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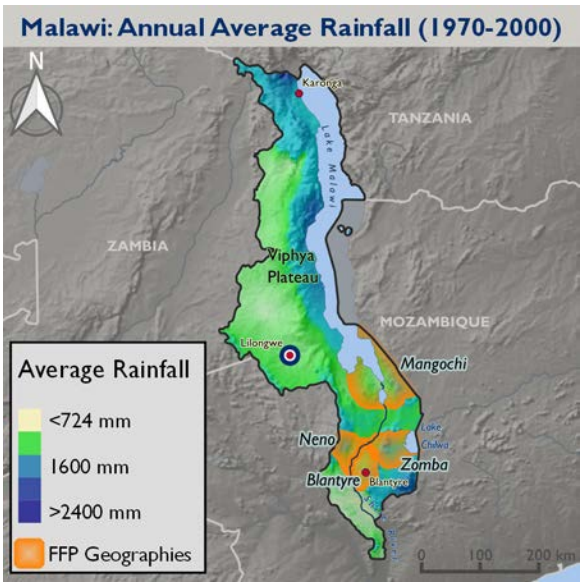
Climate Risk Profile

CLIMATE RISKS IN FOOD FOR PEACE GEOGRAPHIES

MALAWI

COUNTRY OVERVIEW



Source: WorldClim 2005; Hijmans, R.J. et al. 2005

Malawi, a landlocked sub-Saharan African country, has the lowest per capita income in the world. High poverty rates (50 percent under the national poverty line) and population growth, a heavy reliance on rainfed agriculture and a high burden of disease make the country vulnerable to climate shocks, variability and change. Poverty is most acute in rural areas, where 85 percent of the population lives. Rates of malnutrition in children vary across regions and tend to fluctuate with seasonal rains, with the highest rates found in the densely populated and flood-prone Southern Region. An overreliance on cash crops (e.g., tobacco) and drought-sensitive maize cultivation has posed a challenge to reducing malnutrition. Rapid population growth in the south has been accompanied by widespread deforestation for fuelwood and conversion into farmland. The soil on the limited arable land is overused and highly susceptible to erosion and degradation during floods and droughts. Agriculture, which is predominantly rainfed and confined to a short growing season, contributed 26 percent of GDP in 2017—down from a high of nearly 40 percent in 2002, partially due to repeated episodes of delayed rains, prolonged dry spells and pest infestations. The number of weather-related disaster events in Malawi has been increasing since 1974, and the country has experienced more than 40 disasters between 1970 and 2006. Rising temperatures coupled with increased frequency and intensity of floods and droughts will increasingly put the livelihoods and health of Malawi's rural populations at risk. (24, 50, 25, 26, 34, 51)

CLIMATE PROJECTIONS

- 1°C–-3°C increase in temperatures by 2050, with larger increases in the Southern Region
- Increased frequency and intensity of heavy rainfall events
- Increased incidence of drought and floods, with increasing flooding events in the south

KEY CLIMATE IMPACTS

Agriculture and Livelihoods

Reduced crop yields and livestock productivity
Shift in timing of planting/growing
Food shortages
Reduced income opportunities

Health, Nutrition and WASH

Increased vector- and waterborne disease
Increased food insecurity and malnutrition

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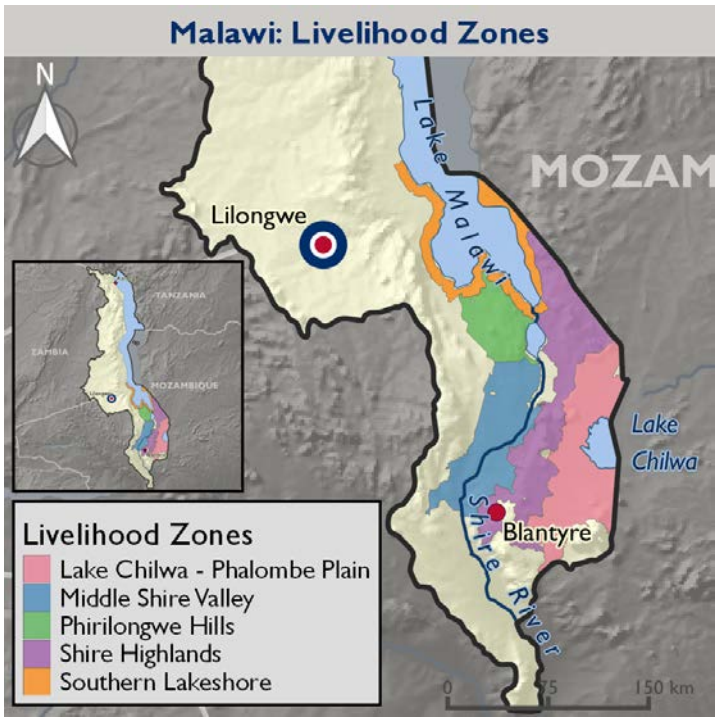
This document was prepared under the Climate Change Adaptation Thought Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00013 and is meant to provide a brief overview of climate risk issues. The key resources at the end of the document provide more in-depth country and sectoral analysis. The contents of this report do not necessarily reflect the views of USAID.

