FOUNDATION FOR A SMOKE-FREE WORLD

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Agricultural Diversification

Climate Risks to Smallholder Agriculture in Malawi: Recommendations for the Agricultural Transformation Initiative

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Disclaimer

About the Foundation for a Smoke-Free World and the Agricultural Diversification Team

The Foundation for a Smoke-Free World (the Foundation or FSFW) was launched in September 2017 as an independent, nonprofit organization dedicated to accelerating global efforts to reduce deaths and harm from smoking, with the ultimate goal of eliminating smoking worldwide. Since the adoption of the World Health Organization (WHO) Framework Convention on Tobacco Control (FCTC) in 2003, countries that compose 90% of the world's population have resolved to achieve significant reductions in smoking rates by 2025.

The Foundation's mandate and global efforts in this field promise many positive health impacts. These efforts will invariably entail a reduction in smoking and, thus, a reduction in the incomes of tobacco-producing farmers in tobacco-reliant economies. This economic disruption will not be felt uniformly and will disproportionately affect socially and economically vulnerable populations because they represent much of the rural poor and the agricultural labor force globally. This creates a unique opportunity to (a) support smallholder tobacco farmers as they transition to alternative crops and livelihoods, and (b) catalyze a sustainable and inclusive transition.

Through its various programs, the Foundation's Agricultural Transformation Initiative (ATI) works to prepare smallholder tobacco farmers for an era of reduced demand for tobacco. The Foundation does this by helping to facilitate the establishment of more secure, equitable income strategies for farmers and will seek to partner with a diverse set of stakeholders to ensure success and sustainability.

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Keywords:
Climate change; climate-smart agriculture; climate adaptation; Malawi; agriculture diversification; tobacco farming; agricultural value chains.

Table of Contents

Acronyms

ATI	Agricultural Transformation Initiative
C	Celsius
CCAFS	Climate Change, Agriculture and Food Security Program
CGIAR	Consultative Group for International Agricultural Research
CORDEX	Coordinated Regional Downscaling Experiment
CSA	Climate-smart agriculture
DoDMA	Department of Disaster Management Affairs
EAD	Environmental Affairs Department
ENSO	El Niño-Southern Oscillation
FAO	Food and Agriculture Organization
FISP	Farm Input Subsidy Programme
FSFW	Foundation for a Smoke-Free World
GCF	Green Climate Fund
GCM	Global circulation model
GDP	Gross domestic product
GHG	Greenhouse gas
GII	Gender Inequality Index
GNI	Gross national income
GoM	Government of Malawi
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
MGDS	Malawi Growth and Development Strategy
MoNREM	Ministry of Natural Resources, Energy and Mining
NAP	National adaptation plan
NCCIP	National Climate Change Investment Plan
NCCMP	National Climate Change Management Policy
NDC	Nationally determined contribution
NDPRC	National Disaster Preparedness and Relief Committee
NEPAD	New Partnership for Africa's Development
NGO	Nongovernmental organization
NRS	National Resilience Strategy
PRA	Participatory rural appraisal
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollar
VC	Value chain
WCRP	World Climate Research Program

Executive Summary

This paper was commissioned by the Foundation for a Smoke-Free World (FSFW) to assist the efforts of the Agricultural Transformation Initiative (ATI) in Malawi. ATI's objective is to support the livelihoods of smallholder farmers by helping them transition from tobacco cultivation to more sustainable and profitable alternatives.

The paper draws together the findings of current climate change research in Malawi, examines the government's response, and describes the ways in which climate risks intersect with the lives of smallholder farmers in Malawi. The paper also presents a series of decision-support tools that can help ensure climate resilience is built into ATI's investments and programs.

The methodology of this paper draws upon successful experiences in promoting climate-resilient cropping patterns in other parts of the world, such as South Asia. Those experiences highlight the importance of the economic drivers that underpin agricultural interventions, including the shift away from tobacco. After all, farmers are economic actors and profitability – in financial, subsistence, or cultural status terms – is a key driver of their decision-making.

In addition to being one of the poorest countries in the world, Malawi is highly vulnerable to climate change. This vulnerability is due in part to a highly degraded natural environment, with population pressures serving as a key driver of environmental decline. Agriculture itself is both a contributor to, and victim of, this environmental decline. It is a cause of environmental degradation due to expansion of cropping onto marginal lands, hillsides, and forested areas, and a victim because of declining yields caused by farming unsuitable land and using unsustainable agricultural practices.

Climate change is also exacerbating the agricultural sector's vulnerabilities, bringing with it more frequent extreme weather events, such as droughts, floods, and heatwaves. Initiatives designed to improve the productivity and profitability of Malawi's agriculture sector must explicitly address climate risks in allocating investments, and they must build climate resilience into their programming.

Smallholder farmers are among those most affected by climate change because of their limited capacity to adapt to its impacts. They can therefore benefit immensely from efforts to strengthen their capacity to adapt.

Modeling climate projections for Malawi is constrained by the scarcity of long-term historical weather data. However, sufficient local data, combined with datasets based on global and regional models, allow trends to be identified and a range of climate projections developed.

Average maximum and minimum temperatures are increasing, and there is consensus across a range of climate models that the mean annual temperature and frequency of very hot days will continue to rise. There is less agreement across climate models on the way in which rainfall patterns are changing, with projections ranging from significant increases to modest declines.

At present, Malawi's weather forecasts do not provide enough detail for farmers, the government, or others to plan ahead effectively. However, a combination of new policy and financing (for example, from the Green Climate Fund) seeks to make major improvements to the accuracy, relevance, accessibility, and timeliness of weather forecasts.

The Government of Malawi (GoM) recognizes the country's vulnerability to climate change and has a range of policies and institutional arrangements to respond to climate change risks. The Environmental Affairs Department, within the Ministry of Natural Resources, Energy and Mining, coordinates the implementation of the majority of climate change-related policies. Other ministries and agencies directly implement their own policies and programs to manage and respond to climate risk.

However, the GoM has struggled to effectively implement its wide range of climate-sensitive policies. Coordination across government agencies presents a major challenge. There is also a shortage of skills and expertise within the government to lead and implement adaptation and mitigation efforts.

In addition, there is often a mismatch between policy intentions directed to address climate risk at the national level and sector priorities at the local level. This is compounded by social, economic, and institutional barriers that constrain full participation by local communities and reduce their adaptive capacity.

Some policies may work against efforts to build resilience into smallholder farming systems. For example, current agricultural input subsidies have been criticized for providing incentives to continue the cultivation of crops that are neither drought nor flood tolerant.

Malawi faces longstanding environmental pressures, ranging from poor natural resource management practices to population pressures that are exacerbated by high levels of poverty. These pressures, combined with the government's limited capacity to implement policies, puts Malawi's natural environment in a precarious position. Climate change adds a further level of vulnerability.

Malawi's strong dependence on rainfed cropping, in particular, makes the agriculture sector vulnerable to climate change. The projected rise in temperature and rainfall variability will have multiple impacts on the water sector, amplifying existing pressure on water resources and the degradation of Malawi's rivers, watersheds, and wetlands. This represents a major risk to the country's economy, as agriculture will remain an important pillar of the economy, particularly in terms of food security and rural employment.

Farmers recognize that weather patterns are changing, and many are already innovating in response to these changes and associated yield reductions. For example, some are changing cultivation practices or planting different crops or crop varieties. However, the majority of small farmers have very limited opportunities to build resilience into their farming systems. There is a need to speed up and spread innovations that promote climate-resilient agriculture.

Women in Malawi are disadvantaged by a range of economic and cultural practices. As a result, they represent the largest proportion of poor people most vulnerable to climate change impacts. Agricultural investments and interventions geared to building climate resilience need to be gender-sensitive and take into account the different ways men and women can respond to opportunities. Women smallholders often lack access to labor-saving technologies and even basic farm tools, leaving them unable to adopt farming practices that could build resilience to climate change. Yet women also play an active role as agents of change and have the knowledge and capacity to respond to climate impacts. Their role needs to be explicitly recognized in the design of any future agricultural initiatives.

Malawi's agricultural systems must adapt to the new climatic conditions. Climate-smart agriculture (CSA) highlights both climate risk and responses, providing a framework to identify and support approaches and practices that can transform agriculture to suit a rapidly changing climate (FAO, 2017). CSA aspires to a "triple-win" of increasing production, adapting to climate change impacts, and mitigating agriculture's contribution to greenhouse gas (GHG) emissions.

While CSA is primarily identified by activities at the farm level, climate change has impacts along the whole agricultural value chain (VC). This needs to be explicitly recognized when planning investments and programs to avoid missing pressing constraints elsewhere along the VC.

In addition to recognizing how different climate risks impact differently along segments of the agricultural VC, it is also important to recognize that the most significant resilience-building interventions may not necessarily require changes to technology or assets. Constraints may actually be closely linked to areas such as existing policies, access to finance, or access to knowledge. Looking at opportunities to make changes in these domains may also be as or more important than technical changes.

This paper provides an overview of how a climate-resilient approach can be incorporated into the process of identifying alternatives to tobacco or increasing agricultural productivity, while supporting the promotion of these new cropping patterns in the context of the whole farm system.

Four simple decision-support tools are presented:

1. A multicriteria approach to selecting agricultural products that are both profitable and climate resilient;
2. A practical approach to mapping the VCs of selected climate-resilient agricultural products;
3. A framework to identify investments in CSA; and
4. A systematic approach to prioritizing identified investment options.

There are a few ways in which using these tools can prove helpful. At the start, their use will ensure problem identification. Subsequently, response planning will need to consider the entire agricultural VC, rather than simply what happens at the farm level. In addition, use of decision-support tools helps ensure that decision-making and planning interventions consider policy, financial, and knowledge constraints and opportunities, not just technical ones. Used together, the tools can help to identify potential crops, cropping patterns, and additional farm products from activities such as beekeeping and vermiculture. Farmers can also add value by processing crops on the farm. Such alternatives provide smallholders with alternatives to tobacco cultivation and can be both profitable and help to build climate resilience into smallholder farming systems.

Decision-support tools have already been used successfully in South Asia to identify investments and interventions that build climate resilience. Used together, they provide a simple way of identifying a range of possible entry points for investment and program design, along with a straightforward way of prioritizing them.

Of course, final decisions on investment and interventions are not purely technical in nature. They are inevitably political, as they represent tradeoffs between different and sometimes competing interests. Nevertheless, the approach presented here evidences the utility of structured decision-making. This in turn provides a strong basis for discussion and consultation between and within different interest groups as a key part of the process of making investment decisions and designing climate-sensitive interventions.

Introduction

This paper has been commissioned by FSFW to support the work of the ATI in Malawi. ATI's objective is to support the livelihoods of smallholder farmers by helping them transition from tobacco cultivation to more sustainable and profitable alternatives.

Globally, adapting to a changing climate is now an important factor influencing farming options. As Malawi is subject to a very high level of climate vulnerability, it is particularly urgent that climate risks to smallholder farming are well understood, and responsible and effective responses are taken.

This paper draws on a range of recent research to describe the way climate risks intersect with other risks faced by smallholder farmers in Malawi. It presents an approach to ensuring that building climate resilience is effectively included in future investments and interventions.

The paper is divided into three sections. Part 1 provides an overview of the current understanding of Malawi's climate risk and vulnerability. Part 2 discusses how these risks impact the agricultural sector. Part 3 presents a decision-support framework, with tools that can help guide ATI's ongoing programming efforts to ensure building climate resilience is effectively included in the design of investments and interventions.

The methodological framework adopted to identify climate-resilient interventions and investments is based on successful experiences in applying it in South Asia. The framework deliberately situates farmers' own socioeconomic benefits (including financial, subsistence, and cultural values) as a major criterion that underpins interventions to shift cropping patterns away from tobacco. After all, farmers are economic actors and profitability – in financial, subsistence, or cultural status terms – is a key driver of their decision-making.

Part 1. Climate Change in Malawi

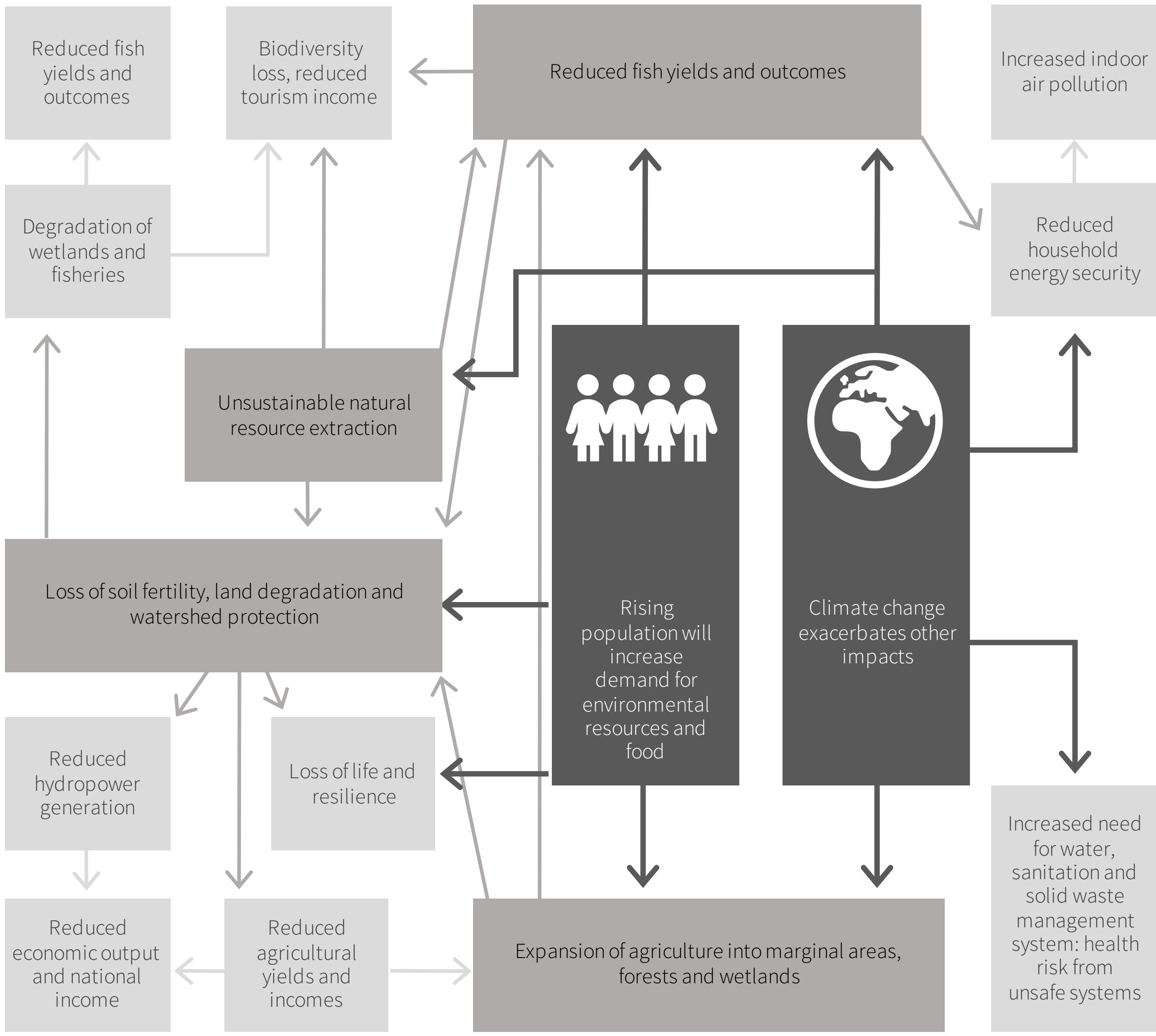
Overview

Malawi's natural resource base is not in good shape. Widespread and severe land degradation, deforestation, and deteriorating water resources place enormous strains on its environment. The pressure of a rapidly rising population, with a large proportion still dependent on the country's natural resource base for their livelihoods, adds to these challenges as people extend farmland into unsuitable areas and agricultural productivity remains low (see Figure 1). As a result of these combined pressures, the country's natural capital endowments are declining at an alarming rate, while any transition to an economy based on manufacturing, industry, and services remains a long way off (World Bank, 2019).

