Coping more than adapting; Information access weak
Variety (frameworks, actors, sectors, solutions)	Growing number of actors and sectors engaged in discussions	Building adaptive capacity in the face of a high degree of climate uncertainty, variability and complexity.

7.0 CURRENT ADAPTIVE STRATEGIES

This section lays out the many complex ways in which climate has worked through biophysical impacts to trigger changes in the human system. Starting with changes to the value chain and economic aspects of the six studied crops, this section explores changes to Malawian livelihoods (agricultural, fishing, livestock and other), wellbeing and government institutions that are already happening.

7.1 VALUE CHAIN ANALYSES ([VCA], SIX CROPS)

Across Malawi, reports concur that changes occurring in the climate and biophysical systems are influencing multiple links of the complex chains that carry each crop from field to mouth. During the Malawi VA, findings surfaced to reflect current strategies employed by producers and buyers to compensate for a jumbled set of impacts that invariably includes climate. The six studied crops are addressed in order of least to most climate-resilient.

Table 7.1 summarizes the impact of multiple climate variables on three links of the value chain (field, storage/processing and transport/trading) for each of six studied crops.

Farmers have been implementing a variety of strategies to cope or adapt to these impacts:

Maize. Results from the maize value chain analysis revealed what has been a striking trend of producers moving between varieties of maize. Although it appears that more and more farmers are moving to hybrid varieties for their shorter growing seasons, the current dynamic is not quite that simple. Firstly, hybrid seeds must be purchased each year and are not accessible to the poorest households. Secondly, many farmers who have already been using hybrid maize seeds perceive that the increase in hybrid yields is often met with an equal or larger increase in post-harvest losses; they then opt to return to traditional varieties. A reported prevalence of pests has resulted in premature harvesting, shorter storage, and a general move away from household and community granaries.

Another coping strategy that farmers are forced into is that of replanting. With each maize crop that is planted but met erratic or insufficient rains, a second or third planting is required. Delayed planting, or repeated replanted, has become the rule rather than the exception.

Although the PRA research also found a shift to improved seed to address the shortened season and low productivity of traditional varieties, it was noted that there had been a swing back towards traditional varieties of maize, because of the disadvantages of improved varieties. The outcome is that households that can afford to buy seed and fertilizer do grow improved varieties, but they additionally plant traditional varieties both because they prefer it for home consumption and because the seasonal conditions might better suit the traditional varieties, such as if there is a normal period of rains, but with a prolonged dry spell during the season. Thus, where they can afford to, households are generally pursuing a dual production strategy of both traditional and improved maize.

Maize can fall vulnerable to late rains that negatively affect pre-harvest drying in the field. One farmer (a value chain study respondent) mentioned that in 2003, rains had come in April and had significantly slowed the drying of his maize. The farmer stated that he had removed all leaves from the plants at this stage in an effort to speed up the drying. Despite his efforts, the farmer estimated that he had lost a significant portion of his harvest.

TABLE 7.1. MAIZE: CURRENT IMPACTS, VALUE CHAINS

Link Crop	Field (e.g., planting, harvesting)	Storage and processing	Transport and Trading
Maize	No/erratic rains: Need to replant Excessive rains and water logging damage root system Drought/winds and frost damage or destroy crops Late rains affect pre-harvest drying in field Erratic rains push for pre-mature harvesting	Moisture and high temperatures trigger storage losses (esp. hybrids) due to increased pests/aflatoxin (result is shorter storage, granaries going out of style)	Flood events make farm to trading center roads impassable (result is reduced revenue)
Groundnuts	Erratic rains: Replanting Shorter rain periods reduce soil moisture: Short-duration varieties and/or use of gypsum to retain moisture; pes before planting, farmers ensure the whole ridge is fully covered by moisture. Short rainy season: Early-maturing varieties. Prolonged dry spells: More drought-resistant varieties.	Prolonged dry spells can be beneficial—nuts can be stored longer under lower residual moisture levels. However, processors prefer high oil content varieties; but early maturing and drought resistant varieties tend to have lower oil content.	Late, heavy rains: May promote aflatoxin, reducing export market opportunities.
Pigeon-peas	Short rainy season: Move to early maturing varieties. Late onset: Changes in timing of planting. Effective intercropping with maize (common) challenged if maize must be replanted. Early cessation or dry spells with high temperatures during maturing/harvesting: Pods shatter, reducing yield.	High temperatures: Increase in weevils, mitigated by use of actellic dust. Late rains combined with high temperatures after harvest: Increased mold risk.	Not applicable: Most pigeon peas are consumed by the household.
Cowpeas	Dry spell or heavy rain after planting: Plants die; replant if possible. Increased temperatures/prolonged dry periods: In-field losses due to ants, aphids and grasshoppers Early cessation or dry spells with high temperatures during maturing/harvesting: Pods shatter, reducing yield.	High temperatures: Post-harvest losses due to weevils; may be controlled with actellic dust. Late rains combined with high temperatures after harvest: Increased mold risk.	Not applicable: Most pigeon peas are consumed by the household.
Soybeans	Erratic rain onset: Replanting High temperatures: Reduce yields Variable rainfall: In-field losses due to cutworm, snout beetle and wireworm; Dry spells: Fungal infections Early cessation or dry spells with high temperatures during maturing/harvesting: Pods shatter, reducing yield.	Late rains combined with high temperatures after harvest: Increased mold risk.	Not applicable. Processing for commercial use is not widely undertaken by smallholders
Sorghum	Erratic rain onset: Replanting Dry spells: Increased vulnerability to wilting disease; use box ridges to retain moisture Increased temperatures: In-field losses due to grasshoppers; Erratic rains: In-field losses due to fungal infections Reduced production of sorghum overall	Processors have been importing more sorghum, due to overall production decrease in Malawi	Not applicable: The majority of sorghum in Malawi is white sorghum grown for domestic consumption, increasingly as an alternative to maize.

After the move to hybrid maize, the second major change has been a general shift from maize (such as was found in Felo and Mulupha villages) to more drought resistant food crops, such as cassava. A related shift from maize into cotton has also occurred due to the drier conditions. For example, at Lupanga the maize-to-cotton production ratio was formerly 50:50, but has now changed to 20:80.

Groundnuts. Due to its dual food and cash status, groundnut cultivation has been expanding in Malawi. However, the recurrent late onsets of rains have led to the adoption of hybrid or early maturing varieties. According to the PRA results, there has been a reduction in the cultivation of the more moisture-sensitive crops such as groundnuts, beans, rice, sweet potatoes, and pigeon peas in Chiluzi, Liguluche, Mulupha, and Nkasala.

Pigeon peas. According to MoFS production statistics, over the last five years, production of pigeon peas has doubled in Malawi, with much of the production intended for the export market (GoM National Export Strategy, 2012). The most prevalent drivers of this increase are not directly climate-related; they include production and market dynamics in India and promotion by donors for their environmental positives such as nitrogen fixing, strong root system and the maintenance of soil structure. According to the PRA results (e.g., Mulupha and Nkasala), some of the more moisture-sensitive crops like beans, groundnuts, rice, and pigeon peas have reduced or been abandoned.

Intercropping: cassava and pigeon peas

Cowpeas. The majority of climate influences for cowpeas reported include in-field and post-harvest losses due to rising prevalence of pests related to increased temperatures, especially during prolonged dry spells.

Soybeans. Production of soybeans in Malawi remains irregular at best. Like cowpeas, soybean production is mostly driven by external factors (promotion by donors and export markets) linked partially to its nitrogen fixing properties and multiple uses such as seed for livestock and fish, bio-fuel, industrial oil, and for human consumption. As medium-term maturing varieties are being negatively affected by late rains due to fungal infections, smallholder farmers of soybeans often chose to reduce risks by using lower-yield medium-maturing varieties.

Sorghum. Sorghum in Malawi has been recently plagued by irregular rains that fuel fungal growth, posing a challenge for farmers, especially during post-harvest handling. Climate conditions that have reportedly driven preferences for cultivating sorghum include those in arid or more drought-prone areas.

7.2 LIVELIHOOD EVOLUTION

All of the climate manifestations, biophysical and socioeconomic impacts, and disruptions to the value chains of the studied crops described to this point have had a role in influencing the livelihoods of most rural Malawians in the study area. The livelihood evolution described in this section organized by agricultural, fishing, livestock, and other (employment and IGAs).

AGRICULTURAL LIVELIHOODS

Most of the agricultural livelihood decisions that have been undergoing change in the recent past are described above under crop-specific value chain and economic analyses. For this reason, this section only addresses generalities across crops and for crops beyond the six studied. See Table 7.2 for a synthesis.

In terms of planting and harvesting strategies, farmers are compensating for climate-driven lower yields by increasing their cultivation of improved, drought resistant varieties (as reported in all nine PRA villages). In response to observed changes in weather and to the perceived impacts of climate change, farmers are changing the dates for planting their crops and making use of selected seed for shorter cycle crops. Others are reportedly clearing land and planting their crops closer to stream and water bodies.

Another strategy reported as being employed in all nine of the PRA villages was an increase in conservation agriculture techniques (e.g., ridging). Increasing numbers have adopted no-till agriculture in order to conserve soil moisture, along with increased investment in dry season irrigated vegetable gardens (Hobbs, 2007 and 2008). Others are adopting inter-cropping and diversifying their crops. Conservation agriculture has been demonstrated to be an effective practice to conserve soil moisture and to increase crop yields, particularly during periods of erratic or reduced rainfall and on soils with lower clay content (Total Land Care, 2012).

