USAID
FROM THE AMERICAN PEOPLE

Climate Risk Profile

CLIMATE RISKS IN FOOD FOR PEACE GEOGRAPHIES
ZIMBABWE

COUNTRY OVERVIEW

Zimbabwe, a landlocked Sub-Saharan African country, faces risks from an increasingly variable and changing climate. Combined with years of political and economic instability, challenging and contentious land reforms that leave many farmers without title to the land they work, and rapid population growth, climate risks create substantial challenges for a country with a high poverty rate (63 percent) and recurrent food insecurity. Agriculture, largely rainfed and highly sensitive to a variable climate, is the backbone of Zimbabwe's economy and constituted on average 10 percent of gross domestic product (GDP) between 2012 and 2016. Nearly 80 percent of the country's 16.1 million people, the majority of whom (70 percent) live in rural areas, depend on rainfed farming and livestock rearing for their livelihood. As Zimbabwe's climate becomes more erratic, estimates point to widespread crop failures occurring every three out of five years, so food and nutrition insecurity among rural populations are expected to remain persistent. Droughts, which affect Zimbabwe's southern and western regions and parts of the eastern region, devastate crop yields and livestock production, stripping farmers of critical food sources and the means to generate income. Continued population growth will likely exacerbate competition for and degradation of the natural resource base, contribute to an increase in greenhouse gas emissions, and intensify vulnerability to climate-related hazards. The increasingly erratic, unreliable nature of the rainy season and resultant uncertain water availability, coupled with more severe and prolonged extreme weather events, could place additional pressure on already vulnerable livelihoods, erode current coping strategies and continue to threaten health. (12, 60, 62, 77, 84)

CLIMATE PROJECTIONS

- 1.2 (RCP 2.6)–2.2°C (RCP 8.5) increase in temperature by 2050
- + 53mm to -56 mm change in precipitation by 2050
- Increased frequency of floods and storms
- Increase in severe drought by 2050

KEY CLIMATE IMPACTS

Agriculture, Livestock and Livelihoods

Crop loss/failure
Shifting planting/harvest seasons
Increased food spoilage
Increased presence of pests/diseases

Health, Nutrition and Water Resources

Increased food insecurity
Increased vector- and waterborne diseases
Declining water security
Increased heat stress
Increased hunger and malnutrition

November 2019
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.