LIVELIHOODS AND CLIMATE IN FOOD FOR PEACE PROGRAM AREAS

In Malawi, the USAID Food for Peace (FFP) program aims to sustainably improve food and nutrition security and resilience capacities of the ultra-poor and most vulnerable communities. In alignment with the new National Resilience Strategy, the development activity will focus on reducing the number of chronically food and nutrition insecure households as well as enhancing the capacity of governance structure to implement resilience-focused priorities. FFP's development investments will target districts with high levels of poverty and food insecurity and very high prevalence of stunting in children under five, as well as high exposure to natural disasters, particularly in Mangochi and Zomba.

LIVELIHOOD ZONES

With nearly 84 percent of the population dependent on crop production for their livelihoods, agriculture is the mainstay of Malawi's economy. In the FFP program areas, crop production is dominated by maize, grown by more than 95 percent of farmers, and tobacco. For more well-off households, livestock-rearing (cattle, goats, pigs, sheep and chickens) provides cash income, meat and milk. Income-generating opportunities outside of agriculture are limited and many people barely meet their minimum annual food requirements. Wealth is directly linked to the size of land holdings and the ability to afford agricultural inputs, such as improved seeds and fertilizer. High dependence on rainfed agriculture for income and food security means that livelihoods are impacted by seasonal rains, temperatures and extreme weather events. Table 1 provides more information and details of the livelihoods and climate-related hazards in the FFP program areas. (15)



CLIMATE SUMMARY

Malawi's landscape is dominated by the Great Rift Valley which runs north to south, along with mountain ranges and high plateaus on either side and Lake Malawi across the entire eastern boundary. Its climate is heavily influenced by these topographical features. Most of the country experiences a tropical continental climate, ranging from semiarid to subhumid and characterized by two distinct seasons: a rainy season (November to April) and a dry season (May to October). Along Lake Malawi, where annual rainfall reaches 1,600 mm, flooding and heavy rainfall events are frequent. Low-lying areas in the Shire Valley receive 500 mm or less of annual rainfall, while northern and eastern mountain regions experience up to 3,000 mm annually. Southern Malawi is mostly low-lying and drier than central and northern regions, experiencing only one short rainy season between December and February. The south is also characterized by higher temperatures, which range from 9°C to 39°C, on average. The highest temperatures (reaching 40°C) in the country occur between October and November in the Lower Shire Valley. (42, 16, 15) Agroclimatic conditions are unfavorable in the south compared with the north. Drought and flood cycles occur on almost a yearly basis. Dry spells and droughts are occasionally amplified by El

Niño Southern Oscillation events, which are linked to lower-than-average rainfall for southern Africa. The Shire Valley, Nsanje and Chikwawa districts in the south are most at risk for floods, dry spells and droughts. (15)

Table 1: Livelihood zones and climate in Malawi's FFP program areas

Livelihood zone	Main economic activities	Annual rainfall	Main climate-related hazards
Southern Lakeshore (Mangochi)	Fishing was historically the predominant activity in this area along the southern end of Lake Malawi, but the sector has been in decline. Very poor households rely on agricultural or fishing labor and self-employment. The main food crop is maize, which is rainfed, but small amounts of irrigated maize are grown during the winter months. Cotton is grown as a cash crop and livestock production is becoming more widespread.	600–1,000 mm, concentrated between November and March	Dry spells, strong winds, occasional flooding and crop pests and livestock disease (e.g., armyworms affecting maize, New Castle disease among chickens)
Phirilongwe Hills (Mangochi)	The zone is heavily forested on the hills. Higher rainfall amounts improve crop production but also cause flooding and waterlogging of soil. Crop production includes maize, sorghum, cassava, pigeon peas, ground nuts and sweet potatoes, with the addition of cotton and tobacco as cash crops. Tobacco is only farmed by wealthier farmers who can afford fertilizer inputs. Livestock includes chicken and goats only. Groundnuts and firewood sales serve as important sources of income for very poor households.	800–1,400 mm	Waterlogging, crop pests, livestock disease and flooding
Shire Highlands (Blantyre urban, Mangochi, Zomba urban)	This zone is the country's most densely populated and poorest region. Most of the population is smallholder farmers highly dependent on maize. Smaller amounts of sorghum, ground nuts, pigeon peas, sweet potatoes, tomatoes and rice are cultivated. Livestock holdings are limited and include mainly goats and chickens. Poorer households face a significant food gap starting in December and lasting through February.	750 mm–1,400 mm from November to April	Erratic rainfall and dry spells, crop pests
Middle Shire Valley (Balaka, Blantyre rural, Machinga, Neno, and Zomba rural)	This is a dry zone despite some areas being close to the Shire River. The area is a mix of topography with some riverine flood plains. Crop production is the main livelihood and is dominated by maize and rice. Very poor households sell charcoal or firewood and perform agricultural labor. Cotton is a cash crop for wealthier farmers in the zone. Livestock is only for supplementary income.	500–850 mm from November to March	Dry spells during key crop stages, livestock disease, flooding and pests
Lower Shire Valley (Chikwawa and Nsanje)	This southern-most zone is poor and chronically food insecure; it is a mix of forests, grasslands, protected areas and game reserves. Livestock (plough oxen) is the major source of income for wealthier households. Casual labor (*ganyu*) is a major source of income among poorer households, as they only meet 50 percent of annual food requirements through crop production. Aside from *ganyu*, crop production is the main livelihood, including maize, cotton, rice, sugarcane, sweet potatoes and sesame.	600—700mm from November to March	Dry spells during key crop stages, livestock disease, flooding and pests
Lake Chilwa	Similar to the nearby Shire Highlands, this zone is very poor and food insecure, and few opportunities exist to generate income outside of crop	700–1,000 mm from October to March	Dry spells during key crop stages, flooding