TABLE 7.2. CURRENT IMPACTS, AGRICULTURAL LIVELIHOODS

Activity	How Does Climate Impact the Activity?	Adaptation Strategies Observed
Planting and harvesting	• **Rising temperatures and erratic rainfall** contribute to crop destruction and lower yields	• Changes in dates of planting • Replanting • Increased cultivation of improved/hybrid varieties • Increased cultivation of drought resistant varieties • Crop diversification (to cassava, sorghum, cotton) • Addition of winter cropping and dry season vegetable gardens • Increased demand for irrigation • Increased use of small scale irrigation (i.e., watering cans); stream diversion
	• Climate impacts on soil fertility (and then, lower yields)	• Expansion of cropping to *dambos* and river banks[40] • Increased use of conservation agriculture • Afforestation: In-field tree regeneration • Improved husbandry methods, such as use of compost, organic vegetative and animal manure as fertilizer
	• **Heavy rains** at end of season damage crops or trigger pests	• Increased planting of sugar cane and bananas at field edges (to prevent wash away by rains) • Premature harvesting
	• **Wind and flooding** damage to crops	• Increased planting of trees and sisal near field boundaries and riverbanks
Storage and processing	• **Rising temperatures** engender pests and disease (e.g., locusts and termites)	• Shorter storage periods • Earlier selling (with lower profits)
Transport/ trading	• **Heavy rains and flooding** make roads to/from markets impassable	• Not selling (loss)

Farmers are attempting to cope with declining soil fertility by using increased amounts of manure and compost. Some farmers are taking steps to protect and regenerate trees in cultivated fields (a form of assisted natural regeneration or "farmer managed natural regeneration") in order to help replenish soil organic matter through leaf drop and leaf litter from trees in farm fields. Many farmers are working to increase the density of *Faidherbia albida* trees in their fields. (*Faidherbia* is a nitrogen-fixing legume that helps to replenish both nutrients and organic matter in cultivated soils [Garrity et al., 2010, p. 197-214].) Trees in agricultural landscapes also provide a source of poles, fuel wood, fodder, and other non-timber forest products, and have a favorable influence on reducing rainfall runoff, increasing infiltration, helping to recharge aquifers, and secure local water supplies.

Crop residues are in increasing demand for use as livestock fodder, and are sometimes burned to hunt mice in fields, or removed to control pests and diseases.

In summary, the most important climate-related constraints to profitable agricultural livelihoods include the following.

- Erratic rainfall constrains crop choices, with beans, sweet potatoes and, most significantly, maize particularly affected.

[40] Cultivating in *dambos* and river banks are both illegal in Malawi.

- Already degraded through poor husbandry and lack of access to inorganic and organic fertilizer, soil leaching is exacerbated by heavy rain/floods that are likely to increase with climate change. Floods may also transport sandy soils that do not retain moisture.

- Land area is constrained in many communities due to settlement/population pressures that have taken up both available farmland and resulted in cultivation or settlement in previously shared-resource areas like *dambos* and forests to compensate for lowering yields. Clearing of forests further contributes to climate change-induced flood events.

While farmers can be quite innovative in responding to climate change, more attention is needed to closely monitor the coping responses of rural communities to find better alternatives to strategies that are maladapted and serve to increase and not decrease vulnerability in the medium and longer term. The truly successful and sustainable adaptation strategies are those that contribute to resilience and are not linked to unsustainable use of natural resources (Oxfam, 2007 and 2008).

FISHING LIVELIHOODS

According to community members (PRA respondents) in Mangochi District, climate change has been negatively influencing fisheries for some time. Although not typically listed as *the* most important variable, erratic rainfall, winds or increased cloud cover (which makes it impossible to sun-dry fish) were routinely ranked by PRA respondents as among the top four factors of a suffering industry. In many areas, communities reported moving away from fisheries (in three of nine PRA villages) or moving from fishing in the drying Lake Chilwa to seasonal fishing in nearby rivers. The precise changes in fishing livelihood strategies and adaptations have not been studied and merits intensive research. The findings to date are summarized in Table 7.3.

TABLE 7.3. CURRENT IMPACTS, FISHING LIVELIHOODS

Activity	How Does Climate Impact the Activity?	Adaptation Strategies Observed
Catching	• **Winds** are destructive (fishermen have lost their lives when boats overturn in Lake Malawi)	• Change times of fishing on lake
	• Lower fish stocks, species and sizes (all factors combined) and lower water levels	• Change fishing gear (i.e. finer nets to catch smaller fish) • Move from lake to seasonal river fishing • Renting boats
Processing	• **Prolonged cloud cover** makes it impossible to sun-dry/process fish. "*Weather is an economic threat*" --A female fish trader	• Sell fish earlier (often with reduced profit); suffer loss
Transport/ trading	• **Heavy rains:** As water levels rise, wetlands will become inundated and roads can be cut off, hindering the transport of fresh fish to markets	• Change to processing (drying); move away from fishing

PRA respondents in one village felt so strongly about the precarious livelihood that during a hazard mapping exercise, they drew small nets to demonstrate the importance of threats from the use of mosquito nets for fishing. Specifically, freely distributed mosquito nets by the Ministry of Health (and other even smaller nets) are reportedly being used by some fisher folk as fishing gear to catch progressively smaller fish (e.g., *mkacha*, *ogo*, *kandwindwi*, *chafi*, and *ngwelele*).

On the other hand, the PRA exercise revealed that there appears to be an increasing number of farmers starting up fish farming enterprises. By converting non-productive agricultural plots to aquaculture, farmers are using fish farming to enhance in household food security as well as a source for income generation. Studies have shown that farmers who integrate fish farming activities into a holistic farming system increase crop production and income (Brummet and Noble, 1995; Andrew et al., 2003; Jamu at al., 2002). This observation has led to an increased effort by NGOs and donor-funded projects to promote fish farming as a livelihood strategy for the poor. Several NGOs such as World Vision-Malawi, Concern Universal, Oxfam and Action Aid-Malawi and many others have included fish farming in their developmental agenda (Morgan, 2013; Oxfam, 2009; ICLARM/GTZ, 1991).

In Felo, a PRA village, the range of fish species found in the rivers was reported to be decreasing. Villagers reported that, at present, only "mud" fish (catfish) are found, a loss attributed at least partially to the drying of rivers, though also as a consequence of overfishing. Siltation of the river was reported in Mulupha, also resulting in only catfish surviving. In Nkasala, 15 fishponds in the south of the village have dried up. This was attributed to low rains and high temperatures causing high evaporation rates.

A key informant at the National Aquaculture Center (NAC) demonstrated how farmers can adapt their livelihoods to include fish farming to compensate for climate variability. Their lands were no longer profitable, so they turned a portion of their agricultural plots into three fish ponds that yield more profit for them than did the crops (Jamu, 2011; WFC, 2004). Dams in Malawi, historically linked to crop irrigation, are also being used more and more in conjunction with fish farming and ponds. Fisheries management is being incorporated as one strategy for diversifying community livelihoods (NAC interview with Fisheries Officer, 2012; Jamu, 2003; Njaya, 1999).

According to interviews with Lake Chilwa local leaders, researchers from the World Fish Center (WFC), and women leaders from the Lake Chilwa Climate Change Group (organized to promote fish drying and packing), migration from Mozambique and destruction of wetlands are rapidly destroying the ecosystem. The Lake Chilwa community is enforcing management along heavily fished zones of the lakeshore, but they report a need for further funding to assure successful results. Since many of the near-shore fish stocks are dwindling due to a range of factors (fewer/smaller recruitment zones, wetlands to muddied waters, excessive deforestation, siltation during the rainy season), some species cannot find their way from the streams to the rivers to the lakes, so fisherfolk are adapting by changing their fishing gear to finer nets and fishing for smaller fish (Jamu, 2011).

Although most fishing was done in Lake Chilwa, as the lake dries, fisherfolk are searching for other strategies. Community members have adapted their fishing gear to use in shallower water (lower water levels). The former tall funnels and large fish traps are used less and less often and are being replaced by short funnels and smaller fish traps. Key informants explained to Malawi VA team members a shift to seasonal fishing during the rainy season: Fishing for catfish on the Mikoko River during the rainy season when the water levels are higher is now a compensatory strategy.

LIVESTOCK LIVELIHOODS

Although there is no history of pastoralism in Malawi and few households rely predominately on livestock, almost all rural households own some type of livestock. While cattle populations have remained roughly the same since the 1970s, the number of goats has risen significantly since the late 1990s and the number of pigs has started to rise more recently (Livestock in Malawi, n.d.). The number of chickens at the national level has also risen considerably since 2005.

Although livestock were not included as a Malawi VA component, still, some findings were revealed related to livestock livelihoods during the course of the PRA. The importance of livestock in Malawi was confirmed in the PRA as it was cited as a common differentiator of wealth groups. In all but one of the nine villages (Nkasala), livestock was the second most[41] frequent criterion proposed to divide the village households into classes of wealth. The type of livestock held and the number held were both considered to be wealth differentiations.

Increases in livestock disease was commonly reported and often linked to, particularly that higher temperatures were promoting disease. Cattle were commonly reported to be affected by Foot and Mouth

[41] The most common differentiator of wealth among the nine PRA villages is household consumption.