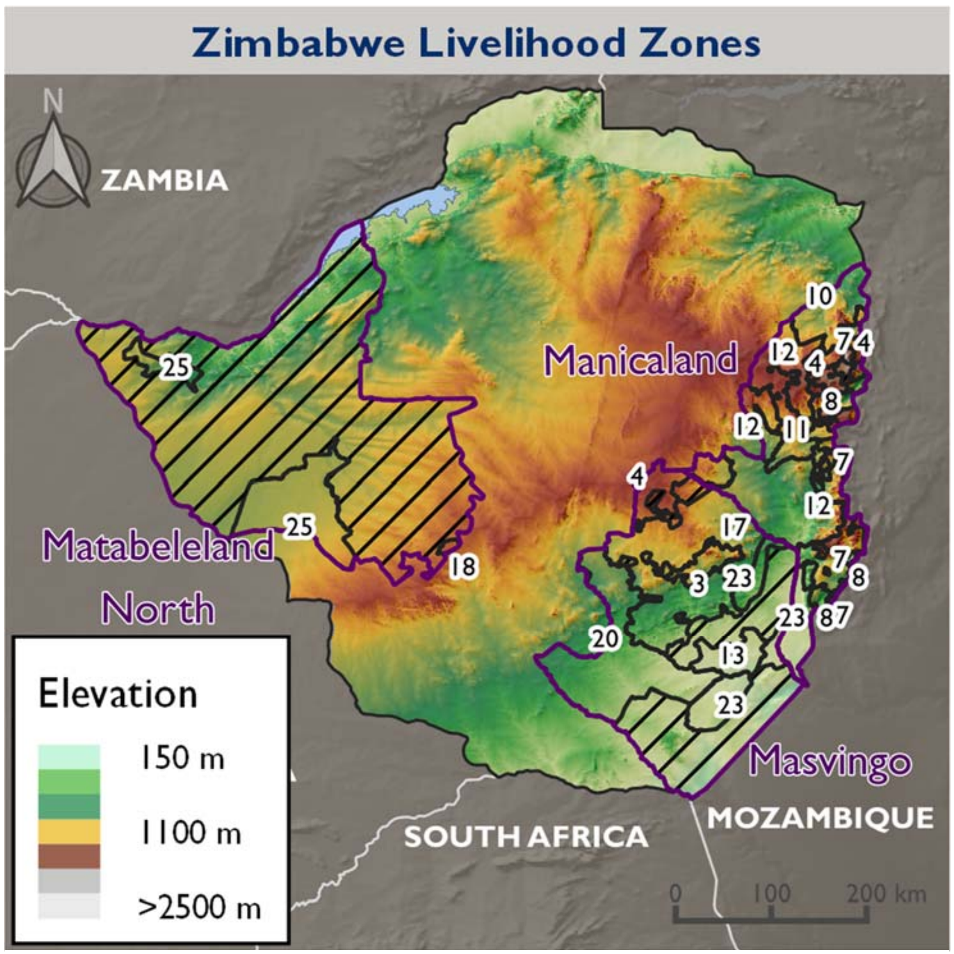
LIVELIHOODS AND CLIMATE IN FOOD FOR PEACE PROGRAM AREAS

In Zimbabwe, the USAID Food for Peace (FFP) development food security activities aim to sustainably improve food security and reduce the need for humanitarian assistance in the provinces of Manicaland, Masvingo and Matabeleland North. (69, 71)

LIVELIHOOD ZONES

Zimbabwe's agriculture sector underpins the country's economy, food security and poverty reduction efforts; and is the main source of livelihood for 90 percent of rural households. The sector contributed between 10–15 percent of annual GDP between 2000 and 2017, employing nearly 70 percent of the population. Over the last decade, however, agriculture's share of GDP hovered around 10 percent or less annually due to a combination of economic shocks and variable rainfall. Rainfed agriculture (e.g., maize, millet, sorghum, wheat, though the latter is not grown in FFP areas) is the norm in the sector, rendering the livelihoods of rural communities highly vulnerable to erratic rainfall patterns, recurrent droughts, and extreme weather events (e.g., floods, cyclones) that are exacerbated by climate variability and change. Zimbabwe's topography creates a country of contrasting agriculture and livelihood profiles. High potential prime (resettled) areas in the highlands are found alongside drier, lower-lying valleys, all within the same administrative districts. Table 1 provides more information and details of the livelihood zones and climate-related hazards in the FFP program areas. (14, 62, 63, 71, 84, 85, 88)

Figure 1 Zimbabwe Livelihood Zones and FFP Geographies



Source: FEWS NET 2011

Regionally, subsistence agriculture, supplemented by other sources of income, high concentrations of commercial farms dominated by maize, and designated resettlement areas for poor and middle-income small-scale farmers characterize the FFP program area of northern Manicaland. Total crop production is lower in the more arid southern and western provinces of Matabeleland North and

Masvingo due to low and erratic rainfall and underdeveloped irrigation systems; therefore, livestock are more prominent there. Many of the FFP program areas have high population densities, often leading to small individual landholding sizes; as a result, wealth and food security are driven by land area available to each household, land access and oftentimes livestock ownership. In these areas, the main source of food is subsistence farming, which is not sufficient to meet the annual needs of lower-income households. As a result, lower-income households rely on other income-generating opportunities to make ends meet, including casual labor (e.g., on cotton fields, game parks, ranches or mines), cash cropping (e.g., groundnuts, cotton, tobacco), gold panning, employment in other mining and timber harvesting, sales of traditional handicrafts, and remittances from migratory labor in South Africa and Botswana. When faced with food shortages, poorer households will supplement their diets by increasing their consumption of wild fruits, mushrooms and insects. (14, 28, 49)

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

Livelihood zone	Main livelihood sources	Annual rainfall	Main climate-related hazards
Zone 3: Bikita Zaka Highlands Communal (Masvingo)	Intensive farming of maize and groundnuts on this relatively high-potential land provides better-off farmers with a stable food and income source. Lower-income households rely on a combination of crop production and casual labor. The zone is densely populated, resulting in small farm size. Wealth is linked to land access, livestock ownership and remittances. Poor households do receive food aid from NGOs and the government. There is a poor mix of maize cultivation with gold panning and local employment on farms and in mines.	600–800 mm	Droughts, dry spells, fires, crop pests and livestock diseases (e.g., fall armyworm, foot and mouth, anthrax, Newcastle disease among chickens)
Zone 4: Central and Northern Semi-Intensive Farming (Manicaland)	Rainfed agriculture – mainly of maize and small grains – characterizes this zone and provides both food and cash income. In normal years, harvests of better-off, resource-rich households, plus remittances, translate into self-sufficiency in food and cash income. Cash crop (such as soya beans, cotton, and tobacco) and cereal sales are important sources of income for these households and wealth is linked to land area cultivated. Poorer households with small landholdings depend equally on own food crops, daily wages from casual labor, gold panning, and food aid.	650–800 mm	Droughts, deforestation, fires, dry spells, malaria, crop pests and livestock diseases (tick-borne disease)
Zone 7: Eastern Highlands Commercial Farming (Manicaland)	Livelihoods in this high-potential mountainous, forested zone are centered on commercial farming and timber. Most of the produce, which includes fruit, vegetables, flowers, tea and coffee, supplies the export market. Commercial farms and sawmills offer vital employment for poor farmers as well as for farm workers, both of whom often need additional seasonal work to supplement on-farm income. The main source of food is the market using cash earned from casual labor.	750–1,000 mm	Cyclones, fires and malaria
Zone 8: Eastern Highlands Prime Communal (Manicaland)	This high-density, productive mountainous zone is characterized by intensively farmed small plots of mixed food and cash crops. Due to small farm sizes, most households rely on market purchases to meet food needs. Maize is the primary crop, but diversity is a key feature here (e.g., cereals, root crops, fruits, tea/coffee, tobacco, wheat). Poor farmers find wage work locally in the commercial agriculture or forestry sector and engage in local trade, mineral panning and mushroom sales.	750–1,400 mm	Insufficient precipitation, cyclones, fires and livestock diseases (tick-borne and internal parasites)