Malawi is highly vulnerable to the impacts of climate change, experiencing frequent cycles of droughts and severe flooding, which are associated with substantial economic and social costs. Agriculture, a sector that is particularly vulnerable to adverse weather events, remains a mainstay of the economy and accounts for well over a quarter of the country's gross domestic product (GDP).

Even a single severe weather event can have a very large economic impact. For example, severe flooding followed by a prolonged drought in 2015-16 saw real GDP slow from an annual growth rate of around 5.7% to a sluggish 2.5%, a significant drop to the already low per capita GDP (World Bank, 2019). That drought period also left 6.5 million people needing food aid (World Bank, 2016). Malawi's reconstruction and rehabilitation costs following floods caused by Cyclone Idai in 2019 are estimated at USD $370.5 million (Government of Malawi, 2019a). This is nearly 5% of GDP and close to the government's current fiscal deficit, which means that the government will struggle to meet these costs in the near future.

Figure 1. Malawi's environmental drivers, pressures, and impacts



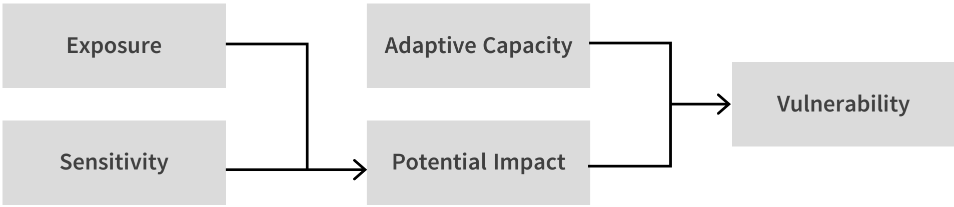
Source: World Bank (2019)

Malawi's agriculture sector faces many challenges – such as intensive competition for land and water resources and a degrading environment – in meeting the food requirements of an ever-increasing population. These challenges are compounded by a changing climate. Climate change alters the basics of productive ecosystems (e.g., temperature and rainfall), impacts natural resources (e.g., land and water availability), and affects food security, rural livelihoods, and sustainable development at national and local levels. Smallholder farmers are among those most affected by climate change because of their limited capacity to adapt to its impacts. Smallholder farmers can benefit immensely from efforts to strengthen their capacity to adapt. Adaptation is needed now and postponing action increases adaptation costs.

Understanding vulnerability to climate change

Vulnerability to the impacts of climate change is frequently described in terms of levels of exposure, sensitivity to the adverse impact of changes in weather, and the capacity to adapt to resulting impacts. These three factors include both biophysical and social aspects of climate risk (see Figure 2). Any specific response to agricultural vulnerability to climate change must address at least one of these factors. Often the three are closely interlinked, and adaptive responses can address more than one of them.

Figure 2. Climate change vulnerability



Exposure:
The presence of people, livelihoods; environmental services and resources; infrastructure; and economic, social or cultural assets in places that could be adversely affected by climate change.

Sensitivity
The degree to which a system or species is affected—either adversely or positively—by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).

Adaptive Capacity:
The combination of the strengths, attributes and resources available to an individual, community, society, or organization that can be used for actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities resulting from climate change.

Source: Definitions based on IPCC (2012)

The ability of natural or social systems to respond effectively to climate change challenges is frequently referred to as resilience, "the ability of countries, communities, and households to manage change by maintaining or transforming living standards in the face of shocks or stresses without compromising their long-term prospects" (Sturgess and Sparrey, 2016). Pre-existing vulnerabilities, exacerbated by changes in weather patterns, can undermine attempts to adapt to changes in climate and weather patterns: In other words, inherent levels of resilience are low. In some cases, attempts to adapt bring in short-term gains but undermine efforts to build longer-term resilience to climate change impacts. As examples, cultivating closer to riverbanks increases the sediment load in water bodies, and clearing forests to expand cultivated land reduces valuable ecosystem services that protect water and soil resources.

Malawi's capacity to adapt is severely limited by numerous interlinked factors. The government has extremely limited fiscal space for suitable investments in actions that will effectively reduce climate vulnerability, and the level of appropriate expertise it can mobilize to design and implement adaptation activities is very limited. The majority of rural households are also quite poor, and most have little access to relevant information. As a result, they cannot invest in appropriate actions to adapt their natural resource-based livelihoods (agriculture, forestry, and fishing) to the impacts of climate variability and change (Government of Malawi, 2017a).

Climate change trends and projections

Malawi is already seeing rising average temperatures and shifts in weather patterns. The rate of warming is in line with global trends, which suggest a significant rise in average temperature between 1960 and the mid-2000s. Observed and projected changes in temperature, and their implications for weather patterns, are described in more detail in this section.

Over the past two decades, the Malawi Department of Climate Change and Meteorological Services (DCCMS) has reported relatively sharp increases in both maximum and minimum temperature, compared with historical averages (DCCMS, 2021). The DCCMS has reported a mean annual temperature increase of 0.2°C since 1971, with an average rate of increase of 0.04°C per decade (DCCMS, 2021). The largest of these shifts are in the early summer (November and December) with slightly lower increases in late summer (January and February). The warming trend is evenly distributed across the whole country (FCFA, 2017) and the higher average summer temperatures increase the vulnerability of many crops to heat stress.

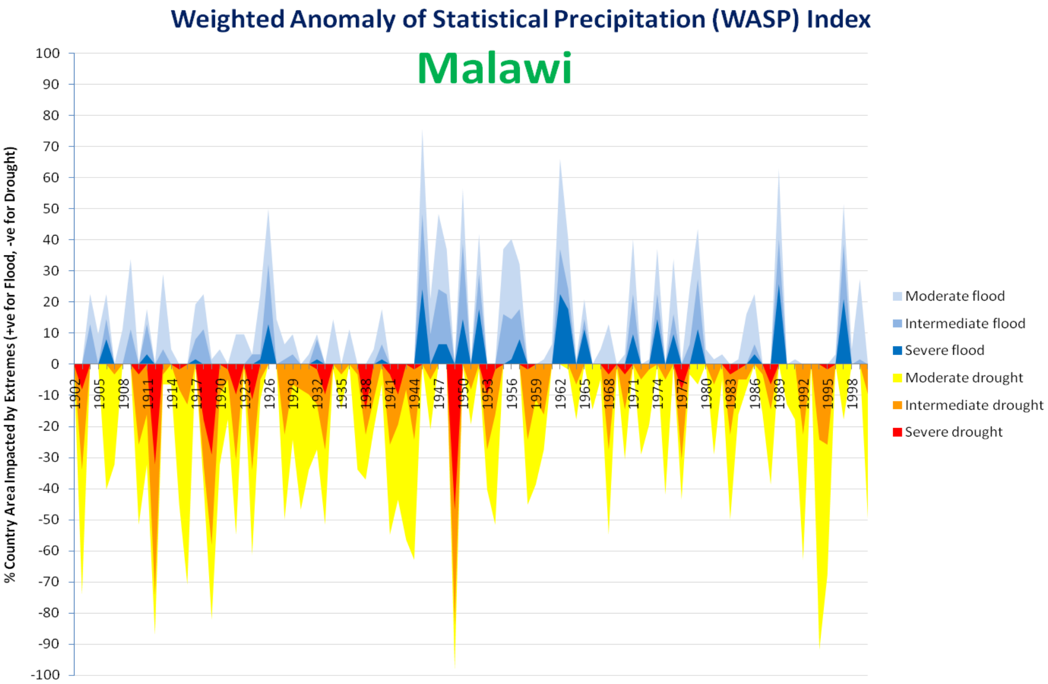
Significant changes to recent rainfall patterns are harder to determine. The changes in rainfall are not uniform across the country historically, though the negative trend is common throughout several regions (DCCMS 2021).A drying trend began in the early 2000s, but the picture is not clear-cut: Parts of northern and southern Malawi experienced moderate drying between 1981 and 2016, while the central parts of Malawi experienced a very small wetting trend during that same period. Generally, large sections of the central and northern region have been experiencing a drop in rainfall of 10-20% during January and February (DCCMS 2021). Numerous studies of Malawi's weather patterns and climate, including Warnatzsch and Reay (2019), FCFA (2017), and Zulu (2017), provide evidence of this trend.

What is certainly increasing are the number, and severity of impact, of extreme weather events. For example, the total number of droughts, heavy rains, and flood-related disasters increased from one event in the 1970s to six, 14, and 19 events during the 1980s, 1990s, and 2000-2006, respectively (ActionAid, 2006). Recent years have seen a continuation of weather-related disasters, with a series of severe floods and droughts from 2015 to 2022.

Farmers' own perceptions of changes in temperature support observed recent changes. Farmers are, of course, very aware of weather patterns. A number of community-level participatory rural appraisal (PRA)-type assessments undertaken over the past few years report that farmers perceive maximum and minimum temperatures to be increasing, which is in line with observed weather data (USAID, 2013; Zulu, 2017).

Modeling future climate change scenarios indicates that Malawi will experience substantive changes to temperature and rainfall patterns in both the medium and long term (DCCMS, 2021). Malawi's weather patterns are characterized by variability (see Figure 3). Projections of future shifts indicate these will exacerbate numerous existing vulnerabilities to droughts and floods. While there is still considerable uncertainty about the frequency and intensity of future floods and droughts, the majority of climate models agree that mean temperatures will rise. Recent research analyzing 34 climate change models predicting trends up to the end of this century indicates a reduction of mean number of rain days and an increase in the amount of rainfall on each rainy day (FCFA, 2017). In simple terms, this means that dry spells will become more frequent (although not necessarily more severe), and intense rainfall events (which are often associated with flooding) are more probably. These changes are likely to present serious risks to both livelihood and food security, and to adversely impact overall economic growth. Projections of future changes and impacts show spatial variations, yield and economic gains and losses, winners and losers (Zulu, 2017).

Figure 3. Historic climate variability



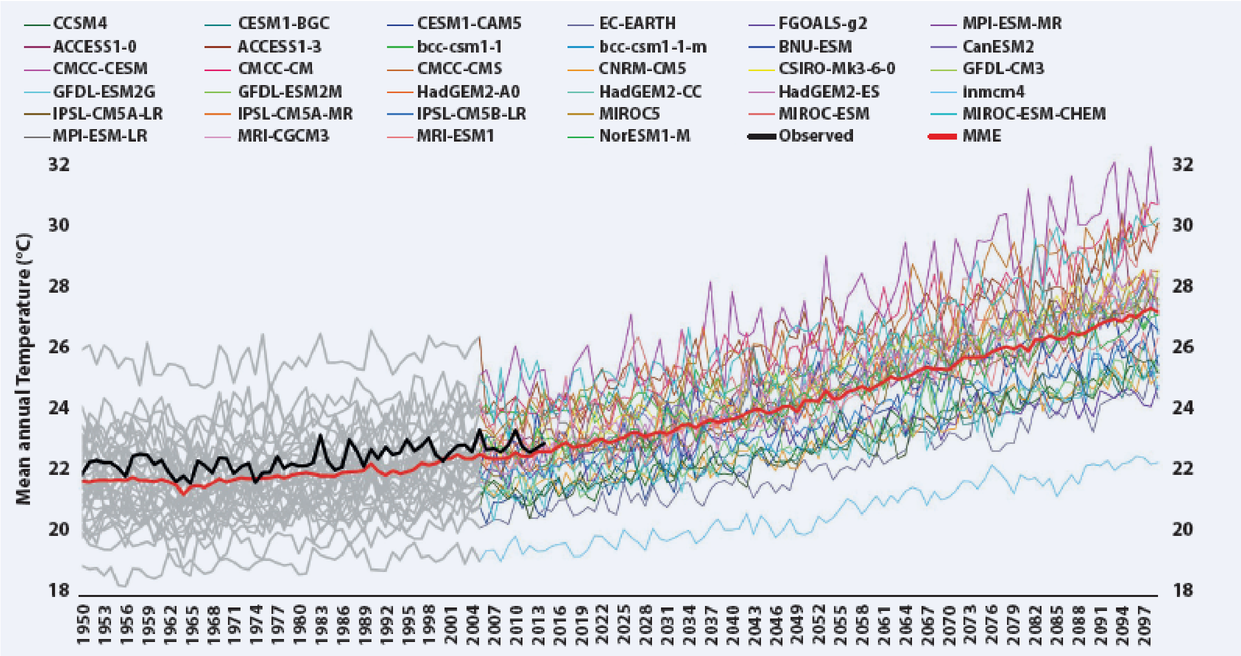
Source: The International Resources Institute for Climate and Society at Columbia University, derived from the CRUT-S (Climate Research Unit, University of East Anglia, UK)

Note: Yellow-red indicates drought; blue indicates higher than normal rainfall. The higher the curve, the greater the proportion of the country affected.