Disease (FMD) or "*chigodola*" in Chichewa, as well as by ticks and, related to this, by East Coast Fever (ECF). Pigs were reportedly affected by African Swine Fever (ASF) and high temperatures. Goats were reportedly affected by ECF, ticks, and worms. Chickens were mainly affected by Newcastle Disease (ND), particularly in hot weather. Aggravating these climate (particularly temperature-related) diseases was a reported lack of access to veterinary services and dip tanks. While the better-off can afford treatments, the poorer groups cannot, so they slaughter diseased animals and eat them, as reported at Thambolagwa. In Lupanga, the community reported that the cattle population was lost to FMD and there were also heavy losses of chickens to ND. In Felo, the community reported that ECF has affected the pig population and ND the poultry.

Access to grazing was a problematic issue in some communities, particularly Mulupha, where there is little available land due to the village being surrounded mainly by tea estates. Scarcity of pasture was also reported at Chiluzi and Lupanga. Part of this loss of pasture was reported as being due to cultivation of the *dambos*, such as at Thambolagwa where all *dambos* that were used for livestock grazing have been turned into cultivation land. As noted earlier, the free grazing of goats and pigs has created conflicts with crop farmers, particularly those that are growing in the *dambos* during the winter dry season, as this is the time and area that traditionally has been available for free-grazing of livestock.

It was clear from the PRAs that livestock is typically seen as a means to store accumulated wealth. Selling of livestock in times of need is a long standing adaptation strategy throughout Africa. However, the pressures on food production and poor harvests in recent years have resulted in a decline in livestock numbers, such as in Kawelama and Nkasala. In Liguluche, a community that previously benefited from fishing as a major source of income, there has been a major shift over the last 10 years by households from fishing to keeping cattle, so that cattle numbers have been steadily increasing. It was stated that households that did not have any cattle 10 years ago now have 20 or more.

> *"The lake is no longer what it used to be and cattle now help a lot when you are in problems."* Community member, Liguluche.
>
> *"Cattle are <u>now</u> our wealth and when a cow dies I cry as if a person has died."*
> Community member, Liguluche (underlining added by consultants).

According to the PRA results, there is a trend to diversify from other livelihoods towards the inclusion of livestock, and to diversify the types of animals that households own or raise. In general, there appears to be a decrease in the numbers of large ruminants due to the lack of pastures and an increase in theft. Contrary to the statistics at the national level, the PRA pointed to a decrease in poultry in the studied area–given their sensitivity to high temperatures. Other than Liguluche (where there is livelihood strategy to increase cattle numbers) and Chiluzi (where the numbers of goats and pigs were increasing while cattle and chickens were decreasing), most communities reported overall decreases in livestock in recent years.

OTHER LIVELIHOOD STRATEGIES

The PRA distinguished three wealth groups identified characterized in relative terms as "better-off," "average," and "poorer" (see Text Box 7.1). The poorer had fewer options, being much more agriculture-dependent with few alternative income sources. The poorer may already have rented out part or all of their land in order to raise cash; and the poorer lack resources to invest in a business or even a small IGA. When agriculture was not doing well, the main strategy for the Poorer was to undertake *ganyu*, mainly working on the land of others:

> *"In the old days* ganyu *was done by children to raise money for Christmas festivities but these days it is done by everybody in the family for survival (food security)."* Community member, Lupanga

Although changes to livelihoods chosen by households among those studied seem to vary from place to place with little apparent pattern, one trend was apparent: Nearly all households are looking for alternative ways to increase revenues to compensate for lower yields–and they start their search in the natural reserves closest to home. All across the studied area, the greatest reported IGA is derived from forest products: Firewood and charcoal. In their efforts to cope with the impacts of climate change, most rural households are investing more time and effort in harvesting, producing, and marketing of charcoal and firewood.

Overall, the key changes were a reduction in reliance on agriculture with more emphasis on businesses and IGAs; an increased reliance on *ganyu* (casual labor) and timber, firewood, charcoal, and brick making; and the further development of remittances as a strategy to improve livelihoods. There appears to have been shifts to a more diverse range of livelihoods, as agriculture is no longer seen as reliable, a sentiment that was expressed at Felo and Mulupha. There were differences according to wealth groups, with the better-off engaging in businesses, such as grocery, trading, and brewing, as well as benefiting from more regular employment and supporting relatives who travel to South Africa and other places within Malawi to find work and develop a remittances stream.

TEXT BOX 7.1. WEALTH RANKING

A key aspect of the PRA socioeconomic profile is the **wealth ranking**. All the communities defined and labeled key groupings in their own community based on wealth. These were relative rankings derived from community perceptions. The research team guided community respondents to think about families who were "Average," "Better-off" and "Poorer." Given the widespread nature and depth of rural poverty in Malawi, the use of relative terms was considered to be more appropriate than absolute terms such as "rich" and "poor."

Depending on the village, key differentiators included food adequacy, diversity in the diet, reliability of income sources, livestock or other asset ownership, land ownership, ability to buy agricultural inputs, housing materials, household assets, and ability to pay school fees.

> *"Every household here has one or two [family members] in South Africa with the aim of buying cattle."* Community member, Liguluche.[42]

Another alternative is for households suffering low agricultural yields to utilize forest and other natural products. This includes hunting, a limited and dwindling option; collecting mushrooms, fruits, wild honey, reeds for weaving into mats, and firewood for sale; making charcoal; firing bricks; and cutting trees for timber. It appears that the loss of forest to over-harvesting of its trees and over-exploitation of its resources, as well as to settlement/farming, and pressure on other communal natural resource areas, like river banks/*dambos*, has likewise resulted in loss of the related livelihood opportunities. There are still forest resources, but these are now limited and tend to be located further away from villagers:

> *"I used to mold small clay pots [for household use] and bigger ones for sale and I could provide for my household, but I stopped as I am now old and not physically fit to travel longer distances to collect firewood, grass and clay soil as these days these materials are scarce to find due to change in climate."* Elderly community member, Felo.

These continue to be exploited at a seemingly unsustainable rate:

> *"As you can see on the road those people with firewood are going to sell it and buy maize on their return."* Community member, Chisambamnopa.

The cutting of trees from communal land might have been expected to generate conflicts over the use of communal forest resources. However, the view appeared to be that those who were not able to feed themselves in a poor agricultural season had no choice other than to make use of the natural resource base, particularly trees to be cut for firewood and timber to be sold. It was often young men who were identified as

[42] As they previously had fishing as a main livelihood, the community was relatively better-off and had resources to invest, including in sending young men to SA to send remittances.

being those who cut trees for charcoal and brick-making, as they had little choice. Only in Chiluzi did villagers not tolerate people cutting trees for their own needs, including food insecurity. In this case, the female village headwoman strictly enforced rules on no wood removal from the forest area, other than for sanctioned community projects. This stance was strongly supported by the community, in contrast to the passivity and almost helplessness found in the other communities.

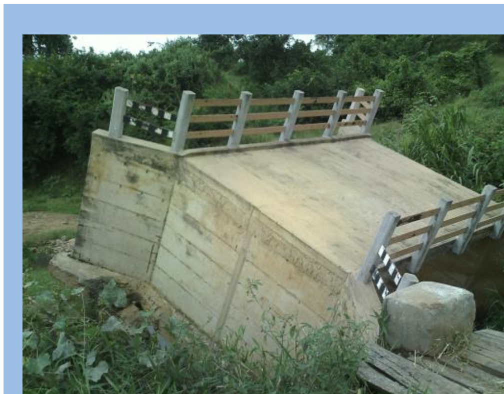
Although the use of communal forest resources by parts of the community was not a cause of open conflict, there was conflict over access to the forest areas for firewood in Chisambamnopa, where it had an explicitly ethnic dimension. The established Yao community members said that the (more recent) Lomwe migrants put snares in the forest to injure Yao who were collecting firewood. This was reported by several "Yao" sources, but not by the Lomwe.

The development of remittances was also mentioned as a coping strategy. This was a core strategy for Liguluche, and to a lesser extent in Chisambamnopa, Felo, Lupanga, Mulupha, and Nkasala. Arguably, these are some of the communities with the most significant problems agriculturally, resulting in people moving away in search of alternatives. Sadly, in addition to the mainly male migration, the women who were left behind turned to casual prostitution to raise money when it was needed, as reported at Felo and Nkasala. This was not a permanent or full-time livelihood, but rather a means to supplement family income sources at times of pressure.

In conclusion, Malawian livelihoods are in a massive state of flux. Due to a combination of climate change and other drivers, there is major transitioning from one sector to another as well as transitioning with a sector. At precisely the same time in Malawi's history, farmers are changing crops and often moving from agriculture to fishing, while fisherfolk expand to fish ponds or livestock and everyone is reaching out for the nearest forest. Trends are localized to reflect the different portfolio of opportunities dominated by natural resources (e.g., proximity to water and forests) and by wealth, skills, and tolerance for risk taking.

7.3 HOUSEHOLD WELLBEING

Biophysical changes due to climate change and their impacts on livelihoods lead inevitably to changes in the wellbeing of individuals and households. Although beyond the scope of the Malawi VA, the PRA exercise included aspects that begin to reveal a clear link between human wellbeing and climate change that included the impact of extreme or rapid-onset events, such as flooding, on the asset base and health of Malawian populations. Less visible but equally troubling is the impact of slower-onset hazards such as drought and climate-related soil and natural resource degradation that slowly erode the asset base of even wealthier households. At times, Malawian households may be exposed to both rapid-onset hazards and slow-onset phenomena within the same short time period. It also became clear, through the PRA exercise, that climate change affects the poor disproportionately. Sudden-onset hazards, slow-onset phenomena, and the differential impacts of both are explored briefly in this section.