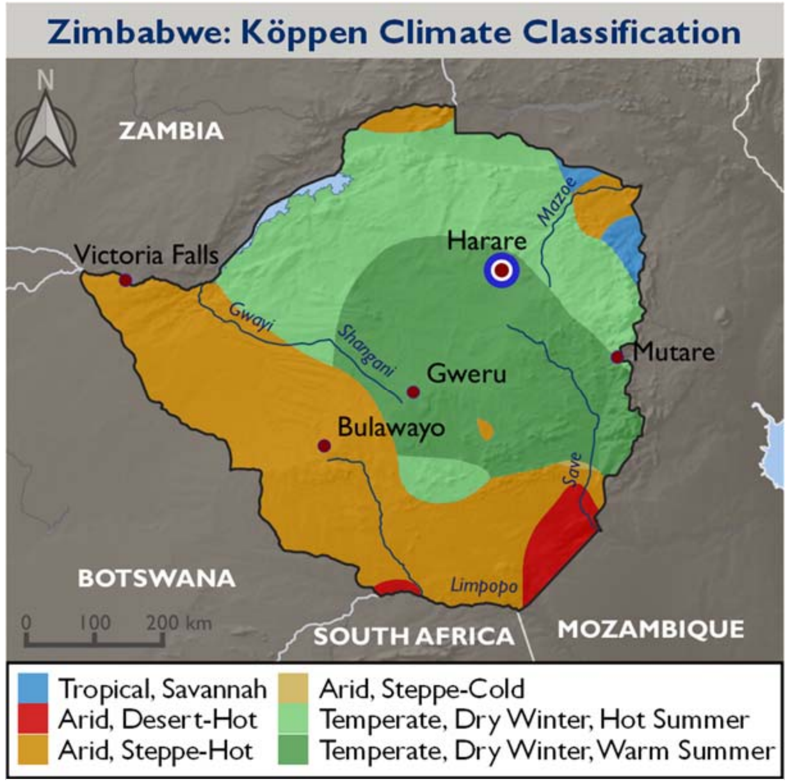
Table 1: Livelihood zones and climate in Zimbabwe's FFP program areas			
Livelihood zone	**Main livelihood sources**	**Annual rainfall**	**Main climate-related hazards**
Zone 10: Greater Mudzi Communal (Manicaland)	Livelihoods in this northeastern zone depend on the extensive, rainfed cultivation of maize, small grains and groundnuts; production is supplemented by income through cotton, gold panning, animal husbandry and employment. Own crop production is the primary food source for most households; in low yield seasons, all households depend heavily on the market to meet needs. Poor households have diversified income sources, including casual labor, gold planning, wild foods sales. Better off households earn cash through cash crop and livestock sales.	<750 mm	Erratic rainfall, drought, water- and vector-borne disease (malaria, cholera), fires, crop pests (armyworm), and livestock diseases (anthrax)
Zone 11: Highveld Prime Cereal and Cash Crop Resettlement (Manicaland)	This northern and central livelihood zone is characterized by some of the most fertile soils in the country; the majority of households in this zone are resettled and depend on rainfed food and cash crop production (maize, tobacco, soya beans, groundnuts, and some wheat). Since the government's land resettlement program, the zone has seen an increase in mixed farming (livestock and crops). Aside from smallholder farmers, large scale dairy farms are a major market for landless laborers, who rely on the market for food. Poor households rely on land cultivation, employment, food gifts, and some food aid to make ends meet.	750–1,000 mm	Droughts, dry spells, fires, crop pests, deforestation and livestock diseases (foot and mouth)
Zone 12: Highveld Prime Communal (Manicaland)	This is a prime agriculture zone, densely populated with high productivity of diverse rainfed cash and food crops that sustain the livelihoods of most households. Maize is the staple food crop; vegetables, sunflower, tobacco, and cotton are the main cash crops. Unlike many of Zimbabwe's livelihood zones, crop production is the most important source of food for all households. Wealth is linked to land area and livestock ownership. All households, especially middle and better off, generate significant income through cash crop sales. However, dependence on cash crops renders farmers vulnerable to fluctuating prices and markets. Poor households supplement incomes through casual labor.	650–1,000 mm	Erratic rainfall, fires, siltation, deforestation, crop pests (armyworm), and livestock disease
Zone 13: Irrigated Commercial Sugar and Fruit Farming (Masvingo)	Livelihoods are heavily dependent on permanent and long-term employment on irrigated commercial sugar and fruit estates southeastern Zimbabwe. The main source of income and cash are estate employment, seasonal work, and some small-scale trading. Due to low annual precipitation, agriculture is based on irrigation. Food is almost entirely purchased from established supermarkets and flea markets.	372 mm	Drought, Water- and vector-borne diseases (malaria, cholera)
Zone 17: Masvingo Manicaland Middleveld Smallholder (Manicaland, Masvingo)	Livelihoods in this zone are primarily agricultural, but due to the drier climate, crop production is supplemented by cash cropping (groundnuts, round nuts, cotton), animal husbandry and remittances from migratory labor. Sales of wild fruits, vegetables, beer and handicrafts, gold panning, legal gold mining and casual labor are other income sources for poorer households. Rainfed crop production and market purchases are the main sources of food. With increasingly unreliable sources of food, poor households respond by migrating to neighboring countries (e.g., South Africa).	450–800 mm	Droughts, dry spells, erratic rainfall, malaria, fires and crop pests (quelea birds)