Climate change projections for Malawi are subject to considerable uncertainty. Climate models attempt to combine a number of variables. The important ones require scaling down local-level weather impacts from global circulation models (GCMs) as well as factoring in differing future socioeconomic and emission scenarios. Since these variables depend on a large number of assumptions, the results are bound to contain levels of uncertainty. Using several models provides the likely boundaries of this potentially wide range of possible impacts.

There is a consensus across all modeling scenarios that mean annual temperatures in Malawi will rise, but there is less certainty about the way in which rainfall is changing (Figure 4). Recent modeling for Malawi has estimated that by the 2040s temperature will increase 0.5-1.5°C, compared with temperature averages during the 1960s-1980s. These projected average temperature rises are distributed relatively evenly across the country.

Figure 4. How different climate models project temperature change for Malawi

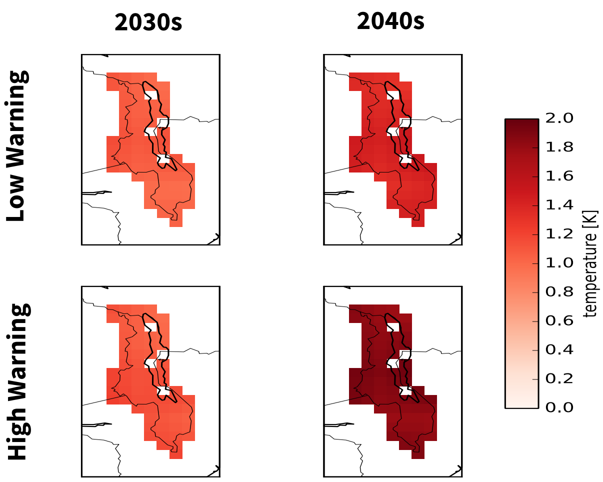


Source: FCFA, 2017

Note: Time series of mean annual temperature (C°) for 34 CMIP5 models and their ensemble (bold red line) for the period 1950-2099 and CRU observations (bold black line) for the period 1950-2014

Figure 5, below, shows the World Climate Research Program's estimated temperature changes in Malawi for the 2030s and 2040s. As modeling advances, confidence and consensus on rising temperatures have grown. The rises in average annual temperatures will also be accompanied by an increase in the frequency of very hot days (Figure 6).

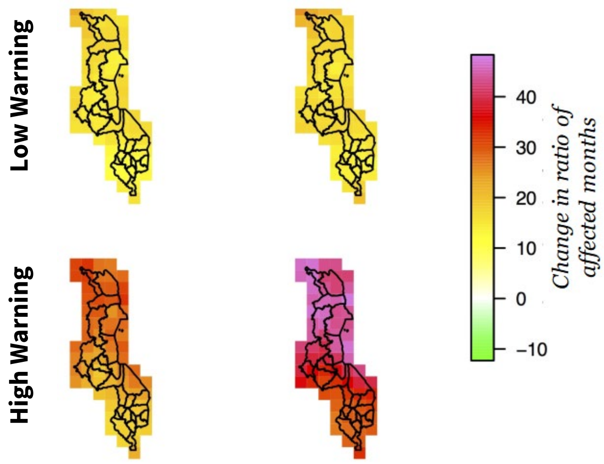
Figure 5. Projected average temperature increase in 2030s and 2040s compared to the period 1986-



2005

Source: Government of Malawi (2017a). Computed using data from the World Climate Research Program's (WCRP) Coupled Model Intercomparison Project Phase 5

Figure 6. Changes in heat extremes

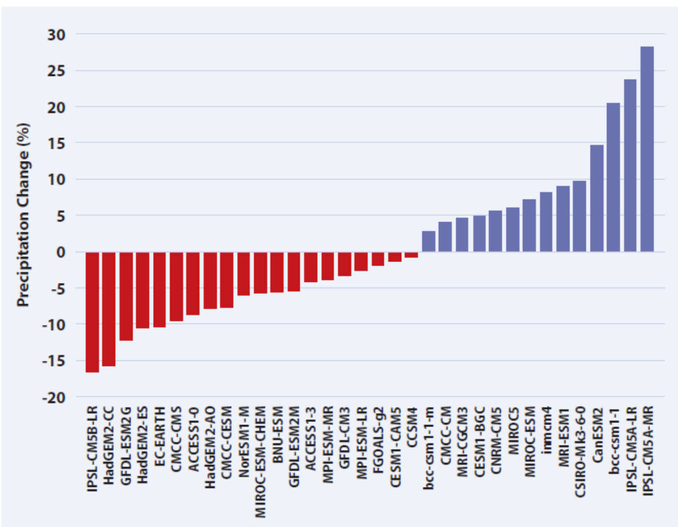


Source: Government of Malawi (2017a). Computed using data from the World Climate Research Program's (WCRP) Coupled Model Inter-comparison Project Phase 5 (CMIP5)

Note: In these projections for two different warming scenarios, exposure to heat extremes are represented as the increase in the frequency of historically unprecedented heat extremes (two standard deviations above the historical mean in the period 1986-2005) for the warmest three-month period of the year.

There is less agreement on changes in annual rainfall, with projections varying from increases of up to 400mm to modest decreases (Warnatzsch and Reay, 2019; Asfaw et al., 2014; Nicholson et al., 2014; Ziervogel et al., 2009; Jury and Mwafulirwa, 2002). Recent research analyzing 34 climate models found that 21 of them (62%) project wetter conditions, while 13 models (38%) project reductions in annual rainfall for the 2030s (FCFA, 2017). Looking further ahead, 20 models (58%) project drying by the 2070s. The models also project differing changes in annual mean rainfall, ranging from -8% drying to +20% wetting. Around half the models project modest rainfall changes of ±5% for the 2030s, compared with current figures. Projected rainfall changes for the 2070s are larger, ranging from a 17% decrease to a 27% increase, with only 12 models indicating changes of less than ±5% (see Figure 7.

Figure 7. Projected percent change in annual mean rainfall for all Malawi for the last decades of the 21st century



Source: FCFA (2017)

Note: Percent change in annual mean rainfall for all Malawi between the GCM simulated current period (1976-2005) and 2070-2099 for 34 GCMs. Red indicates a decrease in rainfall; blue indicates an increase in rainfall.

Developing future climate projections for Malawi is constrained because there are limited long-term weather data to draw upon. Downscaled climate models are key in determining long-term climate projections, but in Malawi's case less than half of the country's 761 rainfall stations have more than 10 years of information (Vincent et al., 2014). These data gaps make it difficult to determine longer-term temperature and rainfall trends accurately and present a huge challenge to building downscaled climate models.

Malawi's geographical position adds to the difficulty of arriving at confident projections of its future climate, especially for precipitation. The country is positioned between two opposing climatic-response regions (eastern equatorial and southern Africa). In addition, the El Niño-Southern Oscillation (ENSO) influences interannual rainfall variability by altering the Indian Ocean sea surface temperatures. Confidence in projected change to ENSO is low. According to the IPCC AR5 WG1 SPM, "Natural variations of the amplitude and spatial pattern of ENSO are large and thus confidence in any specific projected change in ENSO and related regional phenomena for the 21st century remains low." Malawi's weather patterns are also influenced by the movement of the Intertropical Convergence Zone (ITCZ)[1] which, like ENSO, does not follow a fixed pattern year on year (Zulu, 2017).

Malawi's short-, medium-, and long-range weather forecasts do not currently provide enough detail for farmers, government, or other stakeholders to plan confidently and effectively. The inadequate number of functioning weather stations, combined with a shortage of relevant expertise at district level, has meant that the reliability and level of detail of weather forecasts has often been weak. Additional long-standing challenges include the coarse geographical scale of forecasts: Specific, locally relevant forecasts are often unavailable. In addition, the timing of official clearances and release of forecasts frequently fails to align with the timing of important decisions, including those needed to guide seed purchases, planting dates, or harvest planning. Forecasts are mainly distributed through government channels as bulletins published in newspapers or distributed through district offices and radio broadcasts. Local languages are rarely used. A new policy enacted in 2019 (Government of Malawi, 2019b), and a major project mainly funded by the Green Climate Fund (GCF, 2017), seek to address these multiple weather forecasting challenges and make significant improvements to the accuracy, relevance, accessibility, and timeliness of weather forecasts.

Malawi's climate change policy framework

Malawi has a range of existing policies and institutional arrangements designed to respond, in whole or in part, to climate change risks. These policies take their lead from Malawi's constitution. Although it does not mention climate change specifically, the constitution highlights the state's central role in preventing the degradation of the environment and providing a healthy living and working environment for all citizens. It explicitly recognizes the state's imperative to protect the environment as a right for current and future generations. Malawi 2063 (NPC 2020) outlines the collective goals of the government to transform Malawi into a wealthy and self-reliant industrialized upper-middle-income country by the year 2063. These goals reinforce the vision of an "environmentally sustainable" nation (NEC 2020). Key government policies are the National Climate Change Management Policy (NCCMP), the National Climate Change Investment Plan (NCCIP), and the National Resilience Strategy (NRS). Others include a nationally determined contribution (NDC) plan to the United Nations, as part of the country's commitments made in the Paris Agreement.[2] In addition, a number of other policies that are not directly focused on climate change impacts have various levels of relevant climate

[1] The ITCZ is a zone of convergence of weather systems that roughly straddles the equator. It is a low-pressure belt, resulting in a band of heavy precipitation around the globe. The boundaries of the ITZC shift during the year as the sun moves north and south, relative to the equator.

[2] The Paris Agreement was adopted at the United Nations Climate Change Conference in Paris (COP21) in December 2015. It sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2°C.

change responses. The most important and relevant of these, along with explicit climate change policies, are listed in Box 1, below.

Box 1. Key policies and strategies relevant to government responses to climate change in Malawi

Updated Nationally Determined Contribution (2021)

- National Resilience Strategy (2018)
- Climate Smart Agriculture Framework (2018)
- Environment Management Act (2017)
- National Landscape Restoration Strategy (2017)
- National Climate Change Management Policy (2016)
- National Fisheries and Aquaculture Policy (2016)
- National Agriculture Policy (2016)
- National Irrigation Policy (2016)
- National Forestry Policy (2016)
- Malawi Growth and Development Strategy II and III (2011-2016, and 2017-2022)
- Intended Nationally Determined Contribution (2015)
- Nationally Appropriate Mitigation Actions (2015)
- National Disaster Risk Management Policy (2015)
- National Adaptation Programmes of Action (2006, revised in 2015)
- National Climate Change Investment Plan (2013)
- National Water Policy (2005)
- National Environmental Policy (2004)
- Decentralized Environmental Management Policy (1998)

Malawi is also a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. These international treaties and instruments oblige the country to put in place policies and legislation to address climate challenges. In 2021, Malawi submitted its updated NDC to the UNFCCC.

The Environmental Affairs Department (EAD), within the Ministry of Natural Resources, Energy and Mining, coordinates the implementation of the majority of climate change-related policies. However, other ministries and agencies often directly implement their own policies and programs concerned with managing and responding to climate risk.

Climate change is a key strategic priority of the Malawi Growth and Development Strategy (MGDS) III (2017-2022) (Government of Malawi, 2017b). The MGDS is the government's main guide to development planning, translating the overarching goals of Vision 2020 into a five-year strategy with guidelines for resource allocation. MGDS III explicitly recognizes that, if climate change is not addressed effectively, the country risks losing many of the development gains in multiple sectors since independence.

Table 1. MGDS III targeted outcomes, relevant to building climate change resilience

Key Area	Outcomes
Agriculture	☐ Increased land under irrigation ☐ Increased agricultural diversification ☐ Enhanced agricultural risk management
Climate change	☐ Improved weather and climate monitoring, prediction, and information and knowledge management systems ☐ Strengthened policy operating environment for climate change and meteorological services ☐ Enhanced community resilience to climate change impacts ☐ Enhanced climate change research and technology development
Water resources development, utilization, and management	☐ Increased access to water resources ☐ Enhanced integrated water resources management at all levels
Vulnerability and disaster management	☐ Developed and strengthened people-centered early warning system ☐ Improved preparedness for response to and recovery from disasters
Environmental sustainability	☐ Strengthened environmental management ☐ Enhanced environmental degradation preventive measures

Source: Based on MGDS III, Government of Malawi (2017b)

In 2014, Malawi began the process of developing a national adaptation plan (NAP). Developing the NAP is a continuous, iterative process that follows a country-driven timetable (Box 2). The focus of Malawi's NAP is improving community resilience to climate change through enhanced agricultural production, infrastructure development, and disaster risk management. It seeks to accomplish this by improving environmental management (especially of soil and land), and enhancing the sustainable utilization of natural resources (particularly forest, water, fisheries, and wildlife). Another priority is strengthening climate services and improving links between national hydro-meteorological services and various user communities. The aim is to integrate climate change adaptation into national, sectoral, and district development planning, and to provide climate change adaption advocacy and advice to policy makers. Although progress appears to be slow, this does not accurately represent the level of work that has been achieved. A key result of the NAP process to date is securing a USD $12.3 million grant from the Green Climate Fund for scaling up Malawi's climate services and early warning systems.

Box 2. What is a NAP?

All countries that are party to the UNFCCC are developing NAPs. NAPs have two main objectives. The first is to build adaptive capacity and resilience at country level and thereby reduce the vulnerability to climate change impacts. The second is to ensure that climate change is integrated into policies, programs, and other activities related to national development planning. NAPs are designed to address medium- and long-term adaptation needs. NAPs are not directly linked to any funding mechanism. Full details of the NAP process can be found at: https://unfccc.int/topics/adaptation-and-resilience/workstreams/national-adaptation-plans.