Infrastructure Damage Due to Flooding

SUDDEN-ONSET HAZARDS/FLOODING

Unexpected heavy rains and resulting flooding have already destroyed homes, infrastructure, and crops in Malawi. It has been reported that increased flooding events have recently affected the transmission and incidence of malaria, cholera, and schistosomiasis (GoM Ministry of Environment and Climate Change Management, 2011). Health was reported to be significantly affected within the PRA villages, with a wide range of impacts that are inextricably climate-linked. In PRA villages there were reported increases in water-borne disease (cholera and diarrhea) from more flooding combined with poor sanitation, as well as increases in malaria reportedly linked to an increase in flooded areas.

The PRAs also confirmed the impact on infrastructure of flooding and storms as many villages reported damage to the roofs of houses and school blocks, the inability of schools to operate outdoor classes (e.g., completed destruction of the school building), and difficulties in getting to school due to flooding and swollen rivers. Although these impacts cannot be entirely attributed to climate change and, in fact, are not entirely new problems, local perceptions hold that their occurrence has become more frequent. Land was one of the common areas of conflicts within communities. This was reported as being both a function of a relative shortage of land (such as in Felo and Mulupha) and loss of land due to flooding (such as in Kawelama).

SLOW-ONSET HAZARD/DROUGHT

Slower-moving hazards, such as drought, are undeniably linked to reduced yields, reduced income, and reduced purchasing power–growing levels of poverty. Across Africa, the relationship between poverty and school absenteeism─leading at times to early marriages, prostitution, and eventually incidence of HIV/AIDS─are often observed. To compensate for climate-triggered reductions in yield, five of the nine studied villages cited remittances sent home by family members who traveled to find work in South Arica.

It was the poorest[43] households among the nine PRA case studies that were found to be disproportionately impacted by climate change. The poor were found to be more vulnerable to erratic rains and high temperatures because they do not have alternative sources of income to replant or buy food if they lose their crops. The poor also cannot plant high-input, improved, higher-yielding, and shorter-maturing maize varieties since they cannot afford the additional inputs, and are left with access only to the traditional variety. For the same reasons, the poor cannot adopt the dual strategy of planting some improved and some traditional seeds to benefit from whichever is best suited to the coming season, thereby spreading the risk. Given limited resources for irrigation or alternative crops, the poor cannot diversify or intensify as can their wealthier neighbors in the face of erratic rains. The poor are also more affected by the indirect impacts of climate-triggered disease because they do not have the resources to prevent disease or to travel to get (or even pay for) treatment. The vicious circle of poverty means that the Malawian poor need to engage in *ganyu* to meet immediate food needs, thereby neglecting their own crops. As witnessed in the Malawi VA PRA villages, the poor also often rent out their fields, ending up with insufficient production to feed themselves.

Of importance for food security were the coping strategies of the poor in the event of reduced yields due primarily to erratic rains. The major coping strategy was to reduce calorific intake. This enables the households to get through to the end of the hunger period, but it weakens them at the time when their production effort is greatest. Shortage of food can also contribute to and exacerbate poor health. A second method reported was to change consumption from maize to other foods, such as cassava, or dilute maize flour with bran or cassava flour. These have similar calorific and nutritional content, but for Malawians it is a major psychological blow not to be able to eat maize at least once a day. Nonetheless, the PRA did find evidence of a slight shift from the deeply entrenched adherence to maize. A third reported method was to search for alternative foods, such as wild tubers/yams, wild fruits, and even water lilies. These have limited effectiveness either because they are increasingly rare and in demand by many, or they have limited nutritional value.

[43] The PRAs classified households using standard wealth ranking procedures that engage a small group of community members to divide their village into most commonly three different classes, using criteria they identify themselves. As a result the classifications–different for every village–clearly demonstrate what elements are of most value to the community as well as the rough proportion of households within each class. Furthermore, the classifications are then used to make sure that PRA respondents for each village include individual households from each class –to gain understanding of the differential impacts of climate across the village. In this manner, qualitative evidence allowed a comparison of the climate adaptation strategies that are employed by the poorest households to those employed by the wealthiest. Adaptation strategies are then proposed as a proxy for adaptive capacity, with the caveat that poorer households currently only coping, may simply need more support to identify sustainable adaptation strategies. Here, the difference between coping and adaptation strategies is key.

7.4 GOVERNANCE

Although governance, institutions, and policies were not a component of the Malawi VA, some elements of these important factors were gleaned from the ensemble of studies and hint at institutional change as a result of climate variables.

The main change noted was the competition and confusion that emanates from often-contradictory messages coming from various institutions. For example, changes in the climate have already triggered Malawian agricultural officers to push for irrigation, fish farming, use of hybrids seeds, and planting of drought-tolerant crops in order to help farmers compensate for climate-related yield loss. In adopting these recommended changes, farmers begin capturing water (e.g., diverting streams) and/or expand cultivation into areas that may once have been reserved for other ecosystem services (e.g., river banks and *dambos*). At the same time, also responding to climate changes, environment officers are edging rural populations to participate in afforestation, bank reinforcement, and use of vetiver[44] to stabilize ecosystems near water channels. Quite clearly, these two very different uses of land nearest waterways are often conflictual.

In response to reduced surface water availability, other behaviors of institutions include the rationing of hydropower since 1997 (especially during the months of October and November). While this has little to no impact for communities "off the grid," rationing may begin to seriously disrupt economic activities in urban areas, if other supplies are not identified to meet a growing demand.

7.5 ANTICIPATED FUTURE STRATEGIES

7.5.1 NATURAL RESOURCE MANAGEMENT

Many sources have projected that Malawi will become a water scarce country, with less than 1,000m^3 of rain-fed freshwater resources available per capita per year, by 2015. Table 7.4 shows water predictions for 2020 under low, medium, and high economic growth scenarios, and for 2035 under a medium economic growth scenario. By 2035, under the medium economic growth scenario, wet season demands for water will not be met using the current operating capacity of the existing infrastructure. During a typical extreme drought event in 2035, the availability of water resources is expected to decrease due to the impacts of climate change that reduce dry season river flows. This reduction is such that there is predicted to be an actual water resource shortfall in the Lower Shire of approximately 2,350 million liters per day (GoM, April 2011).

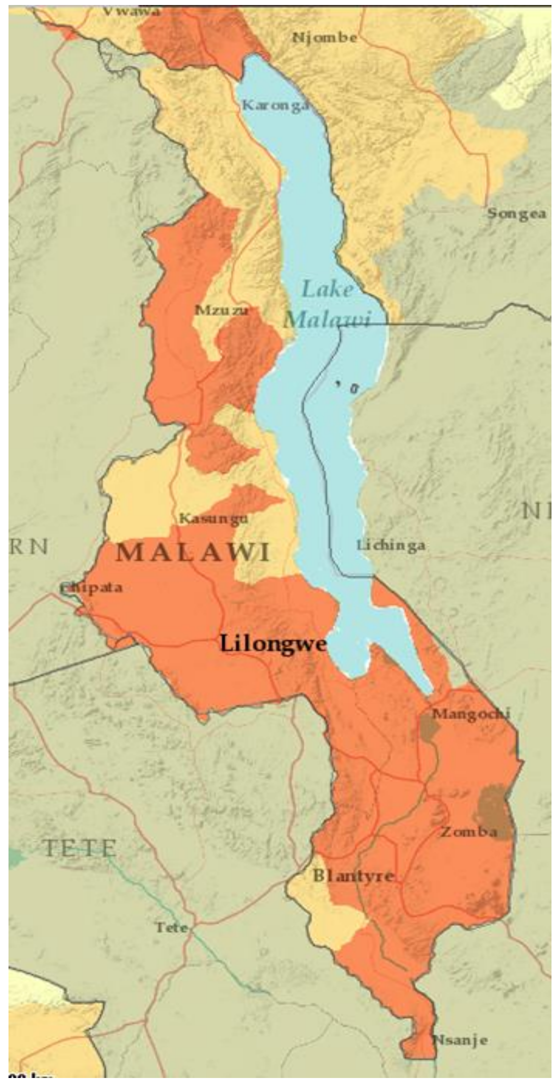
TABLE 7.4. PROJECTED WATER DEMANDS BY SCENARIO

Average demand	Dry season demand	Dry season demand/available water supply
In the year 2010		
2,900	3,900	10% (of 3900)
Predicted by 2020, low economic growth scenario		
3,625 (+25%)	4,850	12.5%
Predicted by 2020, medium economic growth scenario		
4,350 (+150%)	11,650	30%
Predicted by 2020, high economic growth scenario		
19,575 (+150%)	35,300	90%
Predicted by 2035, medium economic growth scenario		
-----	23,650	60%

[44] *Chrysopogon zizanioides*, commonly known as vetiver, is a perennial grass native to India. The root system of vetiver is finely structured and very strong. It can grow 3 to 4 meters deep within the first year. Because of these characteristics, the plant is highly drought-tolerant and can help to protect soil against sheet erosion (www.wikipedia.org).

According to climate modeling carried out under the GoM Water Resources Investment Strategy: Component 1-Water Resources Assessment published in 2011, due to the effects of climate change, by 2035 wet season surface water resource availability is predicted to increase, but dry season resources are predicted to decrease. The wet season yields will rise by approximately 4 percent, while average dry season resources are predicted to go down by about 10 percent, with the result that dry season resources are predicted to decline by nearly half (GoM, 2011, p. xv). These projections are of great concern, as Malawi is already considered water-stressed with its renewable water resources less than 1,400m^3 per capita per year.