Table 1: Livelihood zones and climate in Zimbabwe's FFP program areas			
Livelihood zone	**Main livelihood sources**	**Annual rainfall**	**Main climate-related hazards**
Zone 18: Matabeleland Middleveld and Highveld Communal (Matabeleland North)	Livelihoods in this zone are characterized by cereal agriculture and cash cropping (groundnuts, roundnuts, cotton), but due to the semi-arid climate, crop production alone is an unreliable source of food and income. For better off households, animal husbandry makes up the balance. Poorer households earn cash income through gold mining and panning, beer sales, and casual/seasonal employment. Households engage in fishing activities are pronounced around Lake Mutirikwi as well. Wealth is determined by area and quality of land, livestock ownership and remittances.	450–800 mm	Erratic rainfall, water- and vector-borne diseases (malaria, cholera), fires, crop pests (quelea bird), and livestock disease (anthrax)
Zone 20: Mwenzi Chivi and South Midland (Masvingo)	Livelihoods depend on crop production, livestock production, casual employment and remittances. Poverty and food insecurity are chronic in this resource-poor zone, which experiences erratic rainfall and consequently unreliable harvests. The main cultivated crops include cereals (millet, sorghum), maize, legumes and some cash crops. Casual and seasonal work opportunities for the poor are found on plantations, estates and mines within and outside the zone. Sales of livestock and *mopane* worms (a staple part of the diet in rural areas) provide some safety net and can be sold for cash to meet food needs.	500–600 mm	Droughts, dry spells, erratic rainfall, flooding, crop pests (quelea birds) and livestock diseases (foot and mouth, anthrax)
Zone 23: Save River Valley and Ndowoyo Communal (Manicaland, Masvingo)	This is a dry, primarily agricultural, lowland area in the country's southeastern region. Despite good soils, erratic rainfall limits cereal and cash cropping (wheat, soya beans, tomatoes). Consequently, livelihoods depend on a mix of communal agricultural production of mainly small grains (sorghum, millet), maize and groundnuts, animal husbandry, petty trading and seasonal casual employment. Remittances are also increasingly important to household income. Own crop production is rarely sufficient for households' food needs and is supplemented by market purchase, food aid and consumption of wild foods.	450–600 mm	Droughts, floods, erratic rainfall, fires, crop pests (quelea birds) and livestock diseases (Newcastle disease among chickens)
Zone 24: Cattle and Cereal Farming (Matabeleland North)	Livelihoods in this large central and southern zone rely on livestock ownership (primarily cattle) and crop production of cereals. It is characterized by resettled smallholder and some large-scale commercial farmers. Cattle are found in large numbers, as soils are more suitable for livestock than agriculture. The main crops include maize, sorghum and millet with some irrigation schemes including winter wheat. Wealth is determined by land access and production potential. For farm owners, cattle and cattle sales, surplus cereals, and game are the main sources of income. Farm workers rely primarily on agricultural employment and can earn cash through gold panning, mopane worms, poaching, and laborers in mines.	650–800mm in northeast; <450mm in the southern and central part	Erratic rainfall, drought, bush fires, livestock disease
Zone 25: Western Kalahari Sandveld Communal (Matabeleland North)	Livelihoods in this resource-poor, arid, low-lying zone are based on rainfed cultivation of sorghum and millet coupled with livestock. Livestock holdings are generally higher than in northern regions, with nearly all households owning some livestock. Remittances from cross-border labor migration to major markets in South Africa and Botswana are an important aspect of the household economy in this western zone. Poor households typically produce small harvests and depend heavily on market purchases, the labor market, and food gifts and aid for food and cash income.	450–650 mm	Erratic rainfall, droughts, dry spells, fires and crop pests (quelea birds, crickets)

Source: [FEWS NET 2011](). Livelihood zone in map also noted by number.