Policies in practice

In practice, the GoM faces many challenges with policy implementation. The following summary is primarily based the government's own internal assessment in a report entitled "Strategic Program for Climate Resilience" (2017a).

Despite the wide range of climate-sensitive policies, the GoM struggles to implement these effectively, with coordination across government agencies presenting a particular challenge. For example, while the EAD is nominally responsible for coordinating climate change actions and policy development, the Department of Disaster Management Affairs (DoDMA), the National Disaster Preparedness and Relief Committee (NDPRC), and the National Disaster Preparedness and Relief Fund all have responsibility for disaster risk management, which includes climate-related hazards. This makes it unclear where responsibility for climate variability ends and responsibility for climate change starts.

Multisectoral approaches are key to effectively adapting to climate change. However, similar to many countries, Malawi's ministries tend to work in sectoral silos. This weakens policy implementation as well as risking missing opportunities for cross-sectoral synergies. This is particularly so in ministries that have important roles in land and water management. The Ministry of Agriculture, Irrigation and Water Resources has a Department of Land Resources and Conservation that deals with land use planning and conservation for agricultural land. However, there is no formal working relationship with Ministry of Lands, Housing and Urban Development (UNDP-UNEP, 2018). In addition, some sectoral policies may create perverse incentives that run counter to wider resilience goals (Box 3).

Box 3. Do agricultural subsidies undermine climate resilience?

Current agricultural subsidies may work against efforts to build resilience into the selection of climate-resilient crops.

Most smallholder farmers cannot afford to invest in irrigation and, despite the potential benefits and resources spent on their promotion, there has been limited uptake and use of drought-tolerant crops. Husbandry approaches such as conservation agriculture have been limited (Whitfield et al., 2014; Mango et al., 2017).

Although there is evidence that subsidies for inorganic fertilizer have raised yields considerably (see, for example, Ricker Gilbert, 2011; Dorward and Chirwa, 2011; Denning et al., 2009; and Sanchez et al., 2009), other recent research suggests that the Farm Input Subsidy Programme (FISP) may not have been the success it was thought to be and that fertilizer subsidies may not provide a sustainable strategy for production gains in Malawi (Messina et al., 2017).

A concern for building climate resilience into agricultural practices is that these subsidies may also encourage over-reliance on crops and cultivars that are not flood- and drought-tolerant. This is certainly a concern for the major crop of maize – a crop vulnerable to higher temperatures, erratic rainfall, and drought – as the FISP subsidy has encouraged farmers to plant more land with maize. Conversely, the subsidy may have resulted in less area devoted to more drought-resistant crops such as sorghum, millet, and cassava, hence reducing farmers' resilience by increasing their vulnerability to bad weather conditions (Jayne at al., 2018). Although it should be noted that the more recent 2018/2019 FISP did include a subsidy for sorghum, it is still too early to ascertain whether this has resulted in a significant increase in the area under sorghum cultivation.

The FISP subsidy is expensive and consumes well over half of all public spending on agriculture, crowding out investments in irrigation and CSA that could boost climate resilience (World Bank, 2019).

There are limited skills and expertise to lead and implement adaptation and mitigation efforts. Within government, most sectors have to designate staff from other functions to address climate change issues. Many sectoral staff, at both policy and program level, lack the multiple skills and expertise the interdisciplinary nature of climate change requires. There is still a long way to go to build requisite skill sets for successful adaptation and embed this capacity in sectoral departments and ministries (Government of Malawi, 2017a). Nongovernmental organizations (NGOs), development partners, and the private sector can fill some of these gaps, but the impact is often geographically limited and sometimes restricted to specific subsectors.

Awareness of government initiatives focused on climate change adaptation, and tracking of their progress, is inadequate. A key example is Malawi's "National Climate-Smart Agriculture Framework," which was launched in early 2018 (MoAIWD, 2018). A subsequent analysis of CSA projects in Malawi discovered that many key stakeholders were not aware of this framework. In addition, although a number of CSA projects have been implemented, their progress is not being adequately tracked or reported (World Agroforestry Centre and Unique Forestry and Land Use, 2019). CSA will not evolve in a well-designed and practical manner in Malawi if there is no feedback from experiences from the field.

There is often a mismatch between policies addressing climate risk at the national level and sectoral priorities at the local level. At the local level, sectors and district councils are hardly aware of the content of climate change-related policy documents, despite being geographically close to where resilience should be built. District budgets are very small and fragmented across multiple small initiatives. This results in limited integration of climate change into local plans and budgets.

Multiple barriers constrain full participation by local communities and reduce their capacity to adapt to climate change. These include abject poverty, low levels of education, lack of skills, a dearth of appropriate technologies, environmental degradation, and water scarcity. Adaptation projects need to respond to the perceived and experienced needs and vulnerabilities of the local community.

Part 2. The Effects of Climate Change on the Agriculture Sector

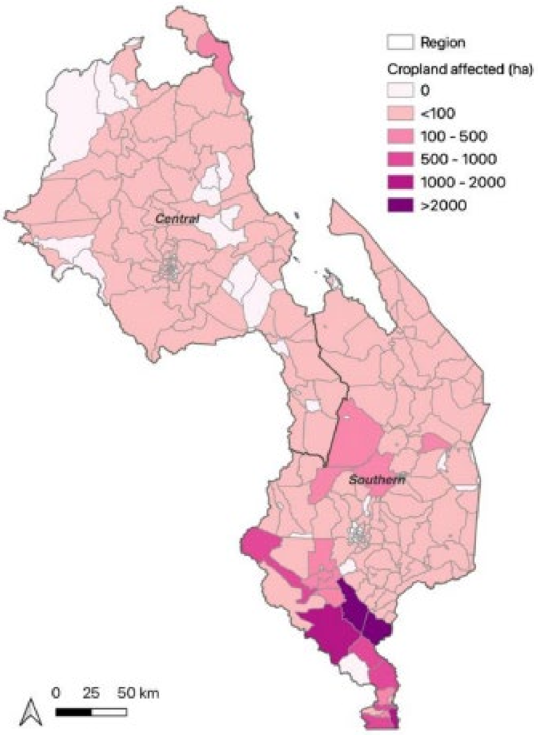
There are many areas of vulnerability in the agricultural sector that can be exacerbated or impacted by climate change. Although the most obvious is agricultural production, other vulnerable areas include access to water resources, gender, farmer perceptions and actions, and adoption and use of agricultural technologies.

Vulnerability of agricultural production

Malawi's strong dependence on rainfed cropping makes the agriculture sector particularly vulnerable to climate change. Rainfed agriculture, the mainstay of Malawi's agriculture-based economy, accounts for well over a quarter of GDP, brings in close to 80% of export earnings (a large proportion of which is tobacco), and employs some 85% of the country's workforce (FAO, 2020; World Bank, 2020). Rainfed maize is by far the predominant crop of smallholders and is the country's most important staple food. Currently, around 99% of national food production each year is grown during a single rainfed harvesting season. In recent years, this specific season has frequently been affected by delays in the onset of the rains, insufficient amounts of rainfall, and major droughts – all of which reduce maize yields, occasionally resulting in food security crises. Poor maize yields are exacerbated by weakened market functionalities, which distort operations and services that link producers and consumers. These weaknesses affect food access and lead to risks of food insecurity. Even if projected economic development significantly changes the economy over the next 30 years, agriculture is likely to remain an important pillar of the economy and society, particularly in terms of food security and employment in rural areas.

Agricultural production in Malawi is not resilient to the current and future impacts of climate change. As a result of the floods followed by extended drought in 2015-2016 and 2016-2017, agricultural production fell significantly. Production loss in maize alone left 6.5 million people requiring food assistance (World Bank, 2016). When Cyclone Idai hit Malawi in early 2019, impacting around 975,600 people, the resulting floods submerged and/or washed away mature crops, and affected both the demand for and the supply of casual labor. With around 3.3 million people already food insecure as a result of previous droughts and flood, the impacts of the cyclone were cumulative. An estimated 500,000 small farmers and micro-entrepreneurs lost part of their income (Government of Malawi, 2019a). More recently, in January 2022, Cyclone Ana hit Malawi, severely impacting the southern and central regions of the country. The resulting floodwater from the heavy rainfall impacted 222,302 people, and caused severe damage to cropland and livestock (FAO, 2022). It is estimated that the flooding damaged about 91,650 hectares of cropland (Figure 8). The effects of Cyclone Ana and the heavy rains Malawi experienced during the beginning of the year have diminished production prospects for the 2022 crop season and are expected to have a negative impact on the food security of local households (FAO, 2022).

Figure 8: Cropland affected by Cyclone Ana



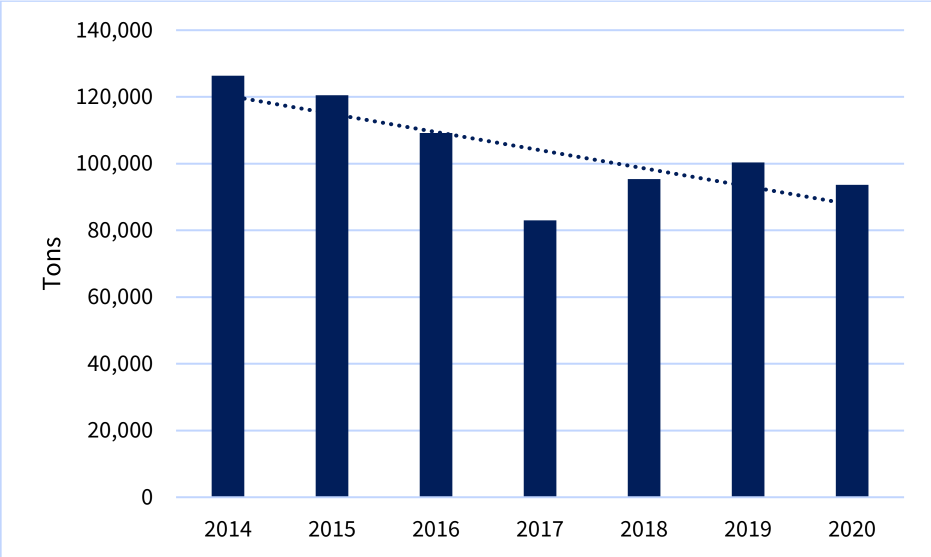
Source: Food and Agriculture Organization of the United Nations (2022)

These events illustrate the vulnerability of Malawi's food and livelihood systems to climate change risks. Although the 2015-16 drought was linked to a severe event triggered by El Niño, which regularly triggers drought conditions across southern Africa, there is growing evidence that climate change will generate increasingly severe El Niño events (see, for example, Wang et al., 2019).

In addition, the amount area under cultivation for major food crops does not reflect their climate resilience. Following this prolonged period of drought, several farmers significantly reduced or abandoned investments in cash crops such as tobacco. In 2017, the area devoted to tobacco production was 40% lower than average due to the lack of resources needed to invest in production (FEWS NET, 2017a). This resulted in a significant reduction of 24% in tobacco production during the 2017 harvest season (Figure 9) (FAOSTAT, 2020).

Additionally, around 60% of total cropped land is devoted to maize, a crop highly sensitive to rainfall. In contrast, in the recent past only about 3% of cropped land has been planted to sorghum, although it is better suited to low rainfall conditions (Government of Malawi, nd.).

Figure 9. Tobacco production (tons)



Source: Food and Agriculture Organization of the United Nations (2020)

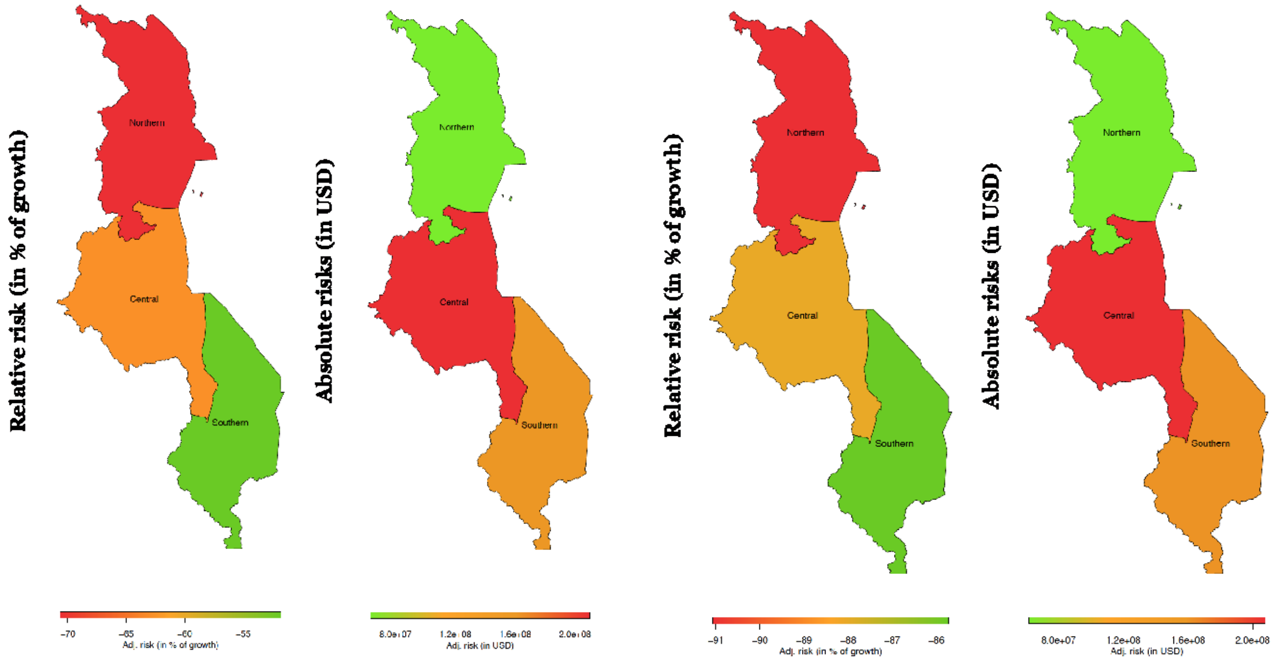
Climate change will affect Malawi's regions differently. In both high and low warming scenarios, the northern region is projected to be most affected by all three primary climate stressors – extreme heat, droughts, and floods. These events will have adverse effects on standards of living and poverty reduction efforts. They may even lead to an increase in migration out of the region, although overall impacts on the national economy may be relatively lower due to the north's lower population and economic output.