(Zomba rural)	production/sales; most households depend on more than just crop production to meet food and cash requirements. The Zomba plateau, rising to 1000m, is found here surrounded by low-lying flatlands. Crop production includes rice, maize (rainfed and irrigated), sorghum, pigeon peas, ground nuts, cassava and sweet potatoes. In addition to goats and chickens, livestock ownership includes cattle and pigs. Other sources of livelihood include livestock sales (mainly poultry), small scale trade, *ganyu*, and other seasonal employment opportunities.		

Source: FEWS NET 2016

CLIMATE TRENDS AND PROJECTIONS

Temperatures are projected to increase evenly across all regions by 1°C–3°C by 2060. There is significant variability in intraseasonal and interseasonal precipitation, making detection and projection of longer-term patterns in precipitation difficult. All climate models agree that the frequency of heavy rainfall events will increase, but rainfall projections remain uncertain. The average number of cold days and nights has decreased in all seasons, except September–November, and the number of hot days and nights has increased by as much as 17 percent, particularly between December and February. These trends are summarized in Table 2. (22)

Table 2: Climate trends and projections

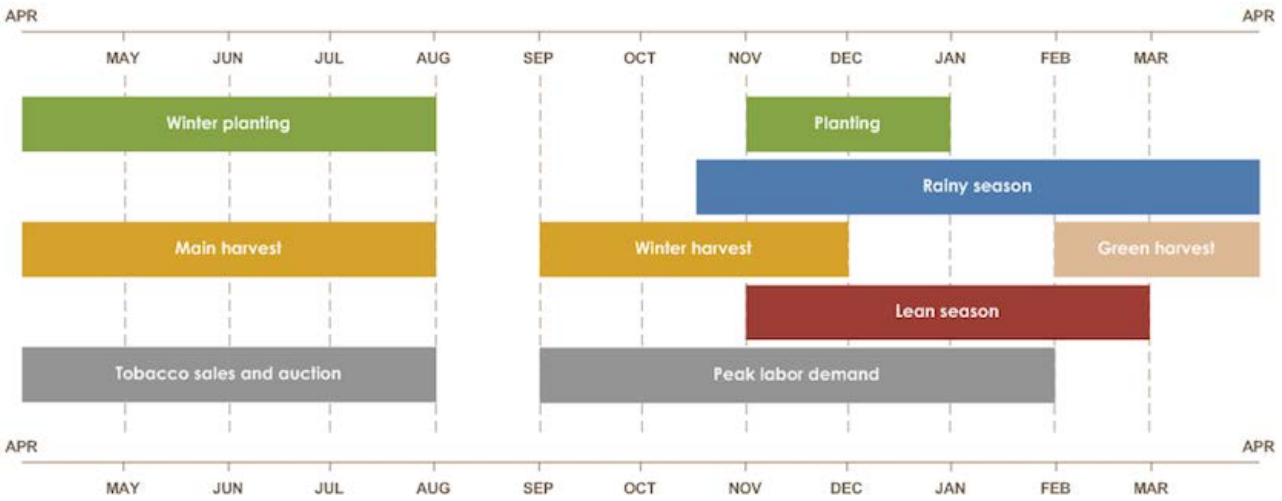
Parameter	Observed trends (since 1960s)	Projected changes (2040–2069)
Temperature 	• Temperature increases of approximately 0.9°C, with the most rapid increase in summer months (December–February), between 1960 and 2006 • Increase in the number of days (+30 days) and nights (+41 days) considered “hot”	• Higher average temperatures of 1°C–3°C by 2050, with largest increases in early summer months • Increase in the number of hot days and nights by 2060
Rainfall 	• Highly variable year-to-year rainfall totals with no statistically significant trends • Increased length of dry spells during the rainy season	• Overall increases or decreases in rainfall difficult to project • Later onset and earlier cessation of rainy season • Increase in average monthly rainfall from December to January and decrease from February to April
Extreme Events 	• Increased intensity, frequency and magnitude of floods and droughts • Malawi has experienced more than 40 weather-related disasters, with 16 of these occurring between 1990 and 2008	• Increases in the amount of rainfall during extreme events

Source: USAID 2017

SECTOR IMPACTS AND VULNERABILITIES

CROP PRODUCTION

Malawi is a predominantly rural and agrarian country, with an overwhelming majority of its population reliant on agriculture for both income and household food security. Most crop production is rainfed and subsistence-oriented, done by smallholder farmers; this accounts for 75 percent of production. More than half (59 percent) of smallholder farmers live under the national poverty line. Changes in the timing and duration of the rainy season can jeopardize production and have devastating effects for poor smallholder farmers whose window for planting is limited to November-January (Figure 1). Even without considering climate stressors, the sector is marked by low productivity due to population pressures, low input use, deforestation, soil degradation and land-use changes. (15, 13)



Note: The “green harvest” (February–April) refers to the early harvest of crops, common among poor households, to meet food needs.