CLIMATE SUMMARY

Figure 2 Zimbabwe According to the Köppen Climate Classification



Source: Peel, M.C. et al. 2007; ORNL DAAC, 2017

Zimbabwe has a primarily semi-arid climate characterized by its topography. The landscape is dominated by a high central plateau (called the "highveld") and a high watershed that sits between 1,200 to 1,600 meters (m) above sea level and experiences a subtropical climate. The hot, dry Kariba Valley and a series of mountain ranges line the country's eastern boundary. The lowlands (called the "lowveld") include the major low-lying river valleys of the Zambezi (northern region) and Limpopo (southern region) Rivers and have a tropical climate. Two distinct seasons are recognized: a rainy season with high temperatures (October to March) and a dry season with low temperatures (June to August). Mean annual precipitation has historically shown substantial variability from year to year; total mean annual rainfall ranges from 300 mm (millimeters) in the southwestern region to over 1,000 mm in the northeastern region of the country. Rainfall seasonality is also heavily influenced by the equatorial, tropical rain belt, the Inter-Tropical Convergence Zone (ITCZ) —the southern migration of the ITCZ brings more rainfall during the southern hemisphere winter, and less when it migrates north. Zimbabwe's relatively high elevation has a moderating effect on temperatures; average temperatures vary from 10°C in Manicaland to 30°C in Masvingo and Matabeleland North. In the south- and north-eastern lowveld areas, temperatures can rise to over 40°C in the summer. (1, 6, 14, 43, 62)

Climate-related hazards in Zimbabwe include shocks such as drought, dry spells (less severe than droughts and defined below), cyclones, and heavy rainfall-induced riverine floods, and gradual onset stressors, such as average temperature increase and long-term changes in rainfall patterns. Droughts, dry spells and flood cycles occur almost yearly, with districts in Matabeleland North and South and Masvingo most at risk of drought. Drought involves a deficiency of precipitation resulting in reduced soil moisture and diminished plant growth over prolonged periods of time. Dry spells, defined as at least 10 consecutive days of dry weather occurring after the onset of the rainy season, lead to early drying or loss of seasonal water sources and have consequences for crop production and yield (e.g., maize, millet, sorghum). The correlation between El Niño events and droughts is high, with these events resulting in lower-than-average rainfall for the whole of southern Africa. This was especially marked during the 2015 El Niño event, when with below-average rainfall in the preceding rainy season, resulted in the worst drought in 35 years. Nearly 2.8 million people were deemed food insecure and more than 23,000 livestock perished due to lack of water, pasture or drought-related disease. (1, 6, 9, 14, 26, 41, 57, 61, 62, 63, 87)

Although landlocked, east and southeastern Zimbabwe—including Manicaland and parts of Masvingo—are also affected by tropical cyclones that develop in the Indian Ocean and generate intense rainfall and subsequent flooding. In March 2019, heavy precipitation and riverine flooding from Cyclone Idai affected infrastructure, properties, and the livelihoods of over 270,000 people across seven districts in Manicaland and Masvingo. The cyclone compounded the already negative impacts of the El Niño-induced drought, ravaging large tracts of agricultural land and further heightening the emergency levels of food insecurity for over one million people. (102, 103, 104).