The greatest absolute losses of agricultural output caused by climate change are likely to be in the central region because of its higher share of total production (currently almost 50% of the value of the country's agricultural production). Similar to the northern region, a large proportion of the central region's population are dependent on agriculture for their livelihoods and are therefore at greater risk from any increase in heatwaves, dry spells, and irregular water flows caused by changing rainfall patterns in the river basins.

Although the southern region is slightly more diversified and urbanized, close to 60% of its population rely on agriculture as their primary source of income. Projections indicate that extreme rainfall events, resulting in increased flooding, are the primary risk to agricultural output.

Tobacco activity is primarily concentrated in the northern and central regions of Malawi (Fraym, 2019). In these regions, about one million people live in households engaged in tobacco farming, many of them under contract (Fraym, 2019). Following a period of drought, in 2017, households in the central region experienced a 15-25% reduction in labor demand due to reduction in tobacco production, which offers the bulk of labor in this region (FEWS NET, 2017b). However, not all changes to agricultural production are necessarily negative. For example, a crop modeling projection suggests that 57% of maize farmers in the Mzimba district will register production gains over the period 2040-2070 (Gama et al., 2014).

Figure 10. Economic risk in the 2040-2049 period in the agriculture sector



Low Warming (IPCC RCP 2.5) *High Warming (IPCC RCP 8.5)*

Source: Government of Malawi (2017)

Vulnerability of water resources

Agriculture is highly water-dependent and will be adversely impacted by projected rises in temperature and rainfall variability. Rising temperatures will accelerate evapotranspiration and decrease soil moisture availability. This will have a significant impact on smallholder farmers who mainly practice rainfed agriculture. For instance, although tobacco is generally considered a drought-tolerant crop, farmers rely on adequate soil moisture to produce it. During periods of rainfall deficit, irrigation is typically used to supplement water needs (University of Georgia, 2022). Conversely, during periods of heavy rain, excess water may cause plant wilting, "wet feet," or "drowning" and may ultimately kill the plant (FAO, 2022b). The observed variability of rainfall in Malawi will likely drive a change in farming practices among smallholder farmers.

Climate change is likely to amplify pressure on water resources and the degradation of Malawi's rivers, watersheds, and wetlands. In the past, Malawi opened up large irrigation systems and a significant hydropower industry, but there was little focus on water allocation or pollution. Although it has abundant water resources, Malawi has only around 925m^3 of available freshwater per capita and is categorized as a water-scarce country.[3] Water consumption in the country has significantly increased in both rural and urban areas. The agricultural sector remains the highest water consumer in Malawi, accounting for over 81% of the country's total withdrawals, followed by the municipal water supply (15%) and industry (about 5%) (Kumwenda et al., 2015). The majority of rural dwellers source their domestic water from groundwater (NEPAD, 2013). These stressed water resources are further challenged by a combination of high population growth, changes in climate and weather patterns, and increased sedimentation in rivers, lakes, and reservoirs caused by catchment degradation. Any additional demand for water to manage heat stresses due to climate change will place additional pressure on water resources, with the potential to trigger conflicts over allocation of water among agricultural, industrial, and domestic users.

[3] UNEP defines water scarcity as water availability less then 1000m^3 per capita.

Factors driving the degradation of Malawi's catchments, watersheds, and wetlands include: [4]

i. Human population pressure on water resources and wetlands;
ii. Agricultural expansion and intensification;
iii. Unplanned settlements and cultivation by the urban and rural poor;
iv. Limited information about water resource and wetland management, combined with a lack of funding and limited institutional and technical capacities;
v. Deforestation through uncontrolled burning and agricultural expansion; and
vi. The lack of clarity on water resource allocations, rights, and responsibilities (World Bank, 2019).

Without effective management, these drivers are likely to exacerbate the impacts of climate change. Supporting good water and land husbandry practices is an important aspect of building community resilience.

Gender and other social vulnerabilities exacerbated by climate change

Agricultural investments and interventions geared to building climate resilience need to be gender-sensitive and to take into account the different ways in which men and women can respond to opportunities. In practice, this means that agricultural investments explicitly recognize structural barriers to women's empowerment, economic development, and societal resilience and ensure their design includes mechanisms that support removing these barriers. This should ensure that practical support for capacity development, along with targeted activities and services, are available for women.

Malawi's constitution guarantees equal rights for men and women, but in practice women are still marginalized in many spheres of life (UNDP, 2019a). Women have limited rights to own land and are frequently not allowed to retain land following a divorce or when the husband dies, unless they have legal documents proving joint ownership or a financial contribution to the acquisition and upkeep of the land. In rural areas, most women do not have these documents, although the increase in literacy levels means that many women are now able to claim land ownership, especially in cases of death of the husband. Women are often effective head of households because men may migrate to towns and, in this situation, they make key land management decisions.

In Malawi, women represent the largest proportion of poor people most vulnerable to the impact of climate change. Female participation in the agriculture labor force is currently 76.5%, compared to 67.4% for men (World Bank, 2020). This shows that women are key to ensuring Malawi's agriculture adapts effectively to climate change challenges. Women often face economic and social barriers due to discriminatory customary and statutory laws, inequitable social norms, and because they are responsible for a disproportionate proportion of domestic work. Women are the mainstay of subsistence farming and responsible for the bulk of cultivation operations, such as sowing and weeding, as well as collecting firewood and fetching water. Yet they have limited access to extension services and credit facilities. They are more likely than men to suffer from the impacts of climate change as they face different vulnerabilities due to legal and social discrimination and also have fewer opportunities and less resources to draw on to adapt to climate change challenges.

Women are disproportionately vulnerable to climate-induced shocks at the household level. Reliance on natural resources for income, subsistence, and many household requirements can lead women to respond to climate-related shocks by using damaging coping strategies, such as reducing their own food intake when crop yields fall or food prices rise (Campos and Garner, 2014). In the face of extreme weather events such as droughts or heat waves, the competition for resources can lead to losing access to land, water, and crops. Sometimes these losses are accompanied by further disturbances, such as fragmenting social cohesion, disrupted livelihood systems, and suddenly reduced employment opportunities, further amplifying gender inequality. In extreme cases, climate change can trigger migration because households' existing livelihood

[4] These drivers have their roots in a complex interplay of historical, political, and social factors, which are beyond the scope of this paper to explore.

strategies are no longer viable. Malawi's high fertility rate (4.055 births per woman in 2020, based on World Bank, 2020) hinders women's capacity to adapt to climate change simply because having multiple children increases the time required for their care, with the added effect of reducing women's opportunities for shifting livelihood strategies or participating in paid employment.

Women smallholders often lack access to labor-saving technologies and even basic farm tools, leaving them unable to adopt farming practices that could build their resilience to climate change. Their low level of agricultural and labor productivity traps them into a level of poverty from which they struggle to escape (this is, of course, also true for other poorer farm households, whether female- or male-headed). These households are simply coping with, rather than adapting to, changes in weather patterns, and it remains unclear whether they will be able to build sufficient resources to remain in farming or they will be forced to leave agriculture altogether (Una et al., 2016). Pre-existing cultural factors, such as a woman's frequent inability to access and control resources, participate in decision-making, or access new markets, may undermine the intended advantages for women of labor-saving technologies (Huyer and Partey, 2019). For women smallholder farmers to become more resilient to climate change, focused gender analysis is required in order to effectively support their access to basic agricultural technologies and adapt climate resilient agriculture technologies to their needs.

Women also play an active role as agents of change and have the knowledge and capacity to respond to climate impacts. Although much gender analysis of climate change focuses on women's vulnerabilities due to their different roles in agriculture and the household, they can also be beneficiaries of initiatives that build climate resilience into farming systems. However, this needs to be explicitly recognized in the design of any new program. For example, because of the gender division of labor in agriculture, men are likely to prefer crops with high market value and demand, while women may prefer varieties that are more nutritious, better tasting, and easier to cook (World Bank, FAO and IFAD, 2015). Similarly, certain technologies, such as zero and low tillage, green manuring, and laser land levelling can be beneficial for climate adaptation and also dramatically reduce women's labor contribution.

Other segments of society in Malawi are also marginalized and at high risk from climate change. Targeted interventions are needed to aid other vulnerable groups among the extreme poor. All vulnerable communities have an important role in developing effective and efficient medium- and long-term adaptation plans because they have direct experience of the negative effects of climate change and so are well equipped to articulate real adaptation needs (UNDP, 2016).

The tobacco sector and climate change

In 2019, tobacco exports accounted for 55.6% of total merchandise exports in Malawi (USD $584 million) rendering it one of the most – if not the most – economically tobacco-dependent country in the world (FSFW 2022). The current pattern of tobacco production does not appear sustainable. The very act of growing tobacco leaf requires extensive use of agrochemicals in the form of growth regulators, fertilizers, and pesticides. The improper handling of these materials, and their runoff into local water supplies, are detrimental to human health and the environment. Moreover, the land clearing and cash crop farming practices deployed on many tobacco farms steadily depletes the soil of nutrients to sustain future growth and degrades and depletes the water supply. Between 1990 and 2007, for instance, Malawi lost 13,400 hectares of land to tobacco farming (Zafeiridou, 2018). Deforestation is estimated to be responsible for 33,0000 hectares of land lost per year, and is mainly attributed to agriculture, tobacco growing, and excessive use of biomass (Ngwira, 2019). In addition to soil degradation and pollution, such deforestation is associated with an abrupt loss of habitat that accelerates the loss of biodiversity in the affected area.

Farmers' perceptions and actions

Many farmers are already innovating in response to changes in weather patterns and associated yield reductions. Farmers are innovating by changing planting timings, increasing their use of drought-resistant varieties, and purposefully selecting varieties with shorter growing periods. An increasing number of farmers are adopting soil and water conservation methods such as ridging, mulching, zero-tillage, and increasing the use of manure and composts. They also frequently adopt risk-spreading strategies such as intercropping and crop diversification. In some places, farmers actively protect and regenerate tree cover in fields. These practices help improve the soil's nutrient and organic matter status by reducing rainfall runoff, increasing infiltration, and helping recharge groundwater. These practices provide positive improvements to land husbandry with or without climate change and, for many years, have been promoted as good practice for smallholder famers. There is evidence that, over the past few years, farmers are increasingly adopting these sorts of measures in response to their perceptions of shifts in climate and weather patterns because they provide practical and effective ways to manage climate risk (see Vincent et al., 2011 for examples).

Not all shifts in cultivation practices are necessarily beneficial beyond the short-term. For instance, cultivating closer to small water bodies (*dambos*), streams, and rivers is a simple way to provide supplementary irrigation. However, this practice can increase vulnerability to flooding and may increase land and water degradation through pollution and sedimentation – an example of maladaptation (see Box 4 below).[5]

Box 4. What is maladaptation?

Maladaptation is a term used to describe practices that help adaptation in the short term, but insidiously may increase a system's longer-term vulnerability and adversely affect its capacity to adapt to climate change. The Intergovernmental Panel on Climate Change (IPCC) notes that maladaptation is increasingly concerning to adaptation planners, where (often unintentionally) intervention in one location or sector increases the vulnerability of another location or sector or increases the vulnerability of the target group to future climate change (IPCC, 2014).

A range of climate-resilient agricultural approaches may be suitable for Malawi. Several assessments of climate-smart agricultural investments, using crop modeling tools[6] to understand the likely climate change impacts on different cropping scenarios, find that benefits of adoption far outweigh costs. This is particularly true where interventions have been carefully designed to suit specific local environments. (See, for example, Branca et al., 2012; Pauw et al., 2011; LTS, 2014.)

Box 5. Climate-smart agricultural practices can increase yields

In dry, degraded catchments of Kapichira in southern Malawi, farmers who stopped burning crop residues (a deep-seated traditional practice) and introduced mulching, zero tillage, and composting, saw a three-fold increase in yields after just two years.

In Lilongwe District, those farmers who left stover (leaves and stalk residues) on the soil surface were able to maintain maize yields even in the 2017 drought. Their neighbors, who did not follow this practice, lost most of their crops.

In Mazimba District, farmers using conservation agriculture techniques (such as minimum tillage and leaving crop residues in the field) as well as diversifying their crops and planting drought-tolerant varieties, reported that their maize yields more than doubled and household incomes increased.

[5] In Malawi, it is illegal to cultivate *dambos* and riverbanks.

[6] Crop models are common in agriculture research. They use mathematical simulations of key factors such as weather, soil conditions, and crop management to examine different cultivation options.

Source: CTA (2017) and CTA (2019) plus author's own field observations

Box 6. Conservation agriculture

Conservation agriculture (CA) promotes:

1. Minimum soil disturbance (e.g., avoiding tillage as much as possible);
2. Maintaining permanent soil cover (e.g., leaving crop residues in the field after harvest); and
3. Diversifying plant species (e.g., crop rotation and intercropping).

CA can improve crop yields by enhancing natural biological processes. Globally, there are many examples of successes on large-scale commercial farms, when a comprehensive package of CA practices, covering all three aspects above, are adopted.

Widespread adoption by smallholders has not taken off in the way some proponents of CA envisaged. There are successes at the community level, and in a number of districts individual farmers can be found who are innovating and using CA practices on their land. Nevertheless, widespread adoption rates remain low for a number of technical, economic, and sociocultural reasons. Many small farmers find the costs outweigh the perceived benefits (see also Box 7, below).

Although some farmers recognize that the climate is changing and are responding by adopting new farming practices, adoption remains low. Table 2 provides an overview of some of the adaptation strategies that have been adopted, but with limited diffusion. There are other climate-smart options that have also yet to be adopted despite their considerable potential. A negative effect of low adoption when promoting changes to husbandry practices among farmers is the inevitable shift to unsustainable responses (maladaptation) such as clearing forests or cultivating *dambos* to compensate for falling yields.