Figure 1 Seasonal crop calendar in Malawi

Source: FEWS NET 2013

Malawi is prone to a range of climate hazards that impact crop production, including dry spells, seasonal droughts, intense precipitation, river flooding and flash floods. The majority of the country is at risk from droughts and floods. These events erode soils, damage crops, and can lead to acute malnutrition. In a 2011 survey, 98 percent of farmers reported being exposed to drought, 92 percent to floods, and 97 percent to crop pests and diseases in the previous decade. Annual losses from shocks to agricultural production averaged US$149 million from 1980 to 2012. Floods cause annual losses of about 12 percent of maize production in the south, where one-third of Malawi’s maize is grown. During the seasonal rains, floods make roads impassable and restrict farmers’ access to markets. Farmers are instead forced into local informal exchanges or markets where prices are lower. For example, widespread flooding in 2015 affected more than 1 million people and caused $335 million in damages and losses from destroyed crops, fisheries, lost livestock and damaged agriculture infrastructure. The following year, the strongest El Niño event in 35 years brought extensive drought and crop failure, leaving 39 percent of Malawi’s population in need of food assistance. The frequency of heavy rainfall events is projected to increase by 20 percent by 2090, and higher temperatures and more hot days are likely to increase the risk of

drought. Climate models project that the largest increases in temperature will coincide with the growing season (November–December), leaving many crops vulnerable to heat stress. (21, 14, 22, 7, 17, 13, 24, 50, 47, 48, 43)

Malawi's staple crops are maize, rice, cassava and sorghum, but maize is the dominant crop across the country. Maize makes up the majority of the population's caloric intake. Maize yields have increased with more use of organic fertilizer, but long-term sustainability is unclear because of soil nutrient depletion. Maize is highly sensitive to drought, which destroys on average 4.6 percent of the country's production each year. In the north and central regions, increasing temperatures are improving yield outcomes; in the south, where temperatures already exceed the crop's thermal threshold, these trends are reducing yields and are exacerbated by evaporation and drying. In addition to chronic threats of maize streak virus, which impacts maize yields across the FFP program areas, the advent of fall armyworm across southern Africa, including Malawi, further demonstrates the devastating consequences of this over reliance on maize for food security, especially in Malawi's rural areas. In December 2017, President Peter Mutharika declared 20 of the country's 28 districts "disaster areas" following a fall armyworm invasion. Within the span of just two months, the pests destroyed the crops of nearly 140,000 farming families. While no clear connection to climate change has been established for fall armyworm, similar pests (e.g., African armyworm) have been observed to increase rapidly after droughts. In early 2014, following consecutive years of dry spells, much of southern Malawi, including Blantyre, Mangochi and Zomba, declared state of disasters having experienced compound impacts of armyworm infestations and heavy rainstorms. (15, 1, 3, 18, 29)

Rice is grown in only a small part of the country, including pockets of Mangochi and Zomba, where there is sufficient precipitation to support production. The market for rice is growing rapidly, especially in two of Southern Malawi's most important urban and urbanizing areas, Blantyre, Malawi's second largest city, and Zomba, creating an opportunity for smallholder farmers in these zones to diversify their agricultural production. Rice is sensitive to heat temperatures in excess of 35°C – even a few hours of exposure can damage crop yields and sterility. The increased frequency of temperatures over the 35°C threshold makes rice increasingly susceptible to a warming climate. (15, 33)

In addition to weather and climate factors, population pressures, forest degradation and deforestation, and limited land in Malawi's Southern Region where FFP works are increasing stress on soil fertility. Poor smallholder farmers are unable to afford costly inorganic fertilizer and have turned to reducing fallow periods and expanding cultivation onto marginal and less fertile land to try to increase yields. Smallholder farmers also turn to firewood production to supplement their incomes, resulting in higher rates of deforestation. Only 1.5 percent of smallholder farm crops are irrigated, leaving them vulnerable to seasonal precipitation variations and longer-term climate changes. (9, 13, 15)

Table 3 lists common crop climate sensitivities, including sensitivities related to changes in pest and disease dynamics. Table 4 summarizes climate risks to crop production in Malawi.