CLIMATE TRENDS AND PROJECTIONS

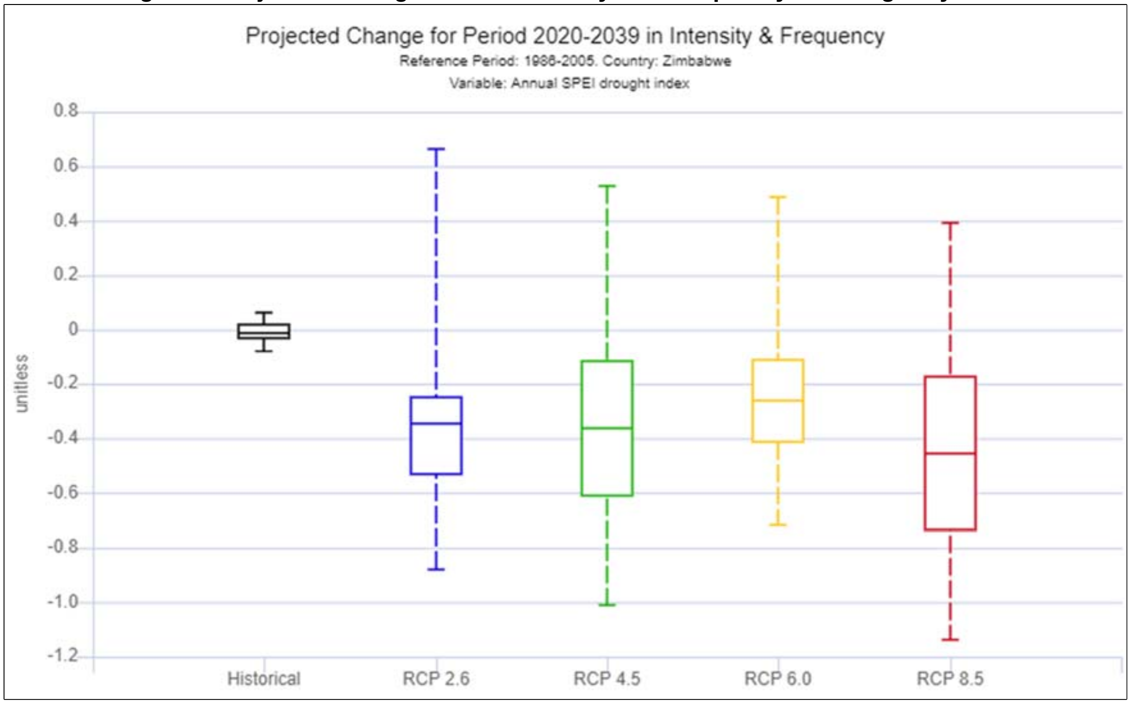
Climate models project that Zimbabwe will become both hotter and drier over the next century. Temperatures are projected to increase across all regions: 1.2 (RCP 2.6)–2.2°C (RCP 8.5) by 2040–2059, with slightly higher warming projected for the southern and western parts of the country. Climate models disagree on the direction of change in average annual precipitation, with some models projecting an increase in the long-term and others projecting a decrease. Mean annual precipitation models indicate high uncertainty in the direction and amount of change, though there is some agreement that in the aggregate, mean annual rainfall is likely to decrease; by 2050, the country could see a change in precipitation from + 53mm to -56mm. Rainfall reductions are projected to be the most pronounced during the rainy season (from October to March); there is also evidence that the rainy season is already starting progressively later than it has historically; this trend is projected to continue. Significant variability exists in regional rainfall projections, however, with the northern and eastern parts of the country expected to experience an increase in precipitation. The southern and western regions, including parts of Manicaland (5.8 percent) and Masvingo (4.7 percent), are projected to experience the largest decreases in rainfall. Finally, the Standard Precipitation and Evapotranspiration Index (SPEI) indicates that Zimbabwe will also likely see an increase in the frequency and intensity of severe droughts by 2050 (see Figure 3). These projections are summarized in Table 2. (1, 6, 8, 26, 62, 84)

Table 2: Climate trends and projections

Parameter	Observed trends (since 1901)	Projected changes (2040–2059)
Temperature	• Increased temperature of 0.9°C between 1901–2012, with most warming occurring after 1980 • Altitudinal variability in maximum temperatures, with a pronounced increase at all altitudes since 1980 • Increase in number of hotter days and fewer cold days since 1950; daily minimum and maximum temperatures increased between 2.6°C and 2.0°C, respectively	• Increase in average annual temperature of 1.2 (RCP 2.6)–2.2°C (RCP 8.5) by 2050, with highest changes projected in the south and west • Increase in days with maximum temperatures >35°C by 39 days in 2050
Rainfall	• Decline in rainfall of 5 percent since 1915, with marked reductions in the south and southeast • Increased temporal and spatial variation of mean annual rainfall, particularly during the rainy season • Increased frequency and length of dry spells during the rainy season	• Decrease in annual average precipitation by 1.2 percent (RCP 2.6) and 4.4 percent (RCP 8.5) • More variable precipitation trends, with some models projecting an increase in the long-term and others projecting a decrease • Longer consecutive dry spells by 13 days in 2050
Drought	• More frequent droughts • Between 1991 and 2016, Zimbabwe experienced six moderate to severe droughts, of which four were linked to El Nino events	• Likely increase in severe drought in 2050, with the south and west most at risk

World Bank 2019. UNDP 2017. GoZ 2016. Mtetwa 2018.