FIGURE 7.1. AQUEDUCT PROJECTED CHANGES IN WATER STRESS (2025)



Competition for water will certainly grow worse: It is expected that smallholder farmers currently reliant on rain-fed agriculture will divert water toward supplemental small-scale irrigation, further reducing the water available for large scale irrigation systems, hydropower, and municipal use. Groundwater is unlikely to be a solution for irrigated agriculture, as the capital costs and lack of accurate data about groundwater inhibit groundwater use for most producers. Other non-climate factors will only exacerbate the situation, including mining extractions, urbanization, and poor land use methods.

Malawi is now moving toward IWRM principles and approaches. However, nascent allocation efforts are largely on a first-come-first served basis and are being applied in a context that lacks the solid institutional capacity needed to deal with the country's growing and significant water scarcity challenges. Significant further efforts will be needed to encompass unregulated small-scale users and address the impacts of climate change. Water scarcity will lead to competition between users–municipal, hydropower, small- and large-scale irrigation, and others–as well as competition and tension among geographic areas, as increases in extraction rates from Lake Malawi or the Shire River will have direct impacts on water availability in the lower parts of the Shire Basin.

In fact, according to macro-level analysis based on global data sets and climate change scenarios compiled by WRI's Aqueduct Water Risk Atlas (Figure 7.1[45] on previous page) water stress is expected to increase in identified sub-regions of Malawi, with some locations projected to be three to eight times more water stressed than recent baseline conditions.

While no quantified projections have been identified to predict the health of forests, biodiversity, fisheries, and agricultural yields in the near or distant future of Malawi–driven by many factors–all signs point to an uncertain future characterized by stress and the need for innovation, resilience and improved adaptive capacity at all levels.

[45] The water stress map is projected to 2025 using the B1 Scenario (World Resources Institute, n.d.).

7.5.2 SOCIOECONOMIC CHANGES

One of the PRA tools, the Village History and Hope, was designed to provide information about expected changes and aspirations that communities and households hold for the future (10 years ahead, with a sense of optimal and worst-case expectations). A total of 13 elements were explored, most of which are linked or can be influenced by climate change—such as the favorability of rainfall, the predictability of rainfall—extreme events, natural resources, agricultural yields, fish catches, and malaria. Although strictly qualitative, the results provide an interesting comparison to the climate projections.

Many household coping strategies[46] hold out promise. Unfortunately, when facing a highly uncertain climate future, each of the strategies comes with some caveats or carries some risk.

- The dual strategy of planting both traditional and improved maize is effective, as it ensures a harvest when the rains are of normal length or are shortened due to late onset and/or early cessation. The proviso is that this strategy cannot protect farmers against prolonged dry spells/droughts mid-season and it is beyond the reach of the poorest households.
- The strategy of moving from traditional or mixed to all improved maize varieties can be effective <u>if</u> the farmer has sufficient inputs, accompanied ideally by access to irrigation or sufficient residual moisture (such as in a *dambo)*. However, the unresolved problem with hybrid varieties is its vulnerability to pests in storage–an impact that remains largely unmitigated to date. In addition, increasing irrigation increases demand on surface water resources (see previous section).
- Adopting a range of improved husbandry methods such as those under conservation farming, zero tillage, and *sasakawa* has proven effective to combat decreased yields <u>except</u> under extreme climate conditions, the frequency of which may increase with climate change.
- Increased irrigation and winter cropping are very effective if they enable diversification and the transfer of risk to a larger set of possible futures, and as long as water supplies are sufficient and close.

The following coping strategies already being used are "no-regrets" with a less direct link to climate change.

- Measures such as inter-cropping with legumes and trees (agroforestry); crop rotation; conservation agriculture (e.g., no-till); planting vetiver (e.g., establishing vegetative bunds/barriers); and adding compost, animal manure, and mineral fertilizers can be effective in improving soil fertility, retaining soil moisture, and reducing rainfall runoff and minimizing erosion. However, access to inorganic inputs and animal manure is constrained, especially among the poorer groups.
- Business and seasonal opportunities can generate income, but many of these options are not available year round and some are generally unsustainable in nature, such as those involving the unsustainable exploitation of the forest (for firewood, charcoal, brick firing, and timber). Often the unsustainable exploitation of the forest is among the few options available to the poorest households.
- The poor have few other options to compensate for reduced yields, the most significant being *ganyu*; it is effective up to a point to generate immediate income or food, but workers are easily exploited and the strategy is only effective in the short-term as it often results in neglect of their own gardens.
- Establishing woodlots has multiple benefits for the communities, including contributing to afforestation which can mitigate climate change, providing a local source of firewood and timber, and a representing a huge savings in time for many (who otherwise must travel long distances to collect forest products).

[46] In this context "coping" is distinct from adaptation because coping refers to the more immediate strategies employed that may not take into consideration long term conditions or sustainability. In fact, many coping strategies across Africa are known to be detrimental to household livelihoods and wellbeing or destructive (i.e., lowering consumption beyond a certain minimum level or selling productive assets). They are hereby referred to as "coping" until evidence is sufficient to consider them more permanent, beneficial, and sustainable.

However, scale of these activities is small and the time to establish the lots is relatively long. Also, just as with crops, tree seedlings can be a victim of erratic or heavy rains.

- Migration to towns, factories, and even migration outside Malawi can be effective in generating income. While the resulting remittances can, and very often do, sustain a farm through difficult periods, the migration may eventually become (semi-) permanent, with migrants establishing second families, leaving the (mainly) wives left behind without the additional resource.

As Malawians continue to search for ways to adapt to climate change, it will become more and more important to build adaptive capacity that positions the country and its citizens to better deal with an uncertain climate future without resorting to unsustainable coping strategies. In the next section, we explore approaches to strengthening adaptive capacity and risk management across communities and institutions at all appropriate levels. By focusing on increasing the resilience of the country and its communities, individuals, and natural assets, USAID's climate change adaptation efforts will help protect existing investments, maintain development gains, and contribute to economic security.

8.0 RECOMMENDATIONS

This section consolidates recommendations derived from the Malawi VA with a stakeholder engagement process (an Options Analysis [OA] workshop) that vetted and expanded on key recommendations. The recommendation options presented in this section are "evidence-based"—they draw on the findings of the Malawi VA—and are confirmed by stakeholders as meeting the following criteria:[47]

Realistic: Implementation of the option is realistic within the current political and social context.

Flexible: The option allows for flexibility in the future to respond to changing risks.

Equitable: The option increases benefits to particularly vulnerable groups and communities.

Urgent: Implementation of the option can be addressed in the next two to five years.

Synergistic: The option is complimentary with GoM and donor objectives.

This analysis led to the definition of four overarching strategies around which to organize an approach to develop and implement the recommendations:

1. Timely, accurate, and relevant information on first order impacts (weather and climate);
2. A "stakeholder group" focus on water and natural resources that provides a consistent framework for implementation across sectors;
3. High-level, cross-sectoral planning, harmonization, and coordination; and
4. A coherent approach to diversifying what will remain (at least in the near term) a largely agrarian economy.

Both long- and short-term, and both local- and national-level recommendations are provided. The longer term, climate-specific interventions seek to position Malawi to better deal with an uncertain future. The shorter-term, "no regrets" options will allow Malawi to react to climate change and climate variability happening now.

8.1 WEATHER AND CLIMATE – MEASURING, MONITORING AND UNDERSTANDING FIRST ORDER IMPACTS

Data, data analysis, and communications all play a key role in planning for, and adapting and responding to, climate change. Absent data, there can be no data analysis; without data analysis, planning is ill-informed and may not impart actionable information to either decision makers or those most directly impacted by climate change. Accurate projections of future climate change are underpinned by knowledge of a baseline of past climate conditions, and on adequately monitoring climate conditions as they evolve over time, extending that baseline. These data, together with the best available science and realistic emission scenarios (as they evolve) are the foundation on which decisions will be made now and in the future. To support this effort, the DCCMS must be strengthened in a number of areas.

[47] The screening criteria were derived from a combination of criteria provided in USAID's Adapting to Climate Variability and Change: A Guidance Manual for Development Planning (2007) and ARCC's Approaches for Adaptation Options Analysis (October 2012). The short list of screening criteria were selected as the most critical for selection while at the same time being manageable in number by stakeholder discussion groups with limited time for analysis.

Weather. The present network of weather stations, existing data sets, stewardship of these data sets, and means by which the data and information derived from the data are communicated, must all be strengthened. The Malawi VA and OA workshop identified the following needs:

- Establish a more extensive network of weather monitoring stations with up-to-date equipment (e.g., weather radar, if appropriate). Siting of these stations should be based on a needs assessment by the DCCMS and in consultation with other relevant parties (e.g., other ministries and institutions that may use these data for future climate modeling purposes).
- Ensure reliable, real-time delivery of weather data from the weather stations to the DCCMS (e.g., via the GSM network).
- Provide DCCMS with the technical and human resources and training necessary to validate, clean, process, and analyze these data in near real time.

To ensure the highest possible level of accuracy and reliability, acquisition of these data, their management (stewardship), and analyses and derived products produced from the data should all conform to international standards. The DCCMS may elect to draw on external consultants to establish these standards, with periodic audits to ensure practices and procedures are adhered to over time, and kept current with changes in internationally recognized best practices. Communicating these data and the resulting analyses and data products at the national, district, and local levels may be addressed as follows.