Table 3: CROP PRODUCTION—Climate sensitivities and adaptive characteristics of key crops		
Crop	**Climate sensitivities**	**Adaptive characteristics**
Maize	• Sensitive to hot temperatures over 35°C • Sensitive to drought during flowering period • Warmer temperature leads to faster growth but lower yields	• Fertilizer inputs can support adaptive characteristics of plant and increase yields despite climate change • Some varieties are more drought resistant • Maize will benefit from higher temperatures in some regions
Rice	• Sensitive to hot temperatures over 35°C • At flowering stage, even one day of heat can cause sterility • Yields decline 10 percent for every 1°C rise in minimum temperatures • Requires significant water	• Increased temperatures will not affect yield if enough water is applied through irrigation or increased rainfall
Sorghum	• Sensitive to moisture stress during grain development • Rainfall less than 450 mm leads to reduced yields • Irregular rains also fuel fungal growth in sorghum • Sensitive to hot temperatures over 35°C	• Drought tolerant, goes dormant during water stress • Tolerates waterlogging of up to two weeks

Source: USAID 2013

Table 4: CROP PRODUCTION—Climate stressors and risks	
Climate stressors	**Climate risks**
Rising temperatures	Crop failure and/or reduced yields
Increased unreliability of rainfall (more variability) **Increased length or intensity of dry periods**	Increased soil erosion and damage to crops from flooding
Increased heavy rainfall frequency and intensity	Increased risk of pests and diseases

Source: Chalmers et al. 2017; FAO 2017; Sheahan 2017; USAID Sector Environmental Guidelines 2014

LIVESTOCK

Livestock production has been limited historically, accounting for just 10 percent of agricultural production value. In recent years, the country has promoted livestock production as both a means of income diversification and a response to climate variability and change. Most households in the Phirilongwe Hills (western Mangochi) raise a small number of goats and chickens, whereas livestock ownership in the Shire Highlands (eastern Mangochi and Blantyre) is very low. In the Middle Shire Valley (Blantyre, Neno, and Zomba), livestock are primarily a source of supplementary cash income from sales and occasionally kept for slaughter. In these areas, some of the hottest in Malawi, livestock production can be more resilient to climate shocks compared with maize crop production, and serves as a buffer against food insecurity for vulnerable households. (13, 14, 15)

Livestock ownership creates wealth for smallholder farmers through sale of meat and milk. Small ruminants (predominantly goats) and poultry make up the majority of household herd composition

across all income levels in Malawi, while cattle are only owned by high-income households. Small ruminants are more tolerant of dry conditions and higher temperatures than cattle, and the quick turnover and low investment needed for poultry production make it an attractive adaptation option. Livestock can be sold to purchase food, serving as a form of insurance during the lean season and when variable rainfall affects maize production. Despite its potential for raising incomes and improving food security, the livestock sector is affected by low productivity due to a combination of factors, including poor genetic diversity and inadequate number of improved breeds, population pressures and land degradation that reduce communal grazing land, and a high prevalence of disease. (15, 11, 7)

Climate variability and change will pose added challenges to Malawi's limited livestock sector (Table 5). In addition to increasing livestock exposure to heat stress, rising temperatures, increased frequency of dry spells and more variable rainfall are likely to affect the range of pests and diseases, such as worms and orf virus in goats and Newcastle disease in chickens, already common in FFP program areas. Heat stress in animals affects growth rates and milk production. Drought reduces water availability and quality, as well as availability and quality of animal feed. Tick-borne diseases (e.g., anaplasmosis, heartwater), also presently affecting FFP program areas (Blantyre, Neno, and Zomba) likely to increase with rising temperatures and more erratic rainfall, as tick populations thrive in drying and drought-affected areas. In addition, severe floods can contribute to significant losses in livestock. According to the Government of Malawi's 2015 Floods Post Disaster Needs Assessment, an estimated 195,000 animals were washed away or killed. (24, 37, 20)

Table 5: LIVESTOCK—Climate stressors and risks

Crop	Climate sensitivities
Rising temperatures	Reduced livestock growth rates and milk production due to heat stress
Increased unreliability of rainfall (more variability)	Loss of grazing land and crop biomass as food for livestock due to floods and drought
Increased length or intensity of dry periods	Increased expansion, occurrence and outbreaks of certain livestock diseases
	Increased temperatures, late onset of seasonal rain lead to drying periods and loss of seasonal water sources

Source: USAID Sector Environmental Guidelines 2015

HUMAN HEALTH, NUTRITION AND WASH

Malawi's hard-fought health gains in recent years—an increase of almost 20 years to the average life expectancy since 2000, a steady decline in maternal and child mortality rates, more than 80-percent access to clean drinking water and 88-percent access to basic sanitation—remain precarious in the face of climate variability and change (Table 6). Climate-sensitive diseases, such as malaria and diarrheal diseases (the second leading cause of death in Malawi), are likely to impact Malawi's growing population. (51, 46)

Impact of disaster events on WASH

Climate shocks such as floods and droughts endanger life, property and assets, including livestock, and the aftereffects of these shocks threaten gains in health outcomes and complicate development efforts. A record rainfall event in 2015 (a 1-in-500–year event) struck Malawi's Southern Region in 2015, bringing with it significant flooding that displaced 230,000 people from their homes and damaged 3,000 boreholes and other infrastructure for water supply and treatment in all of the FFP program areas. The most highly affected districts included Blantyre, Nsanji, Chikwawa, Mulanje, and Zomba. Within one month of the floods, cholera outbreaks had been reported in two affected communities, including Nsanje and Blantyre's neighboring Chikwawa district. The storm and associated flooding forced many to seek temporary shelter, heightening malaria and diarrhea risk. The combination of impacts in WASH, agriculture and infrastructure led to widespread food insecurity and spikes in acute malnutrition rates. (22, 24)