Table 2. Examples of farmers' responses to changes in climate in Malawi

Climate Driver	**Impacts / Risks**	**Type of Response**	**Response Measures**
Extreme weather events (e.g., droughts, floods)	• Crop failure • Negative impacts on infrastructure • Pest and disease outbreaks	Crisis response	• Income diversification • Social support networks • Food rationing • Temporary migration • Liquidation of assets • Infrastructural interventions
Rising temperatures and changing weather and rainfall pattern	• Crop destruction • Lower yields • Water stress • Heat stress • Reduced crop productivity • Heavy rains at end of season damage crops or trigger pests • Wind and flooding damage to crops	Modify farming practices	• Changing plowing and planting dates • Replanting • Cultivation of new and/ or marginal land • Intercropping • Addition of winter cropping and dry season vegetable gardens • Increased demand for irrigation • Increased use of small-scale irrigation (e.g., watering cans); stream diversion • Livestock movement • Livestock feed supplementation • Pest and disease control

			• Increased planting of sugar cane and bananas at field edges (to prevent wash away by rains) • Premature harvesting
	• Changes in production patterns (e.g., growing seasons) • Deteriorated rangeland quality	Modify crop and livestock varieties/breeds	• Crop type diversification • Planting different crop varieties (e.g., drought resistant) • Livestock type diversification • Rearing different livestock breeds • Increased planting of sugar cane and bananas at field edges (to prevent wash away by rains) • Premature harvesting
	• Shifting habitat ranges • Land degradation • Reduced soil fertility (leading to lower yields)	Natural resources management	• Soil conservation • Water conservation • Expansion of cropping to *dambos* and riverbanks • 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
	• Rising temperatures stimulate pests and disease (e.g., locusts and termites) • Heavy rains and flooding make roads to/from markets impassable	Storage and transport	• Shorter storage periods • Selling earlier (with lower profits) • Not selling (loss)
	• Spread in prevalence of human diseases affecting agricultural labor supply • Increased fire risk	Livelihood diversification	• Off -farm / nonfarm work • Migration
		Knowledge management	• Indigenous early warning systems

Source: Adapted from Kuivanen (2015) and USAID (2013), plus author's own field observations

Adoption of climate-resilient agricultural practices

The majority of smallholder farmers have very limited opportunities to build resilience into their farming systems. Most smallholder farmers cannot afford irrigation technologies, and the adoption rate of climate-resilient practices and the use of drought-tolerant crops has been disappointing (see, for example, Amadu et al., 2020; Hermans et al., 2020; and Kaczan et al., 2013., who all explore why farmers in Malawi adopt some CSA practices and not others). Adoption rates of potentially resilience-boosting techniques are low for a number of technical, economic, and sociocultural reasons, despite the potential benefits and the resources spent on promotion (Whitfield et al., 2014; Mambo et al., 2017).

Although there is limited evidence of the widespread adoption of climate-resilient agricultural practices among smallholder farmers in Malawi, there are some successes evident in certain districts at the project level. Where there are concerted efforts to promote climate-resilient technologies among individual projects, there is evidence of higher levels of adoption (Amadu et al., 2020). But this is not the pattern across the country and points to several impediments preventing adoption (Box 7).

Box 7. Understanding why farmers do not always adopt climate-resilient practices

To understand adoption rates of climate-resilient agricultural practices, it is necessary to recognize that:

- Smallholder farmers do not simply maximize profits: They frequently prioritize their family's food security needs rather than cash incomes.
- Different groups of farmers benefit differently: Some increase yields and incomes and others incur greater capital and/or labor costs without gains in yields or income.
- Farmers will not evaluate benefits simply in terms of input costs and revenues. To understand their decisions, we also need to understand the whole-farm management context, including:
  - Interactions between enterprises (e.g., using crop residues for mulch reduces what is available to feed livestock)
  - Constraints on resources (e.g., farmers may not have the necessary labor and capital)
  - Risk and uncertainty (e.g., small farmers' livelihoods are often fragile and highly vulnerable, so they are not keen to take risks)
  - Dynamic effects (e.g., the impacts of different farming practices change from year to year, as well as over longer periods)
  - How long benefits take to become apparent (e.g., how this time lag effects the interest payments on loans; the urgency of feeding the farm family)

Source: Adapted from Pannell et al. (2014)

Smallholder farmers may perceive the costs of adopting new farming practices as outweighing the benefits. Farmers frequently state that new techniques are not suitable for their fields because they require inputs they cannot obtain or afford and/or they are too labor intensive. In addition, smallholder farmers are risk averse and are not willing to make shifts in their farming practices unless they are convinced that the benefits will outweigh the costs. It is not uncommon for farmers to first want to see that some of their neighbors have positive experiences with a new cultivation practice before adopting it themselves.

Farmers are most likely to adopt new practices that address priority issues. If new techniques are suggested that do not address farmers' priorities, it is unlikely that they will see a need to adopt them (Makate et al., 2019; Kaczan et al., 2013).

CSA as the key response to climate change

Agricultural systems must adapt to evolving climate conditions. Any specific response to address agricultural vulnerability related to climate change must address at least one of three key factors: exposure, sensitivity, and adaptive capacity.

This can be done in a number of ways: by altering exposure (for example, by changing cropping patterns or protecting watersheds); by reducing sensitivity (for example, by adopting suitable crop or animal varieties, or enhancing soil nutrition and water management); and by increasing adaptive capacity (for example, by improving water and other infrastructure systems, diversifying income sources, and establishing crop and weather insurance schemes).

CSA provides a framework to identify and support approaches and practices that can transform agriculture to suit the new realities of a rapidly changing climate. CSA aims to build the resilience of farming systems and farming communities by adapting farm systems as the climate changes, reducing agriculture's significant emissions, and ensuring food production keeps pace with a growing global population while boosting profitability. It is an approach, rather than a specific set of technology practices, that seeks to obtain a sensible and practical balance of three key objectives (see Box 8). As an overarching approach, it is now promoted by the Food and Agricultural Organization (FAO) and the Collaborative Group of International Agricultural Research (CGIAR)'s Climate Change, Agriculture and Food Security Program (CCFAS), as well as multilateral development banks, bilateral donors, and many NGOs.

Box 8. Key objectives of CSA

CSA integrates the three dimensions of economic, social, and environmental development by jointly addressing food security and climate challenges. It has three key objectives:

1. Sustainably increasing agricultural productivity to support equitable increases in farm incomes, food security, and development;
2. Adapting and building resilience of agricultural and food security systems to climate change at multiple levels; and
3. Reducing GHG emissions from agriculture and increasing carbon sequestration.

Source: FAO (2017)

CSA provides a useful framework to identify and design climate-sensitive investments because it highlights both climate risk and associated responses. This approach has evolved from previous approaches to agricultural development, adding a specific focus on investments that can manage and respond to climate change. It builds on the concepts of sustainable agriculture, sustainable intensification, and sustainable livelihoods, seeking to ensure that farming is based on ecological principles, conservation, and efficient use of natural resources. It also seeks to protect the livelihoods of farm households and communities by linking resilience-building actions to existing livelihood strategies (Table 3).

Table 3. Comparison of approaches to agricultural development

	CSA	Sustainable Agriculture	Sustainable Livelihoods	Sustainable Intensification
Objectives	Food security, increased resilience, and mitigation of GHG emissions	Maintain natural resources for future generations	Holistic understanding of household strategies	Increased efficiency of resource use for improved production
Focus	Climate change	Environment	Social well-being	Productivity
Scale	Global/regional to local	Global to local	Household / community	Landscape to local
Incremental or transformative	Both	Tend to be incremental	Both	Tend to be incremental
Main response	Adaptation, mitigation, and resilience	Resilience	Vulnerability	Adaptation
When in vogue	2000-present	1970s-1990s, but still relevant	1990-2000, but still relevant	2010-present

Source: Based on Pound et al. (2018)

While CSA aspires to a triple-win of increasing production, adapting to climate change impacts, and mitigating the agriculture sector's GHG emissions, it is not always possible to design actions that simultaneously achieve all three. For example, practical and sustainable adaptation responses, such as widespread soil and water conservation practices or the introduction of drought- or flood-tolerant varieties, may not necessarily have mitigation benefits. However, some land husbandry activities can achieve the triple win. For example, increasing soil organic matter content will increase productivity and increase the soil's resilience to climate impacts, while also helping sequester carbon. Well-planned investments can usually meet at least two of these three objectives.

Agricultural investments can support incremental changes to farm systems as well as more dramatic transformational changes. Incremental changes may be the easiest to manage, as they do not require major social, technical, and institutional shifts. Relatively small and/or simple changes to existing practices and cropping patterns are often sufficient to successfully adapt to the shift in weather patterns and climate. However, in some instances, especially where existing farming systems are already precarious and productivity low, climate-induced changes to ecosystems will be so rapid and disruptive that transformational approaches will be required to shift to new farming systems (see, for example, Carter et al., 2018). Transformational changes involve major shifts to existing farming systems – perhaps moving into a completely new set of enterprises. Changes of this nature need considerable support, as they require changes in agricultural markets and support infrastructure, and farmers must acquire and develop a new range of skills.

CSA has been promoted in Malawi by both government and NGOs. Although adoption rates are still low, there has been considerable analysis of the impacts of climate change on Malawi's major crops. This analysis has indicated potential benefits in adopting a climate-smart approach in every case. For example, Amadu et al. (2020) provide some useful insights on farmers' adoption of CSA practices in Malawi, by balancing consumption and income needs in the context of multiple market imperfections. Much of the research has focused mainly on crop responses to changes in on-farm technologies (CIAT and World Bank, 2018). Interestingly, this research also suggests that the impact of climate change on the livestock sector will be minimal, although this is an area that requires further research.

The best options for building resilience are determined by local conditions. There is no universal set of practices that will suit all farmers. The most suitable options will depend on the specific local context and are influenced by factors such as rainfall, agro-ecological zones, access to markets, and the financial, land, and labor resources of the farm household. It is important that practices suited to specific farming systems are supported. This means that extension messages must be set within a local context. Any approach to supporting CSA must be flexible, so that local-level advice to farmers is both practical and effective in building resilience (Amadu et al., 2020).

Part 3: Implications for ATI

A major challenge for ATI, or any development program that seeks to make changes that benefit resource-poor producers, is to move from problem analysis towards effective action. The complexity of addressing climate risks in the context of farming systems that are already fragile as a result of multiple economic and environmental factors is especially challenging in the Malawian context. There are practical approaches, based on successful experiences elsewhere, that can help link the analysis of climate risk and vulnerability with appropriate actions to reduce these risks for farmers transitioning away from tobacco.

In agriculture, climate risks are business risks. Any initiative or investment aiming to boost the productivity and profitability of smallholder farming in Malawi must incorporate adequate responses to climate risk. Smallholder farmers' decisions are not driven solely by financial profit. However, profit remains a key component: Farmers want to know that the proposed changes to their farm system will improve their economic stability. They will adopt changes to their current practices only if they perceive these as likely to improve profitability or remove considerable drudgery while maintaining current income/subsistence levels.

Identifying specific suitable alternative crops to tobacco is beyond the scope of this paper, but this section does provide a methodology that builds on an understanding of local climate vulnerabilities and incorporates climate-sensitive actions along with various other factors. The approach presented here leverages four simple decision-support tools that, used in sequence, provide the basis for identifying crops, and subsequently identifying and prioritizing opportunities to support proposed shifts in cropping patterns. This methodology has been used successfully in South Asia (in India, Bangladesh, and Pakistan) and is described in Croxton et al. (2019).

The decision-support tools described below will work best when the unit of analysis is at district level and below. This is to ensure that local environmental conditions, climate risks, social structures, market opportunities, and farming systems can be adequately reflected in ATI's investments and interventions. In practice, neighboring districts may share very similar conditions.

If the level of analysis is too general, it is unlikely that useful, locally relevant recommendations will emerge. However, a district-level assessment need not be a very time-consuming task. Some level of assessment already exists (for example, those carried out by academics or NGOs).

A multicriteria approach to selecting agricultural products

Multicriteria analysis tools can be usefully applied to help with selecting key agricultural products that are both profitable and climate resilient. The illustration below looks at crops, although the methodology can also be applied to other agricultural products, such as livestock or timber. Applying the example to crops is particularly useful, given ATIs' aim to promote diversification away from tobacco cultivation. Smallholder farmers' accumulated resources and experience with tobacco production means that other field crops are likely the most viable alternatives to tobacco.

Any crop, mixture of crops, or other agricultural products intended to support a shift in smallholder cropping patterns, either away from tobacco or to contribute to higher agricultural productivity, needs to have the following characteristics:

a. Production requirements suited to the skills and assets of smallholder farmers;
b. Capable of providing a positive economic return; and
c. Suited to local environmental conditions, including resilience to climate change impacts.

These three major characteristics can be broken down further to develop a set of criteria that can be ranked using a simple multicriteria approach:

a. Production
- Input use efficiency (water requirements, nutrient requirements)
- Management practices (tillage requirements, crop duration, crop care, and labor requirements)

b. Economic return
- Crop profitability
- Crop subsistence value (if not marketed)
- Crop marketability and credit facility, contract farming
- National considerations (food security, export potential/import substitution, self- sufficiency)[7]

c. Crop resilience and environmental impact
- Crop resilience (temperature tolerance, salinity tolerance, tolerance to waterlogging and water ponding)
- Environmental impacts (energy footprints, nitrogen requirements, pesticide use)

In practice, the selection of criteria should be determined through a process of stakeholder consultation combined with expert knowledge. These will need to be locally determined but must include farmers, buyers and traders, and government agricultural department staff. The advantage of this approach is that existing data (for example, on water or fertilizer requirements, profitability, labor requirements, and so on) can be used to evaluate each factor. A simple scoring system can then be used for each criterion. For example, scoring using an ordinal five-point scale might be: 5 = excellent; 4 = good; 3 = satisfactory; 2 = below average; 1 = poor.