- Implement a professionally managed web-based weather portal to facilitate access (and stewardship) of these data, both current and historical, and to the resulting analyses derived from the data.
- Develop a mechanism by which the data products can be promptly communicated to appropriate authorities (including to the district level to facilitate timely local-level decision making). Delivery mechanisms may include:
  - via the web-based weather portal,
  - email and/or SMS messages with location-specific weather information sent to district offices, and
  - email and/or SMS messages sent to other subscribers.
- Facilitate data sharing on a regional basis (with neighboring countries) by adhering to internationally recognized standards for collecting, validating, storing, and communicating these data.

Further, timely and accurate dissemination of weather forecasts and weather warnings will permit affected populations (e.g., farmers, fisherfolk, transporters, and merchants) to manage their activities and to minimize losses in the event of extreme weather events. Thus, it is recommended that the DCCMS should:

- Institute a system designed to communicate weather warnings (e.g., potential flooding conditions or periods of high winds) as promptly as possible, via targeted SMS multi-casts to the relevant geographic areas (for example, to village leaders, local businessmen and women and to district extension agents) and/or via radio and television alerts;
- Share longer-term (almanac) forecasts via regularly scheduled radio and television programs, as well as through local extension services and farmer and other community associations; and
- Provide within the web-based weather portal easy access to weather almanac data, present weather conditions, and near-term and seasonal forecasts.

In addition, the DCCMS may work with the MoAFS to identify cost-savings associated with prompt and accurate weather forecasts and warnings, especially for nationally important crops (e.g., export crops and crops important for national food security).

Climate. Over time, "current" weather data becomes the historical foundation on which climate projections are constructed. But, just as the weather changes, so does our understanding of climate drivers[48] and the

[48] For example, the CSAG report prepared as part of the Malawi VA noted that scientists are just now becoming aware of the importance of Atlantic SSTs for influencing weather in Malawi.

actual (versus anticipated) emission scenarios. Therefore, planners must continuously update their climate projections with the best available science, while validating the projections against conditions on the ground. It is recommended that the DCCMS:

- Improve and maintain a clear historical record of weather data over the coming decades—this will be critical for detecting trends related to climate change;
- Due to the critical importance of access to weather data by all sectors of the country's economy, provide, free of charge, historical weather data which are currently only available for purchase;
- Gather additional non-conventional historical proxies—such as lake levels, stream flows, and even crop yields—to validate weather data records and fill data gaps;
- Develop a gridded (rather than point-based) meteorological data product. Use this product together with existing accepted current climate zone maps for Malawi (see Text Box 8.1) to define **future climate zones** within Malawi more clearly (also see next section); and
- Enter into an institutional relationship with an established climate modeling center to carry out periodic downscaling and other state-of-the-art modeling exercises for which the DCCMS has neither the mandate nor the comparative advantage. Through this relationship, periodically update the climate projections (e.g., every five years).

> **TEXT BOX 8.1. MALAWI'S CURRENT CLIMATE ZONES**
>
> A "climate zone" (or "climatic zone") is a geographic area defined using a few key parameters, such as total annual rainfall and average annual temperature. Malawi overall is often defined as being located in a "humid sub-tropical" climate zone, but the country covers areas that range from semi-arid to sub-humid, and includes small areas of "hot, dry steppe" and "maritime." (ILARMA, 1991; FAO, 2000).

Climate Change Adaptation. The Malawi VA showed that Malawian farmers are already experiencing changes in climate conditions—changes in rainfall patterns; changes in the start, end, and the duration of the rainy season; and changes in temperature. These changes are likely to continue, and even intensify, in the future. The Malawi VA also showed that many farmers are already adapting to these changes, although others are only coping. Their efforts are often hampered by lack of resources, among them lack of up-to-date information. Given adequate information about likely long-term trends—in climate and the impact of climate—many are capable of developing adaptation plans that include changes in crop varieties, diversifying crops planted, planting combinations of hybrid and traditional seeds, undertaking multiple plantings at different periods, intercropping, and adapting numerous conservation agriculture techniques. Once farmers understand that the climate is not going back to the way it was, but rather that the changes they have already observed are likely to be exacerbated, those with the resources to do so (see next sections) are likely to continue to invest in such adaptive strategies.

While some farmers, as individuals, have already demonstrated a willingness and capacity to explore adaptation strategies, most such efforts benefit only a few: the individual concerned or their immediate family or their immediate community. The creativity and real-world experience engendered in these efforts can be "harvested" by consolidating these experiences in a "case book" of adaptation strategies, both the successful and the unsuccessful. In this way, the Ministry of Agriculture and Food Security (MoFS) can facilitate identification and adoption of the most successful and sustainable strategies. Further, the ministry can work with appropriate institutions—NGOs and others—to refine and tailor these strategies so that they may remain applicable in the future.

To support successful adaptation efforts among Malawi's farmers and the population in general, and to encourage local creativity in testing adaptation strategies, the DCCMS, in cooperation with the Ministry of Information and Civic Education and the MoAFS, should craft and disseminate clear messages about climate change including:

- What climate change is, what is known with a high degree of certainty, and what remains uncertain about the future climate of Malawi.

- The fact that climate change is now a permanent part of life and not a challenge about which they need only be concerned for a season or two.
- Uncertainties do exist in what the future holds but that broad trends (increasingly erratic rains, higher temperatures) are well understood.
- Variability of weather conditions year to year, and even within a season, will likely increase.

These messages must be crafted and communicated in a way that is not only relevant to rural audiences but also shapes their perspective. Farmers should no longer be asking. "What do I plant and when do I plant it?" Rather, farmers should be asking "How do I diversify my farming strategy to reduce risk overall?" Only by understanding the nature of climate change will farmers understand the very significant difference between these two questions. Essentially the same question, "How do I diversity my livelihood?" applies equally to the non-farming members of Malawian society, particularly those of modest means.

8.2 WATER AND NATURAL RESOURCES

The Malawi VA found that exploitation of natural resources is one of the first places people turn when coping with (rather than adapting to) the impacts of climate change. In many cases these options were unsustainable or detrimental including stream diversion, cropping in *dambos*, fishing out of season or with progressively finer mesh nets, excessive (and often illegal) cutting of trees for charcoal production, and overhunting of bush meat. These are all coping strategies that were more frequently undertaken by those without the resources to implement more sustainable adaptation strategies. While many communities reported feeling helpless to do anything about the unsustainable exploitation of resources, the Malawi VA also found instances where communities were effectively enforcing prohibitions against unsustainable natural resource exploitation, thereby continuing to benefit from their historical patterns of utilization. For instance, in Chiluzi, the village headwoman strictly enforces rules on wood removal from the forest area, other than for sanctioned community projects. Villagers reported that this protection, together with recent additional tree planting, has already begun to restore vegetation cover and improve soil fertility, and over time, promises a potential for income from sustainable firewood sales.[49]

The strategy for water and other natural resources involves identifying "affinity interest" groups and helping them to establish their group identities, establish goals, and identify existing resources; facilitating the coordination of the groups; and facilitating communications between and among groups, as well as to district and central government entities. This strategy is intended to establish a sustainable "learning agenda" through which all sectors of society can mutually benefit—allowing the communities represented in the groups to improve natural resource management, overcome barriers to poor and mismanagement, and increase long-term resilience to climate change.

For example, communities associated with environmentally sensitive areas, or to resources particularly sensitive to climate, represent stakeholder groups that are particularly at risk due to climate change. Looking beyond geographic areas, "affinity interest" groups have a strong stake in the long-term viability of the natural resources available to them. Fisherfolk, charcoal sellers, bush meat sellers—all represent affinity interest groups of stakeholders with vested interests in certain aspects of the natural environment.

Both geographically defined stakeholder groups and affinity interest stakeholder groups are likely to possess a deep knowledge of the present and past condition of the "landscapes" that provide these resources, although they may be less clear on the actual scale or degree of changes to those conditions. They may also have a very

[49] Others report similar cases elsewhere in Malawi. For instance, the village of Nkhamayamaji, Rumphi District, maintains a Village Forest Area lying between it and the border of Nyika National Park. Since a village elder persuaded the village to conserve this area, regeneration is reported to be progressing well, and is already providing livelihoods in the form of mushrooms, traditional medicines, thatching grass, and honey production. Protection of this area is also reported to have reduced soil erosion and contributed positively to water control. (ECODIT, 2013).

good idea of the likely impact of future climate conditions based on their own experience with short-term changes due to natural climate variability.

By taking a stakeholder group approach, these experiences—both positive and negative—can be aggregated into valuable lessons learned for planners, policymakers, and the community at large. A recommended strategy is to:

- Identify, establish, and nurture appropriate geographic and affinity interest stakeholder groups.
- Develop programs for piloting innovations and sharing lessons learned within and among groups.
  - Such sharing can be catalyzed, promoted, and supported by the GoM, NGOs, and development partners.
- Establish pilot programs for upscaling successful adaptation approaches to other groups or other geographic areas, with mechanisms to continue to capture new, or refine existing lessons learned and to share them, including with district offices of relevant ministries.
- Provide support (micro-loans, training, assistance, insurance) to poorer and marginalized households to allow them to more fully participate, and move from coping to adapting.
- Establish communication channels between stakeholder groups and relevant line ministries.