Vector- and waterborne diseases

Malaria is endemic in more than 95 percent of Malawi and one of the major causes of morbidity and mortality across all age groups. In 2017, 24 percent of children under five tested positive for malaria, with the highest incidence in the Central and Southern regions. Transmission rates are high in hotter, wetter and more humid low-lying areas, including Southern Lakeshore (Mangochi) and the Shire River Valley (Mangochi, Blantyre and Neno). Rising temperatures and more frequent extreme rainfall events will have consequences for malaria in Malawi, but they will not necessarily be direct. For example, increased temperatures may lead people to forego sleeping under bed nets and thus increase exposure to malaria-carrying mosquitoes. Heavy rainfall often leaves standing water where mosquitoes can breed. (8, 35, 51, 52)

Floods and droughts can lead to an increase in waterborne diseases, including cholera and diarrhea. Cholera is prevalent in Malawi and outbreaks occur during both the rainy season and during droughts. In April 2018, as many as 893 cases of cholera were reported in northern and central Malawi. Flooding during the rainy season can wash contaminants into potable water sources and droughts reduce river-flow rates, causing the water table to recede and boreholes and wells—both important sources of potable water in rural areas—to dry out. The lack of freshwater inflows enables the spread of bacteria in water supplies, creating conditions for cholera outbreaks. The El Niño Southern Oscillation and other climate patterns can also increase the incidence of cholera, dengue and other infectious diseases. Shifts have recently been observed in the distribution of cholera incidence throughout Africa in El Niño years compared with non-El Niño years, likely mediated by El Niño's impact on local climatic factors. (33, 22, 30)

Nutrition and food security

Despite sustained improvements in reducing hunger indicators, Malawi ranked 90 out of 119 countries on the global hunger index in 2017. Malawians' diet consists mainly of maize, starchy roots (e.g., cassava and potatoes) and fruits (e.g., plantains). Micronutrient deficiencies are common, and 25 percent of the population was considered undernourished in 2015. Childhood malnutrition remains a serious challenge, with 37 percent of children under five experiencing stunting. Food security and malnutrition are closely linked to seasonal climate variability in Malawi. The already low supply of food is sensitive to changes in rainfall and temperature. Food prices are at their highest and cereal supplies at their lowest at the beginning of the lean season. Acute malnutrition rates can rise quickly. The combination of overreliance on maize and the devastating

effect drought has on maize has led to food shortages every two to three years, requiring international food assistance. (19, 12, 45, 15, 44)

HIV/AIDS

HIV/AIDS is the leading cause of death in Malawi. Eleven percent of Malawians between the ages of 15 and 49 years are HIV positive—far above the sub-Saharan Africa average of 6.1 percent. Prevalence is especially high in the Southern Region. HIV/AIDS amplifies the negative effects that droughts and dry spells have on nutrition. Treatment for the disease relies on higher nutritional requirements; coupled with drought-induced food insecurity, this creates a vicious feedback loop. The inability to provide adequate nutrition weakens the immune system and undermines overall nutrition status, leading to more disease-related deaths. The disease burden also reduces productivity of the labor force, which increases food insecurity and stretches Malawi's limited capacity to deliver basic health services. HIV status among Malawian women may also contribute to the poor nutritional status of children. (3, 22, 39, 49, 46)

Table 6: HEALTH, NUTRITION AND WASH— Climate stressors and risks

Climate stressors	Climate risks
Rising temperatures	Increased mortality and morbidity related to heat waves and heat stress
	Expanded ranges of disease vectors (e.g., mosquitoes) and increased transmission of infectious disease such as meningitis and malaria
Heavy rains, storms and floods	Increased flood-related mortality and morbidity, including an increase in infectious diseases from degraded water quality; increased damage to water and sanitation infrastructure
Increased length and intensity of dry periods and drought	Reduced water availability due to drying water sources during more severe dry periods
	Diminished nutrition and food security due to impacts on agriculture from increased heat, heavy precipitation and variable rainfall

Source: USAID Sector Environmental Guidelines 2014

WETLAND ECOSYSTEMS

Malawi has an extensive network of freshwater lakes, swamps, marshes and grasslands that support rural livelihoods and provide ecosystem services such as inland drainage, flood protection, water filtration and erosion control. High rates of population growth have intensified subsistence agriculture, fishing and livestock grazing around the Lake Chilwa Wetland and its catchment in Machinga and Zomba districts. Designated a wetland of international importance upon the Government of Malawi's ratification of the Ramsar Convention in 1997, Lake Chilwa is one of the most densely populated wetlands in Africa and faces compound threats from increasing climate variability and increased deforestation and irrigation to support agriculture. The combination of these pressures continues to degrade these important wetlands. Water levels in the lake have a history of cyclic drying, fluctuating up to one meter between the dry and rainy seasons. The lake dried up completely nine times between 1900 and 2000 as a result of erratic seasonal rainfall and long dry periods. Most recently, in 2012, the lake underwent a severe recession, losing about 80% of its water. In cases of partial or full desiccation, the lake showed recovery within two years when

normal rainfall followed the recession and water tables in forested headwater areas recharged. However, deforestation in the upper catchments increases sediment loads, closing channels that connect floodplain lakes and reducing oxygen availability in the wetland. Future changes to hydrological regimes, more extreme weather events and changes in the quantity and quality of water supply are expected to have pronounced effects on wetlands across Malawi (Table 7). (28, 36)