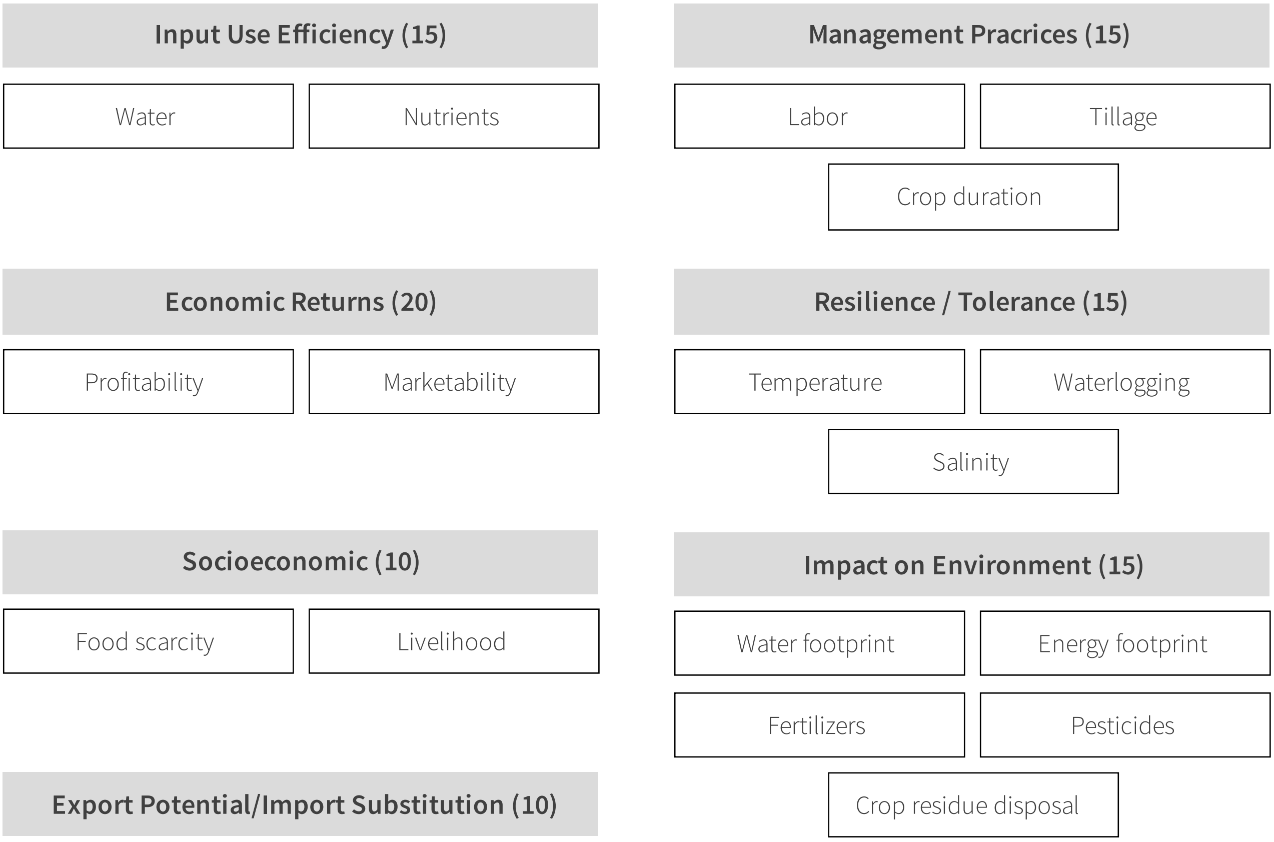
Criteria scores can then be weighted to recognize the relative importance of the various factors. This approach provides a simple means of identifying potential alternative crops for further investigation, while ensuring individual crops' responses to climate change are factored into the selection process. Farmers should be part of this weighting exercise. An example is shown in Figure 11. Each potential crop identified in this way can then be explored in more detail to determine the best options and to identify interventions where investment aimed at supporting shifts in cropping patterns will have the most impact.

The criteria shown in Figure 11 are not exhaustive. For example, they could be expanded to add locally important criteria, such as the desirability of certain crops for consumption or other cultural preferences, and how well cultivation requirements fit with existing local practices.[8]

[7] Export potential is clearly an important factor when looking at alternatives to tobacco in Malawi because tobacco is such an important foreign exchange earner, providing a valuable revenue stream to government.

[8] *For example, Adaptation Fund (2019) includes these factors in a set of criteria used to select climate-resilient crops to promote in Malawi.*

Figure 11. An example of using multiple, weighted criteria to identify suitable crops



Source: Croxton et al. (2019)

Note: The weightings shown here (in parentheses) are only examples. In practice, the final set of criteria and their weightings are determined through a combination of consultation with key stakeholders and use of expert knowledge.

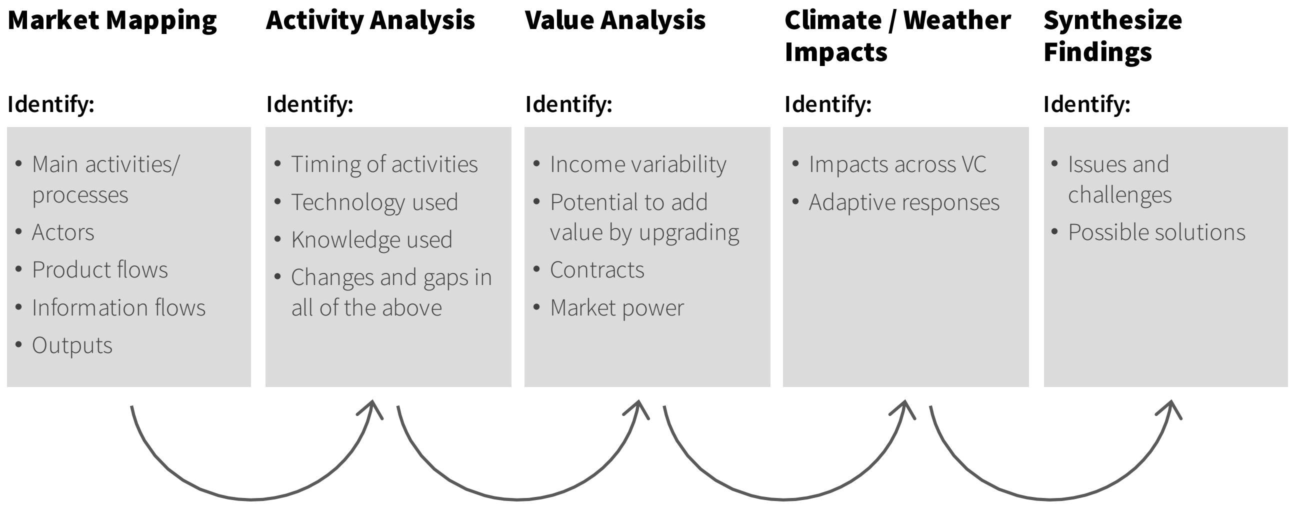
Mapping alternative VCs of selected climate-resilient agricultural products

Supporting climate-resilient agriculture requires more than simply identifying suitable crops or varieties. It also requires practical and targeted support to ensure these crops are cultivated and harvested and can reach respective markets successfully. Opportunities and constraints (including climate risks) are experienced all along any agricultural product's VC. So, for any individual agricultural product, mapping its VC – which involves identifying its different stages, the actors involved, and linkages between them – provides a way to identify both opportunities and constraints. This understanding then provides a mechanism to identify interventions and investment opportunities that are most likely to realize adequate value for the product at hand.

There are five steps involved in mapping a VC (see Figure 12). These are not necessarily discrete steps that require specific sequencing. In practice they frequently overlap. The five steps are:

1. Market mapping;
2. Activity analysis;
3. Value analysis;
4. Assessing climate and weather impacts along the VC; and
5. Synthesizing findings to identify the key bottlenecks and opportunities for intervention.

Figure 12. Mapping an agricultural VC: Key information used in each of the five main steps



Source: Croxton et al. (2019)

Mapping VCs supports analysis and decision-making. It encourages analysis of all stages of an agricultural VC, clarifying the linkages between the stages, and ensuring that all key actors are identified and their roles and power relations explicitly recognized. Table 4 summarizes the key elements that VC mapping provides to analysis and also indicates areas that may require further study as part of the analysis.

Table 4. VC mapping strengths and lacks

VC mapping strengths:	VC mapping lacks:
• Provides good understanding of opportunities and constraints/strengths/weaknesses along the VC	• Not an end in itself; only provides evidence to support decision-making
• Mitigates against focus on just one component of the VC	• Focusing on what happens in individual stages along the VC risks losing sight of the bigger picture, in which linkages between the different stages are important factors
• Highlights linkages between the different stages of the VC	
• Often identifies gaps that need further analysis to understand what is required to address the identified problem	• Does not necessarily indicate which constraint to attend to first; further analysis/discussion may be necessary

Source: Croxton et al. (2019)

Findings from a VC exercise must be shared and discussed with stakeholders. Without this final stage, the analysis risks becoming nothing more than a report gathering dust. Multicriteria analysis and VC mapping are simply tools that can be used to inform decision-making on implementation and policy reform. Presenting results from a VC analysis must include discussion of the findings and their implications with key stakeholders. It should include agreeing on next steps while starting the process of planning and implementing actions to open up the VC(s) under study.

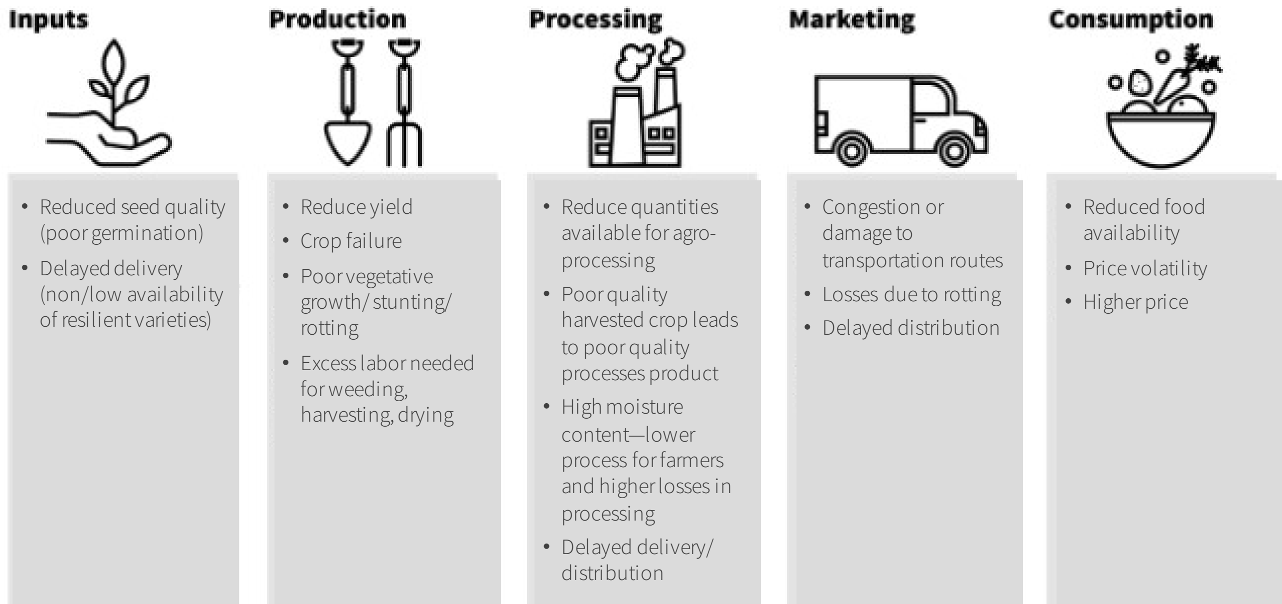
Once a key commodity or VC is identified, a next step is to identify key entry points along the VC for climate-smart agricultural interventions. As in the crop identification exercise, simple decision-support tools can also be applied to identify national and local-level entry points for investments, but within a framework explicitly aimed at building climate resilience into agricultural systems.

A framework to identify investments in CSA

A framework aimed at building climate resilience into agricultural systems can help guide various decision-support tools in identifying potential national- and local-level entry points for investments along a particular VC or crop. However, the primary aim, as presented here, is not to identify every possible entry point for intervention. Such a framework is a generic tool designed to ensure problem identification and response planning considers the entire agricultural VC, rather than simply focusing on what happens at farm level. It explicitly considers policy, financial, and knowledge constraints and opportunities, not just technical ones.

While CSA is primarily identified by activities at the farm level, climate change has impacts along the whole agricultural VC. Figure 13 provides an example of the varied ways climate change impacts an agricultural VC. This is important, because interventions or investments designed with a narrow focus on just one part of the VC (for example, building climate resilient practices into cultivation technologies) may well miss pressing constraints elsewhere along the VC. Many extension providers, both governmental and nongovernmental, focus on providing on-farm advice and support but do not necessarily focus on downstream VC issues, such as transport and markets.

Figure 13. Examples of the impacts of climate change on an agricultural VC



Source: Based on Dekens and Dazé (2016)

The entry-point framework described here always needs to be used in the context of the climate risk and vulnerabilities of the farming system where it will be applied. A climate vulnerability assessment is a precondition for utilizing this framework, which is then used to consider ways to address specific climate vulnerabilities along an agricultural VC.

Adaptation takes place in a wider political and economic context – sometimes referred to as the enabling environment – that determines the scope and nature of support for CSA, at least to some extent. This context covers important issues such as global and regional agreements and commitments; local and international finance initiatives; and local and international research, analysis, and technical support. There are further major external influences that do not always directly affect agriculture but have an impact on decision-making priorities and influence opportunities for, and constraints on, adaptive changes to farming systems. Important examples of these are globalization, financial and civil insecurity, transboundary issues such as river flows and plant quarantine, changing food consumption patterns, population increases, land fragmentation, and natural resource degradation.

The framework also considers nonfarming options. In some situations, the adverse effects of climate change will make agriculture less and less profitable, undermining the livelihoods of individual farmers and farming communities. In extreme cases, where changes in weather patterns make farming increasingly problematic, moving out of farming altogether may be the only viable option for some farmers. In these situations, where technical, managerial, or political responses are unable to adequately address adverse climate impacts, investments that support existing, or develop new, nonfarming options become a sensible adaptive response. A simplified version of the framework is presented in Table 5.