Figure 3 Projected Changes in the Intensity and Frequency of Drought by 2040



Source: *World Bank 2019*

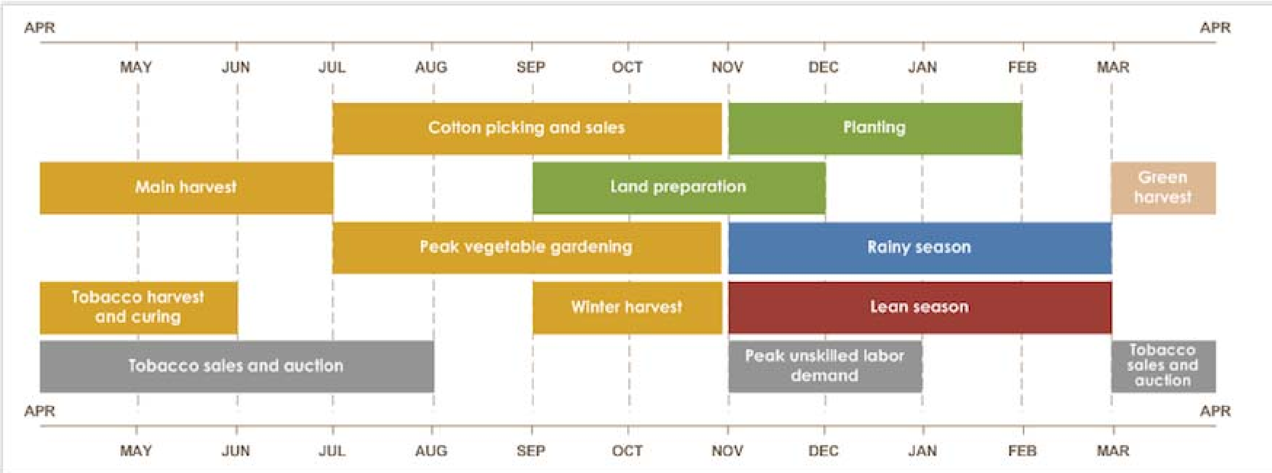
SECTOR IMPACTS AND VULNERABILITIES

CROP PRODUCTION

The introduction of Zimbabwe's fast-track land reform program in 2000 brought significant changes to the agrarian sector. While the government's intent was to more equitably redistribute land from commercial farmers to poor and middle-income Zimbabweans, the short-circuited policy framework and constrained institutional and financial capacity of the agricultural sector to implement and withstand these changes negatively impacted crop production nationwide. Reduced area plantings and limited access to agricultural inputs (e.g. machinery, equipment, seeds, etc.) for the newly resettled peasantry resulted in a shift away from a thriving, large-scale commercial agriculture system to small- and medium-sized land cultivation. Coupled with rising temperatures and interannual precipitation variability, this caused a sharp decline (62 percent) in crop production by 2008; major crop yields today are only one-half of their pre-2000 levels.

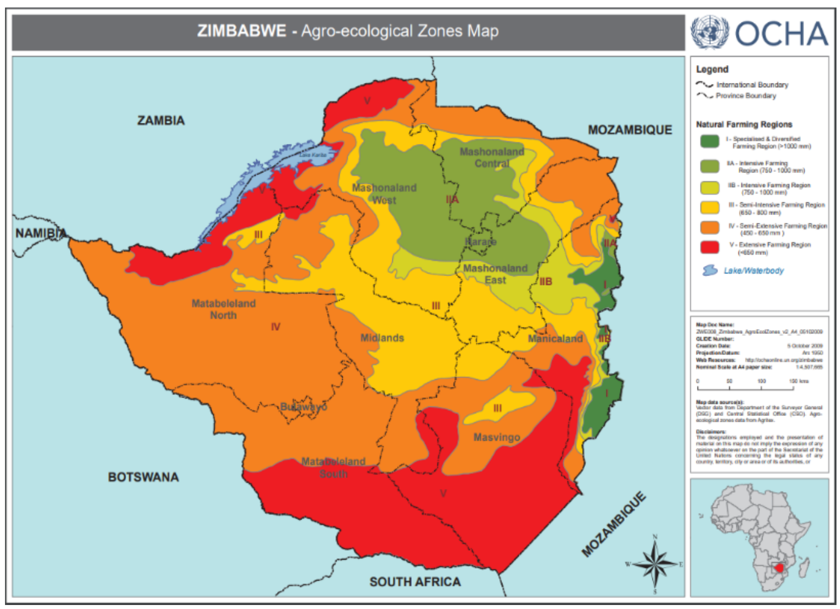
Today, most crop production in Zimbabwe is rainfed (80 percent), subsistence-oriented and done by small-scale farmers. Small-scale farmers, many of whom do not have access to irrigation or other inputs, provide approximately 70 percent of the country's staple crops (e.g., maize, wheat and small grains). These factors render the sector highly sensitive to increasingly frequent extreme heat, erratic rainfall patterns, droughts and floods, all of which have significant negative implications for food security in FFP's target rural communities. For example, changes in the timing and duration of the rainy season can jeopardize crop yields and have devastating livelihood impacts on poor smallholder farmers whose window for planting is limited to November to February (Figure 4). (11, 41, 42, 95, 74, 77, 85)

Figure 4 Cropping calendar in Zimbabwe



Source: [FEWS NET 2013]