Reduced water levels have negative implications on people's livelihoods through loss of income and employment, reduced fish supply, increased conflicts from competition for resources and increased exploitation of birds of international importance. Receding water exposes land to crop farming and livestock grazing which negatively impact wetland vegetation and associated biodiversity. (28, 36)

Table 7: WETLAND ECOSYSTEMS—Climate stressors and risks

Climate stressors	Climate risks
Rising surface temperatures of inland ponds and lakes	Wetland recession and desiccation
More variable rainfall	Improved habitat for disease, such as cholera
Increased intensity of extreme events	Destruction of habitats and biodiversity loss

Source: United Nations Economic Commission for Africa 2011; US EPA 2016

PESTICIDE USE

While common in export crops produced on large estate farms (e.g., tobacco, tea, sugar cane), pesticide use at the household level is low in Malawi. Less than 10 percent of maize is treated. Pesticide use has emerged as a key issue for Malawi, particularly as climate change exacerbates current risks and creates new challenges (Table 8). In 2018, fall armyworm infested more than 380,000 ha of maize, sorghum and millet, damaging 10 percent of the maize harvest and impacting more than 1 million families. Healthy crops can resist pests better, but Malawi's monocropping system has left crops vulnerable. In response to the outbreak, the government is prioritizing pesticide distribution. However, there are environmental and health risks to application of chemicals by untrained farmers and extension workers, and improper application reduces pesticide effectiveness. About 1–3 percent of agricultural workers suffer from acute pesticide poisoning. Apart from acute poisoning, risk of pesticide exposure through soil, air and water is high due to inefficient applications and unsafe disposal, and runoff caused by extreme events. In addition, many Malawian farmers report using illegal or expired pesticides. Increased frequency and intensity of heavy rainfall could increase contamination risks and reduce pesticide effectiveness, especially in areas with poor soils, such as the Middle Shire Valley (Blantyre, Neno, and Zomba). (53, 10, 27)

Table 8: PESTICIDE USE—Climate stressors and risks

Climate stressors	Climate risks
More intense rainfall	Increased surface runoff
	Increased percolation/groundwater infiltration
Longer dry periods	Increased threat from current pests/introduction of

Table 8: PESTICIDE USE—Climate stressors and risks	
Climate stressors	**Climate risks**
Rising temperatures	new pests
	Reduced effectiveness of pesticides applied topically
	Reduced effectiveness of pesticides that are activated/distributed by water
	Farmers' unwillingness to use personal protective equipment in increasingly hot weather

Source: USAID Sector Environmental Guidelines 2009

INVASIVE SPECIES

Invasive species can reduce crop and livestock production and increase production costs. Considerable evidence globally suggests that climate change will further increase the likelihood of invasive species gaining a foothold in new areas, expanding their range in areas where they are currently present, or both. When left untreated, invasive weeds can damage crops and grazing land.

There were 31 invasive species reported in Malawi in 2014. Table 9 describes three of the most common invasive species in Malawi. Maize crops in Malawi are impacted by a range of invasive species (plants and insects), causing crop losses of 6–9 percent of agricultural GDP. Invasive plant species have even been shown to increase incidence of malaria in Africa, as the rapid growing and frequently flowering species are attractive to mosquitoes and provide nectar for long periods. Invasive species are often highly adaptable, frequently responding positively to increased temperatures and variable climate conditions. Climate change will likely encourage expansion of many varieties of invasive plants and pests in Malawi. (23, 34, 4)

Table 9: INVASIVE SPECIES— Characteristics and link to climate		
Species	**Characteristics**	**Link to Climate**
Eichhornia crassipes (water hyacinth)	A fast-growing flowering plant; populations can double in 12 days; a weed that obstructs waterways	Adapted to temperature range of 12°C –35°C; seeds can germinate in a few days or remain dormant for 15–20 years to survive variable conditions
Prosopis juliflora *(mesquite)*	Perennial, deciduous, fast-growing, nitrogen-fixing and drought-tolerant shrubs or trees with deep tap roots; grows in arid and semiarid environments; forms dense stands and outcompetes native vegetation	Adapts well to arid regions and thrives in drought
Parthenium hysterophorus *(Santa Maria, Parthenium weed, carrot grass)*	A flowering plant that affects crops and pasturelands, reduces crop yields and prevents germination. It is also toxic to cattle and humans	Likes drier soils and reproduces quickly in high temperatures (30°C+)

Source: CABI 2017; Biomed Central 2017; Pratt et al. 2017; USAID Sector Environmental Guidelines 2009