Table 5. Entry-point framework with examples of possible investment options

Entry Points	Agricultural VC Phases				Nonfarming Options
	Pre-Production	Production	Post-Harvest	Market	
Policy & Institutions	Climate-proof existing agricultural policies	Climate-proof food security strategy	Develop food storage capabilities	Encourage climate-resilient food choices	Develop policies to encourage diversification of livelihoods
Finance	Provide/enable financial services for farmers for adaption	Review water pricing policy	Develop financial instruments to reduce farmer risk at and after harvest	Develop contingencies for emergency situations (e.g., famine)	Establish off-farm and nonfarm income-generating activities
Information & Knowledge Management	Provide information on climate, risks	Improve weather and climate services	Inform farmers of post-harvest VC diversification opportunities	Reduce food waste	Provide information on nonfarm strategies
Technology & Asset Management	Identify risks and protect agricultural assets from actual and anticipated climate hazards	Improve ecosystem health and buffering capacity	Climate-proof agricultural post-harvest infrastructure	Establish harvest failure contingency systems	Establish contingency actions against climate extremes

Source: Adapted from Pound et al. (2018)

Investments in CSA are never neutral and are influenced by the wider social and political environment in which they are set. Different groups often respond to differing incentives and have different interests. Pre-existing power relationships between groups can, and often will, influence outcomes, as can informal cultural, social, and political priorities. There can be differing views on the best way to tackle climate change in agriculture. For example, some propose tackling climate change through market-based instruments such as tax incentives, while others advocate for direct government support through subsidies and grants. Similarly, there are different beliefs and understandings as to how and why the climate is changing and how best to respond.

Macroeconomic issues can influence investment selection as well as decisions on how, where, and when investments are made, and who benefits from them. Examples of these issues include financial and civil insecurity, population pressures, consumption patterns, land fragmentation, and natural resource degradation. Final decisions are inevitably political in that they represent trade-offs between different (and sometimes competing) interests. Nevertheless, this framework allows evidence for decision-making to be assembled in a structured way. This provides a strong basis for discussion and consultation between and within different interest groups as a key part of the process of making investment decisions and designing interventions.

Effective adaptation investments are supported by evidence that informs both investment design and the level of finance that can be deployed. Evidence needs to be presented in ways such that it can be shared with, and understood by, key groups of stakeholders. Levels of finance that are available need to be clear to ensure realistic investment planning from the outset. Finance can come from domestic allocations for agriculture and allied sectors, as well as from national and international funds explicitly earmarked for climate change.

Prioritizing the investment options

It is not unusual to be faced with a number of possible adaptation options, which then need to be prioritized. This subsection presents a simple decision-support tool to assist with prioritizing investment entry points. This tool can be used to highlight whether, in any specific location, the suggested action addresses an identified vulnerability. Vulnerabilities can be ranked in the table in various ways; for example, by ranking them as high, medium, or low in identifying the most promising options for investments or interventions.

Building climate resilience requires reducing exposure (E) and sensitivity (S) to climate shocks and stressors as well increasing the adaptive capacity (AC) of affected households, communities and institutions. Table 6 provides some further examples of potential entry points for intervention, using the framework shown in table 5. It provides a simple and practical way to prioritize options that emerge from an assessment of potential investment entry points. For each entry point in the table, the acronyms E, S and AC are used to indicate which of these factor(s) the entry point is targeting

Table 6. A checklist of entry points to address climate risk exposure (E), climate change sensitivity (S), and adaptive capacity (AC)

Practical Adaptation Entry Points for CSA Interventions	**Vulnerability** **XXX = High** **XX = Med** **X = Low**	**Priority Level** **XXX = High** **XX = Med** **X = Low**
Policy and Institutions		
Establish a favorable enabling environment for formulating and delivering climate change policy for agriculture (E, S, AC)*		
Screen and climate-proof existing agricultural policies and institutions (E, S, AC)		
Design and deploy new policy instruments aimed at risk reduction for agricultural production through consultative processes (E, S, AC)		
Establish new institutions and approaches to ensure resilience and adaptation options reach and are adopted by farming families (AC)		

Practical Adaptation Entry Points for CSA Interventions	**Vulnerability** **XXX = High** **XX = Med** **X = Low**	**Priority Level** **XXX = High** **XX = Med** **X = Low**
Review existing knowledge on climate change risks to agriculture and fill knowledge gaps through research (E, S, AC)		
Develop climate-proof food security strategies (S)		
Strengthen institutions providing services for agricultural adaptation and resilience (AC)		
Encourage farmers further into the VC as part of income diversification for risk spreading (AC)		
Develop and deploy policy instruments to increase food access and availability (S)		
Explore ways to reduce dependence on agriculture and exploitation of natural resources (E)		
Financial		
Analyze the financial implications of climate change on agriculture (E, S, AC)		
Provide and enable appropriate climate change financial services to farmers (AC)		
Use financial instruments to encourage farmer behavior resulting in greater resilience (S, AC)		
Provide safety nets to farmers against climate change shocks and stress (S, AC)		
Review water pricing policy (S)		
Develop financial instruments to reduce farmer risk at and after harvest (S)		
Establish off-farm and nonfarm income-generating activities (E)		
Information and Knowledge Management		
Conduct studies to provide information on climate change causes, impacts, risks, and options (E, S, AC)		
Encourage long-term continuity and consistency of support for climate change resilience projects and programs in agriculture (E, S, AC)		
Enhance social networks, cohesion, and gender equality for resilience (S, AC)		
Develop information systems (AC)		
Increase the efficiency of food use (S)		
Advise farmers on how to reduce their exposure to climate change risks (E)		

Technology and Asset Management		
Identify risks and protect agricultural assets from actual and anticipated climate hazards (E)		
Identify new approaches to agricultural and natural resource management that respond to climate change (AC)		
Improve ecosystem health and buffering capacity to reduce the impacts of climate change (AC)		
Devise and apply ways to use natural resources more efficiently (AC)		
Devise technical means to reduce climate change risks to agricultural production (E)		
Develop climate-proof agricultural post-harvest infrastructure and technology (E, S)		
Develop and strengthen emergency preparedness systems and procedures (E)		

Source: Adapted from Pound et al. (2018)

Identifying mitigation options

The frameworks above can also be used to identify options for mitigating emissions from agricultural production. Most mitigation options require some change to farm operations, land husbandry, or land use, including avoiding deforestation. In Malawi, clearing forest for agriculture is a major cause of deforestation (Ngwira and Watanab, 2019). Mitigation actions focus on sustainable intensification of cropping and livestock systems, using animal wastes for biofuels, and the careful management and use of synthetic and animal manures. However, it is also important to consider off-farm opportunities for mitigation. Examples include reducing food waste and post-harvest losses, and increasing the energy efficiency of farm vehicles or value-addition manufacturing processes that depend on fossil fuels for energy. Similarly, policy incentives, access to finance, and access to information all play important roles in determining whether mitigation efforts are prioritized and adopted.

Box 9. Primary options to reduce GHG emissions during agricultural production

- Improve the efficiency of production per emission output;
- Increase soil carbon sinks, which move carbon dioxide from the atmosphere into the soil, potentially through reducing tillage, improving grazing management, restoring organic soils, and restoring degraded lands;
- Avoid deforestation for agricultural production; and
- Improve efficiency in food chains, including reducing on-farm and post-harvest losses.

Source: Grist (2015)

Presenting findings and agreeing on next steps

Final decisions on investments and the support required to promote changes (whether these are explicitly climate resilient or not) require a balanced assessment of findings to identify next steps that are practical, add value, and are most likely to achieve a positive outcome. While the relatively simple tools presented here can assist analysis, it is important to recognize what these tools can and cannot provide (Table 4, above). Final decisions may well require further exploration, analysis, and consultation. Nevertheless, this approach provides a structured method to determine sensible ways forward, ranging from small shifts in cropping patterns to major transformations.

Implementing the framework at policy level

Investments at the policy level are often needed to create a policy environment that supports effective responses to climate change in the agricultural sector. However, at this level, important strategies, legislation, and regulations may not have been updated to take into account the challenges that climate change brings to agricultural production.

There are four primary policy areas where investments can play a pivotal role in enhancing the recognition of, and responses to, climate change and its impacts on agriculture:

1. Providing information on climate change that will inform policy;
2. Screening, climate proofing, and implementing existing policies, institutions, and programs;
3. Developing new policies, approaches, and institutional arrangements that reduce climate risks to agricultural production and support farmers in adapting; and
4. Addressing the financial implications of climate change on agriculture.

Providing information on climate change can be done at multiple levels: reviewing current knowledge; identifying knowledge gaps and supporting research to fill them; and ensuring agricultural training centers, universities, and schools include climate change in their curriculum. Agricultural extension messaging and support should reflect clear information on climate risks in local contexts, along with practical, tested advice on adaptation options.

The aim of screening existing policies and programs is to understand the extent to which they adequately cover climate change so that they can be modified if necessary. This includes supporting the implementation of national climate change strategies, NDCs, NAPs, and other similar policies that impact agriculture, as well as policies in related sectors such as water and forestry, that either directly address climate change or reduce climate risk and support resilience. It will also include support for policies and programs that, in the context of changes in weather patterns, build the long-term viability of agricultural production systems and sustain and increase food security. In addition, investment may be needed to build the institutional capacity to implement climate-resilient policies and programs effectively.

Existing agricultural policies, programs, and institutional arrangements often reflect past experiences and are not necessarily sufficiently adapted to take on the challenges associated with climate change. Identifying gaps and then developing new policies and approaches, along with the necessary institutional capacity and arrangements, often requires additional support. Examples of areas that frequently need new approaches to specifically manage and respond to climate risks are hydrometeorology services, farmer training services, and food relief systems.

Supporting farmers requires supportive policies, and conventional extension approaches may provide only a part of these. In some circumstances, diversifying income sources out of farming, or even moving out of farming altogether, can be sensible options. But for resource-poor farmers, with little financial capital and limited nonfarm skills, experience, and social networks, such changes can be extremely difficult. New policies and institutional arrangements are often needed to effectively provide the frameworks that can prepare and support individual farmers and farm communities.

Climate change has large financial implications for the agriculture sector. There are the costs of crop failures associated with increasing severity and frequency of extreme weather events. There are also costs associated with developing and implementing adaptation and mitigation activities, including conversion costs, where yields and profitability fall in the short term as farmers transfer, in whole or in part, from one crop or livestock system to another. Safety nets, such as weather- or crop-based insurance schemes, require national-level policies and regulatory support to be effective. Other costs are associated with building new institutional and technical capacity to respond effectively to climate change. Addressing these financial implications effectively requires both long-term funding and a consistent focus on the funding's purpose.

While some of these financial implications can be managed at the local level through individual projects, they also have national-level budgetary implications. Government budgetary processes usually do not take into account the impacts of climate change. Although governments have always made decisions on how best to allocate scarce financial resources to different sectors, and then within sectors, there is now a need to include a complex set of climate-related factors that, historically, have not been part of national budgetary processes. Developing effective financial frameworks that can support and provide resources for this kind of decision-making can move national budgeting processes into unfamiliar territory. There are short- to medium-term costs associated with developing the technical and institutional capacity to plan and budget in a way that provides the agriculture sector with sufficient, effectively targeted resources to support adaptation and mitigation efforts.

Using the framework for specific projects

At the agricultural project level, there are multiple opportunities for investments. A recent meta-analysis of global CSA experiences, covering 30 countries, highlights the diversity of techniques that can be considered climate smart (Sova et al., 2018). This analysis identifies over 1,700 unique combinations of production systems, regions, and technologies and comments that "the universe of potential CSA technologies… is vast."

The challenge in targeting CSA investments is to ensure that they offer clear costs and benefits from adoption. It is tempting to simply focus on the benefits to changes in farming practices and input use without considering both economic and financial costs associated with them. As noted previously, climate change can have impacts all along the agricultural VC, and it is important not to overlook downstream financial and economic impacts when deciding on priorities. Similarly, it is vital to address non-climate-related constraints and opportunities along the VC in order to support farmers' investments in, and profit from, climate-smart practices.

Project-level investments that aim to build agricultural resilience often focus at the farm level and concentrate on promoting suitable technology options that directly address adaptation and mitigation needs at the field level. These could include, for example, seed varieties that respond well to specific weather stressors, water-conserving cultivating techniques, livestock fodder regimes that reduce methane emissions, solar pumps for irrigation, and many other similar interventions.

Although farm-level technology is important, effective support for CSA needs to look beyond the farm gate as well. The entry point framework (Figures 5 and 6, above) helps identify a range of project-level activities that go beyond improving the technology and techniques farmers use in their fields. Because the framework covers the full range of the agricultural VC, it encourages considering a wide range of options during project design. This is important, as often the bottlenecks to climate-resilient farming systems lie outside the farm itself: Investment designs need to consider the big picture. In addition, the market and consumption side of the VC must be considered, because simply improving the resilience of farm production does not guarantee that the production is profitable (whether this profit is realized through sale or through subsistence). If an agricultural product is not profitable, farmers will not be willing to change their farming methods.

The framework also encourages investments that consider CSA as something more complex than simply a collection of technical options. It highlights the need to consider how financial support can facilitate more climate-sensitive farm practices as well as how to influence and support the flow and use of climate-relevant knowledge and information. For example, the recent meta-analysis of CSA mentioned above also identifies training and information as the largest barrier to CSA adoption (Sova et al., 2018).

The framework provides only a guide to options. It is intended to stimulate thinking and discussions during investment planning – but it does *not* provide an indication of what specific investments are best suited to a specific situation. Decision-support tools can take the decision-making process only so far.

While the drivers and impacts of climate vulnerability in each agro-climatic zone under consideration should provide the starting point for investment decisions, final choices for project-level investments inevitably depend on a number of other nonclimate factors. The methodology described here generates a number of choices for implementation. Final implementation choices then revolve around the level of impact (from high to low), the time frame to reap benefits (from short term to long term), and the financing available to support implementation. There are also political drivers of investment choices that are often only loosely connected to climate change. For example, an investment may be driven by a previously determined political priority, such as expanding irrigation coverage, addressing food security in marginal communities, increasing the productivity of a specific crop, or developing an export market.

Climate change interventions may be the major focus, but often climate change is just one of several complex issues that need to be considered in project design. Even when a rigorous identification process has been undertaken and practical and viable investment options identified, there may be insufficient financing available to do everything. When this happens, it is important to combine an understanding of local climate vulnerability with an exploration of climate-smart investment opportunities. In many cases, the climate-focused opportunities also need to fit within the parameters of other nonclimate investment priorities. Whatever the process, though, farmers must remain central in the decision-making process. This will ensure their perceptions and priorities are understood and incorporated into any final decisions on investments and interventions.

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