Once properly informed themselves about the likely impacts of climate change, policy planners and their district-level representatives will be in a good position to provide affected communities with accurate information on likely future conditions. They can work with communities to explore and assist in the identification of viable climate change adaptation options—especially ones beneficial to both the stakeholder community and the long-term viability of the landscapes they depend on.

Water. Many such stakeholder groups are likely to exist, many representing unique ecological and economic resources. For example, the Malawi VA identified the geographically defined stakeholder group who rely on Lake Chilwa as a source of livelihood. As noted in the Malawi VA water study, the two most important hydrologic systems in Malawi—Lake Malawi and the Shire River—already benefit from significant attention and investment from the government via the World Bank-financed Shire River Basin Management Program. However, the less significant, but nonetheless important Lake Chilwa Basin is highly susceptible to the impacts of climate change and merits further assistance. Examples of potential support for Lake Chilwa Basin include the following.

In the category of long-term, climate specific recommendations:

- Establish a local Water Dispute Resolution Council focused on water resource management, climate change adaptation dialogue, and planning.
- Pilot interactive community water stress projections with Basin communities using WRI's Water Stress Atlas.
- Facilitate local priority-setting and allocation of water resources using most likely projected climate change scenarios.

In the category of "no regrets" recommendations:

- Establish integrated water resource management (IWRM) principles and approaches for the Lake Chilwa Basin within local management structures.
- Promote conservation agriculture focused on techniques and methods for increasing or maintaining soil moisture.
- Promote smallholder and small scale rainwater harvesting and supplemental irrigation.
  - These may be planned through local management structures at the basin level.
- Promote wetland protection and improved land use methods among small stakeholder farmers.

At least some of the sustainable adaptation strategies identified for the Lake Chilwa Basin will also apply to Lake Malawi. In this way, aspects of a "Lake Chilwa Basin stakeholder community" can be expanded to a national "water Basin management stakeholder community." In fact, lessons may be learned from stakeholder groups in neighboring countries, such as the Permanent Okavango River Basin Water Commission (OKACOM) or the Lake Victoria Basin Commission (LVBC).

8.3 CROSS-SECTORAL PLANNING, HARMONIZATION AND COORDINATION

Fundamental to all of these activities is the need for the relevant line ministries (Agriculture, Environment, Water, Energy, Lands) to have a coherent and consistent strategy for managing resources, with both harmonized policies and harmonized messages.

In fact, during the OA phase, among the strongest recommendations of GoM stakeholders was the need to harmonize and improve coordination of existing policies. For example, OA stakeholders reported—as the Malawi VA PRA exercises confirmed—that Malawian agricultural officers are promoting irrigation and, in response, farmers have begun diverting streams. At the same time, environment officers are encouraging rural populations to participate in stream and river bank reinforcement and plant perennial grasses to help stabilize banks. These competing policies and competing messages regarding the use of land near waterways can be in conflict—or are at least confusing to the concerned community members.

Climate change will affect all sectors—agriculture, energy, water, health, environment, and public works. As such, only an "all of government" approach will effectively address climate change impacts in the long term. Just as the Department of Disaster Management is within the Office of the President and Cabinet (OPC), leadership and coordination to address climate change impacts must come from the highest level—either at the OPC level, or just below it. This is especially true for planning, for policy and message harmonization, and for much of the implementation of policy. Such high level coordination will also facilitate the establishment of clear metrics to measure and monitor progress, consolidation of lessons learned, and dissemination of those lessons both across the line ministries and down to the district level. The recommended steps are as follows.

- Establish a high-level "all of government" coordinating committee or coordinating council; one located within the OPC could serve such a purpose.
- Identify an initial set of key policies requiring harmonization across line ministries. Ideally, the specific policy reform targets would follow ultimately from the lessons learned by the stakeholder groups, existing and yet to be formed (as described above). In the interim, investigate key barriers or issues that need to be resolved in order to accelerate the scaling up of improved agriculture practices and natural resource management. For example,
  - Do policies, laws, regulations or customary practices regarding the burning and use of crop residues need to be changed?
  - Is there a need for additional enabling legislation to empower local communities to develop by-laws governing resource use for watershed management and to strengthen local institutions designed to promote and support sustainable land management?
  - Is there a need to shift the attention of the Forestry Department, to ensure they serve as greater champions of more sustainable practices, such as agroforestry, farmer management natural regeneration, and increased density of trees on farms?
  - What might be done to mobilize political will and enforce more sustainable modes of charcoal production?

To address long-term climate impacts in a coordinated manner, develop a single, coherent framework for *explicitly* incorporating climate change considerations climate change into all ministries' programming and investments. This framework should include, at a minimum, guidelines for how to consider likely future climate scenarios when setting new policy and developing long-term economic development investments (see next section), requirements for considering climate risks and risk-reduction measured when developing individual short-term (project-level) investments, and requirements that planners take measures to ensure that both long- and short-term investments do not inadvertently increase vulnerability to climate change by certain population groups or other economic sectors. Such climate "mainstreaming" will help protect the GoM's investments from (at least some) of the impacts of climate change, and protect or even enhance the climate resilience of the nation as a whole.

Significant policy reform takes time, especially in cases requiring policy coordination among many ministries and departments dealing with water, agriculture, natural resources, disaster risk reduction, climate change adaptation, and food security. In the meantime, an expedient means of addressing many of the issues would be to harmonize the delivery of the messages derived from the existing policies.

- At a minimum, this should begin with the Ministry of Irrigation and Water Development (MIWD) and the MoAFS. Stakeholders recommended a five-step process:
  Step 1. Establish a task force to harmonize messages.
  Step 2. Select a priority set of messages to be harmonized.
  Step 3. Harmonize the messages among all the relevant line ministries.
  Step 4. Publish clear guidelines for these "climate smart" messages.
  Step 5. Coordinate line ministries' extension services in the delivery of the harmonized messages, especially at the district level.

  The lessons learned from a successful outcome could then be captured and replicated with other ministries, and other messages.
- To strengthen the district-level messaging, partnerships could be established with Malawian universities and development partners. These partnerships could be used to develop mid-level extension services and/or farmer field schools, and to train extension agents.

In as much as this applies to anticipated climate change, the GoM should provide a clear and concise "story" of what the future holds, without minimizing the uncertainties that exist.

8.4 ECONOMIC DIVERSIFICATION

Agriculture. Perhaps the most unexpected finding from the Malawi VA was the very strong inverse relationship between the climate resilience of the six studied crops and dominance of the crop (in terms of hectares planted) in Malawi—those crops with more hectares planted are least climate resilient. Many of the more climate-resilient crops (such as sorghum and pigeon peas) have historically been among the traditional crops, but over the last few decades these have been gradually replaced by the least climate resilient of all the crops studied: maize.

One of the primary drivers of this shift has been the Farm Input Subsidy Program (FISP) which, by focusing on one crop, maize, ("choosing the winner") has contributed to the expansion of the least climate-resilient of the six crops studied. The Malawi VA showed, however, that some farmers are already moving away from hybrid maize varieties, and back to traditional varieties that are more climate-resilient and less dependent on substantial inputs of mineral fertilizers. Further diversification of the agricultural sector ("choosing to win") will enable farmers and communities to become more food secure in a changing climate. Strategies for doing so are the following.

- At the national-level, focus on research and necessary policy changes, beginning by determining the preferred crop mixes and varieties for the future climate zones (as described above). Specifically,
  - The MoAFS[50] should conduct agricultural research and crop modeling to inform appropriate farming techniques and planting times for each future climate zone, and to identify climate-tolerant "improved" seed varieties, either traditional, commercially available, or newly developed.

[50] It is likely that the appropriate department within the MoAFS for this work would be the Department of Agricultural Research Services (DARS), which mandate it is to "generate and disseminate applied or product-oriented agricultural technologies and provide technical support and advisory services that can be directly utilized by the farming community and other stakeholders for increased agricultural productivity."

- As a first step, the existing phenological analyses should be refined to be made more specific to Malawi[51] and economic analyses of high-priority crops should be carried out using a more rigorous methodology than was possible during the Malawi VA.
- The final output should be recommendations for crop mixes and varieties that take into account not only the climate-resilience of the crops themselves, for each climate zone, but also the pests and diseases associated with them.

- Expand the FISP subsidies program in ways that promote and support climate-resilient crops and crop mixes for each future climate zone. At the local level, this effort will help farmers move away from single-crop agriculture and toward increased diversification and intensification through increased support to farmers for the intercropping of legumes and perennials, agroforestry, and conservation agriculture. In addition to fertilizer and Actellic Super dust (a synthetic insecticide), these may include subsidies for both improved (including disease- and pest-resistant) and traditional seed varieties, other insecticides, and herbicides, as appropriate.
- Support initiatives that can expand access to FISP subsidies and inputs through agro-input dealers and other mechanisms, such as buyers distributing inputs in contract farming schemes.
- To lessen the potential negative impacts of the increased use of fertilizers, insecticides, and herbicides, link subsidy investments to increases in investments in conservation agriculture practices and sustainable natural resource management. For instance, complement the use of fertilizers and other needed inputs with improved management of soil moisture and soil organic matter, which can also help increase fertilizer use efficiency. Complementarily, also increase investments in integrated soil fertility management, as well as agroforestry.
- At the local level, work in concert with local research organizations to test local ideas or provide comparative studies on different efforts as part of a larger "learning agenda" (see next section).
- Also at the local level, balance the attention given to the use of inputs and improved seeds with attention to crop (and non-crop) diversification, in general, such as increasing the use of perennials as well as legumes. For example, provide support for small-scale, gravity-fed, irrigated dry season gardens. These gardens provide a range of crops and products that improve nutrition and increase incomes with modest investments.