KEY RESOURCES

1. Becktold, W. 2017. Fall Army Worm Arrives in Africa on Heels of Climate Change.
2. Beedy, TL. et al. 2013. Scaling up agroforestry to achieve food security and environmental protection among smallholder farmers in Malawi.
3. Bickton, F. 2016. Climate change as the biggest threat to public health in southern Africa and measures to reduce its impacts.
4. Biomed Central. 2017. Invasive plant increases malaria transmission.
5. CABI Invasive Species Compendium. 2017. Prosopis juliflora.
6. Chalmers, M. et al. 2017. Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics.
7. Chikhungu, LC. et al. 2014. Seasonal variation of child under nutrition in Malawi: is seasonal food availability an important factor? Findings from a national level cross-sectional study.
8. Clim-Health Africa. 2017. Identifying Climate-Sensitive Health Risks and Climate Adaptation Strategies in Malawi.
9. FAO. 2005. Aquastat Profile.
10. FAO. 2018. Crop diversification increases productivity and stabilizes income of smallholders.
11. FAO. 2005. Livestock Sector Brief.
12. FAO. 2010. Nutrition Profile Malawi.
13. FAO. 2018. Smallholder farms factsheet.
14. FAO. 2017. Tackling Climate Change in Zambia and Malawi.
15. FEWS NET. 2016. Malawi Livelihood Baseline Profiles.
16. Future Climate for Africa. 2017. Malawi Country Brief.
17. Giertz, A. et al. 2015. Malawi Agricultural Sector Risk Assessment.
18. Global Center for Food System Innovation. 2017. Impacts of Climate Change on Rice and Maize, and Opportunities to Increase Productivity and Resilience in Malawi.
19. Global Hunger Index. 2017. Malawi GHI 2017: Sustained improvement yet persistent hunger.
20. Global Lyme Alliance. 2016. The Effect of Drought on Tick-Borne Diseases in Africa.
21. Global Facility for Disaster Reduction and Recovery (GFDRR). 2015. Country Profile: Malawi.
22. GFDRR. 2011. Vulnerability, Risk Reduction and Adaptation to Climate Change Malawi.
23. Government of Malawi. 2014 Fifth national report to the convention on biological diversity.
24. Government of Malawi. 2015. Malawi 2015 Floods PDNA Report.
25. Government of Malawi. 2011. The Second National Communication to the Conference of the Parties of the UNFCC.
26. Index Mundi. 2018. Malawi Economy Profile 2018.
27. International Food Policy Research Institute. 2018. Malawi's new reality: Fall armyworm is here to stay.
28. Kafumbata, D., et al. 2014. Riparian ecosystem resilience and livelihood strategies under test: lessons from Lake Chilwa in Malawi and other lakes in Africa.
29. Masina, L. 2017. Fall Armyworms Hit Malawi, President Appeals for Help.
30. Moore, S. et al. 2017. El Niño and the shifting geography of cholera in Africa.
31. Nagoli, J. et al. 2017. Coping with the Double Crisis: Lake Chilwa Recession and the Great Depression on Chisi Island in Colonial Malawi, 1930–1935.
32. Oates, N. et al. 2014. Adaptation to Climate Change in Water, Sanitation and Hygiene: Assessing risks, appraising options in Africa.
33. Olson, J. et al. 2017. Impacts of Climate Change on Rice and Maize, and Opportunities to Increase Productivity and Resilience in Malawi.
34. Pratt, C. et al. 2017. Economic impacts of invasive alien species on African smallholder livelihoods.
35. President's Malaria Initiative. 2018. Malaria Operational Plan FY2018.
36. Ramsar Sites Information Service. 2014. Malawi Country Profile.
37. Rojas-Downing M. et al. 2017. Climate change and livestock: Impacts, adaptation, and mitigation.
38. Sheahan, M. 2017. Ten striking facts about agricultural input use in Sub-Saharan Africa.
39. Suarez, P. et al. 2008. HIV/AIDS, Climate Change and Disaster Management : Challenges for Institutions in Malawi.
40. United Nations Economic Commission for Africa. 2015. Assessment report on mainstreaming and implementing disaster risk reduction measures in Malawi.
41. United Nations Economic Commission for Africa. 2011. Climate Change and Water Resources of Africa: Challenges, Opportunities and Impacts.
42. USAID. 2017. Climate Change Risk Profile Malawi.
43. USAID. 2013. Malawi Climate Change Vulnerability Assessment.
44. USAID Office of Food For Peace. 2013. Food Security Country Framework for Malawi FY 2014-2019.
45. USAID. 2016. Malawi: Sustainable Economic Growth Factsheet.
46. WHO. 2015. Malawi Health Profile.
47. World Bank. 2011. Climate Change Knowledge Portal Malawi.
48. World Bank. 2018. Hard hit by El Nino: Experiences, Responses, and Options for Malawi.
49. World Bank. 2008. HIV/AIDS, climate change and disaster management: Challenges for institutions in Malawi.
50. World Bank. 2016. Malawi Economic Monitor: Absorbing shocks, building resilience.
51. World Bank. 2017a. Open Data Portal - Malawi.

52. World Bank. 2017b. Malawi Malaria Indicator Survey.

53. World Bank. 2017c. Malawi Pest Management Plan.