Farmers with the resources to do so are also adapting conservation agriculture techniques including no-tillage, crop residue management, maintenance of soil cover crops, crop rotation, compost and manure application, and intercropping. Such practices should be supported and further promoted throughout the farming community. In addition, the MoAFS should:

- Undertake a national-level systematic survey to identify the more effective innovations and successful conservation agriculture practices already being used by farmers in their efforts to adapt to climate change. In the process, determine what additional resources are needed, at the national level, to promote and support these practices.
- At the local level, using the findings from the survey, review and consolidate key messages for agricultural extension agents to explicitly promote the most cost-effective and sustainable practices and production systems appropriate to each future climate zone to restore and manage soil fertility and to conserve and efficiently utilize rainfall and soil moisture For example:
  - In climate zones more prone to prolonged dry spells and drought, invest in rainwater capture programs and training in agriculture practices that preserve soil moisture.
  - In climate zones more prone to high rates of runoff, floods, and waterlogging, invest in training in soil and water conservation techniques and watershed management approaches to reduce soil erosion and minimize nutrient leaching.

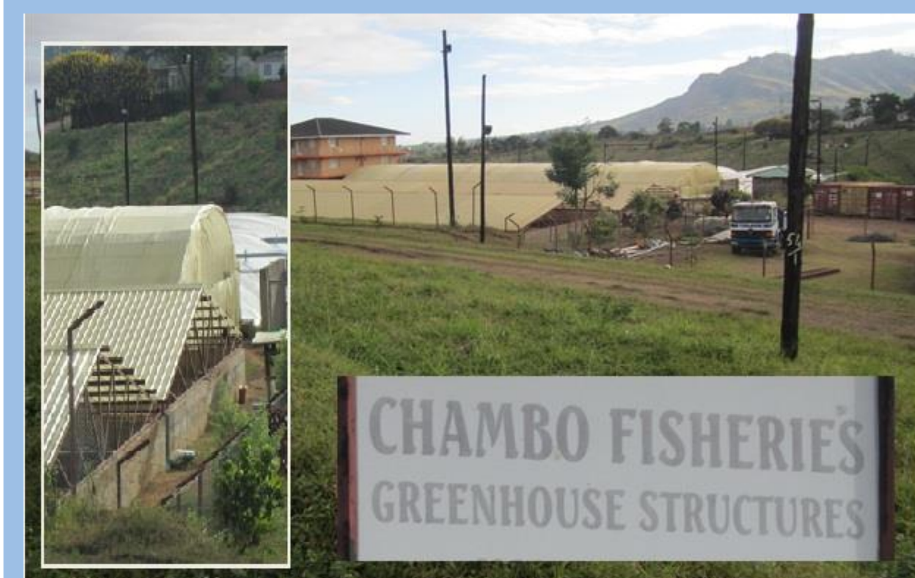
[51] Due to a dearth of relevant published research, the phenological desk study carried out for the Malawi VA was based on generic or, at best, regional research, not Malawi-specific data and information.

- In climate zones most likely to experience erratic rainfall, invest in strategies that balance soil moisture conservation with soil drainage, and invest in providing knowledge and skills that will allow farmers to move from one strategy to another on short notice.

- Promote a range of improved land and water management practices as appropriate for each future climate zone, including farmer-managed natural regeneration and other agroforestry practices; intercropping of perennials; rainwater harvesting; reduced tillage; maintenance of a cover crop; crop rotation with legumes (to reduce the rapid spread of pests and diseases and enhance soil fertility); maintenance of fallow lands; appropriate crop residue management; and the increased use of compost and manure (within a framework of integrated soil fertility management).

Beyond Agriculture. Eventually, the country must diversify its economic base beyond agriculture. Livelihood diversification, at the local level, and economic development diversification, at the national level, will be the day to enhancing adaptive capacity. In addition to "mainstreaming" climate change into economic development investment decisions, as described in the previous section, the Government of Malawi should also begin taking steps to diversify the economy beyond agriculture.

As discussed in Section 8.3, by providing various stakeholder groups with even modest assistance, their efforts could be leveraged to ensure that a longer-term sustainability of these resources while increasing community resilience to climate change. For example, the area of fisheries provides an opportunity to significantly expand agriculture into aquaculture—a national-level "fisherfolk" affinity group may catalyze a much larger impact than would isolated groups associated with specific water bodies.



Recently Completed Commercial Chambo Aquaculture Facility near Blantyre

The Malawi VA fisheries study demonstrated the importance of fisheries in Malawi as a protein source at the household level and for national-level food security. However, the study was unable to identify the existence of a true fisheries "market value chain." Most fish were found to be sold close to the source, individually or by the bucket, or consumed by the household. However, this may be changing. Since the fisheries study was conducted (in mid-2012) at least one large-scale commercial *chambo* aquaculture enterprise has been established (outside of Blantyre). This enterprise could provide a nucleus around which a fisherfolk affinity group could develop a true fish market value chain in Malawi. In addition to forming the affinity group, other recommendations for establishing such a value chain might include the following. At the local level:

- Promote small household and community-level small-scale ("artisanal") aquaculture;
- Provide start-up capital and other support, such as small, low-interest loans, to middlemen helping them to purchase and consolidate fish from numerous small-scale ("artisanal") aquaculture sources. This will allow wider supplier participation in the market (expanding fish sources beyond wild-caught fish and commercial scale fish farming).

- Establish and support cold storage and cold-chain transport facilities.
- Establish and support drying and canning facilities.
- Conduct awareness and outreach to promote acceptance of canned fish products.

The long -term viability of a fisheries value chain at the national level depends on the availability of a sustainable supply of fish. If supplying the value chain leads to further depletion of wild fish stocks—which are already stressed—this would have severe consequences for the many households which depend directly on these stocks. Despite its significance, the Malawi VA found little recent scientific research on fisheries—either wild or farmed—yet sound scientific research is a prerequisite to designing policies, establishing and enforcing regulations, and maintaining and even expanding a wild fisheries industry. To advance the understanding of the complexities driving the fishing industry in Malawi, a set of studies are in order:

- Carry out a quantitative exploration of the climate impact on fish recruitment and stocks in important water bodies and wetlands (Lake Malawi, Lake Chilwa and Shire River).
- Determine the relative amount of farmed (including small-scale "artisanal") versus wild fish already in the marketplace, and the potential for significantly expanding artisanal fisheries to displace wild-caught fish.
- Carry out a cost-of-production analysis, similar to what was carried out for the six crops studied in the Malawi VA, to estimate economic cost valuation of likely climate impacts at each link of the fisheries value chain.
- Collect data on recent and current fish stocks and recruitment in near shore lakes, rivers, streams, and fishponds; update these estimates annually with particular attention to trends in fish numbers and age distributions, and species diversity.
- Establish a monitoring system to track the physical, chemical and biological characteristics of the principle freshwater bodies throughout Malawi. These data will support the effort to predict the effects of future climate change on wild fish populations.

Finally, for wild-caught fish, an enabling environment must be secured and sustained to assure governance at national and local levels with climate-friendly policies that protect the nation's resources while assuring food and livelihood security. Some elements may include:

- Revise national and local policies affecting the (wild caught) fishing industry and the controls set up to enforce them. In addition to the fisherfolk affinity group, this will require open dialogue between the Ministries of Agriculture and Food Security, Water and Irrigation Development, Health, and others.
- Increase patrols along lakeshores to enforce fishing seasons while at the same time carrying out awareness campaigns concerning the negative long-term effects of fishing out of season or with inappropriate technologies.
- Consider community enforcement through locally managed areas (e.g., Beach Village Committees).
- Provide further support to provide a framework for investments such as consultations with federal agencies on permits in state waters, fish stock, habitat restoration, conservation of wild species, regulation of aquaculture facilities in federal waters, and international collaboration and technical assistance.

Stakeholders involved in the options analysis process recognized the need to go beyond both agriculture and aquaculture, and to consider ways to expand the national economic base beyond raw foodstuffs:

- As a first step, improve the ease of doing business in Malawi to encourage domestic and foreign investment in agriculture value chain (processing and value-added) investment and non-agriculture-related businesses.
  - The Ministry of Trade and Industry should
    - Prioritize and improve Malawi's ease-of-doing-business score/ranking to encourage domestic and foreign investment in non-agriculture businesses; and
    - Work with NAFSAM to promote agriculture-related value-chain business development.

- The Ministry of Gender, Children and Welfare should Improve business management skills among women and provide equal opportunity to apply these skills; and
- The Ministry of Labor should strengthen the provision of vocational skills for young people to diversify away from agriculture. One means for doing so would be to work with the OPC's Private Partnership Commission to identify and strengthen links between vocational training, schools and the private sector.

Over time, benefits from diversifying household-level livelihoods to diversifying national-level, sector-specific economic development strategies will improve the resilience of both individual communities and the nation as a whole to adapt more easily to changing conditions—whether they be changing climate conditions, or other changing conditions, such as changing market conditions.

As with all of the recommendations presented in this section, by focusing on increasing the resilience of the country and its communities, individuals, economies, and natural assets to climate change and climate variability, USAID's adaptation efforts will help protect existing investments, maintain development gains, and contribute to economic security.

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10.0 LIST OF ANNEXES

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- Annex C: Detailed Climate Change Projections
- Annex D: Detailed Phenology Report

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