Figure 5 Zimbabwe's agroecological zones



Source: [UNOCHA 2009]

Zimbabwe is prone to a range of climate hazards that impact crop production, erode soils, damage crops and can lead to food insecurity and subsequently acute malnutrition. Crop production choices are strongly dictated by the country's natural agroecological regions, which in turn are determined by the amount of rainfall, soil quality, vegetation and temperature (Figure 5); regions IV and V, which encompass the FFP program areas, are the first to be affected by drought. Even without considering climate stressors, population growth, limited growth, low access to farm inputs (e.g., fertilizers), deforestation, soil degradation and land use changes impact the sector and limit its adaptation options. (43, 64, 66, 77, 84)

Additionally, projected declines in average annual precipitation in all but two Zimbabwean water catchments will render existing sources of water more unreliable; the drier southern Runde and Mzingwane catchments that dominate Masvingo Province will be disproportionately impacted. Irrigated and dryland agriculture in these areas will also face reduced yields due to persistent drought, declines in runoff, higher temperatures and increased evaporation, jeopardizing food security. (9, 23, 25, 41, 46, 51, 86, 90, 92)

Grains and cereals, including maize, millet, sorghum and wheat, are the main staple food crops in Zimbabwe. Maize, which dominates the national diet, is cultivated on one-half of Zimbabwe's agricultural land and accounts for 80–90 percent of domestic staple crop production. It is grown primarily in the north and east, while sorghum and millet dominate the less arable southern and western zones. Tobacco, cotton and sugarcane are the major export crops; Zimbabwe is the sixth largest tobacco exporter in the world. In the FFP program areas, the dominant crops are cereals, including maize, sorghum and millet, groundnuts, small grains, fruits, tea and coffee. However, Zimbabwe has seen a substantial decline in agricultural production since 2000 due to a combination of erratic seasonal rainfall patterns, drought, low soil fertility, and institutional and policy factors related to the country's Fast Track Land Reform. From 2002 to 2017, in order to meet domestic requirements, Zimbabwe became a net importer of maize. In 2007, for example, only 45 percent of national cereal requirements were produced in the country, leaving the deficit to be covered by imports, mostly from South Africa and Zambia. Rising temperatures and increasing rainfall variability, especially drought, are likely to accelerate declining crop production of highly sensitive crops, including maize, sorghum and millet, further compromising food security, economic growth and poverty. (4, 12, 29, 21, 41, 62, 79, 84)

Maize is particularly vulnerable to a more variable climate due to drought intolerance. National maize production has seen a strong negative trend from 1993 onward, with decreased production linked to the abovementioned land tenure changes, droughts and prolonged dry spells (e.g., 2001/02, 2004/05, 2006/07, 2011/12, 2012/13, 2015/16, and 2018/19). During the 2015/16 cropping season, national maize production decreased by 35–50 percent below the five-year average (2010–2015), mainly as a result of below-average rainfall and ENSO-related drought conditions. While more drought-tolerant than maize, sorghum and millet only play a small role in household food security, due to a combination of poor crop management, declining soil fertility, taste preferences, high production costs and limited access to high-quality seeds. Production trends for both crops have also fluctuated in the face of low rainfall and recurrent drought. The availability of wild fruits and other safety net food security options is also affected by extreme temperatures and increased rainfall variability, adversely impacting the livelihoods of poorer farmers. Prolonged, more frequent and intense drought events, therefore, are expected to lead to poor harvests and food supply deficits. By 2050, the yields for maize and cotton are expected to decrease due to their thermal tolerance, with yield declines in excess of 30 percent (Table 3). If no adaptation responses are taken, crop net revenues could decline by as much as 90 percent by 2100. (19, 30, 33, 36, 41, 47, 49, 57, 84)

In addition to these challenges to food security, changes in climate could create conditions more conducive to the increased spread of new agricultural pests, posing threats to key staple crops, specifically maize and sorghum. The advent of fall armyworm across southern Africa, including Zimbabwe, further demonstrates the devastating consequences of the country's overreliance on maize for food security. A case study of smallholder farmers in Chipinge and Makoni Districts in Eastern Zimbabwe determined that in 2016, fall armyworm destroyed approximately 11.6 percent of maize yields; other studies conducted continent-wide estimated losses between 21 and 53 percent, compounding the impacts of the 2015–2016 drought that had already left over 4.2 million people dependent on food aid. More than 50 years of data on the closely related African armyworm (as opposed to the fall armyworm) indicate that its incidence increases after droughts. If proper control measures are not implemented, the pest could cause extensive maize yield losses annually, estimated between $76 million and $191 million in Zimbabwe, according to the Centre for Agriculture and Biosciences International (CABI). Thus, the projected lengthening dry seasons and persistence of drought conditions brought on by climate change could lead to increasing armyworm infestations. (5, 38, 70, 71, 75, 84)

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

Table 3: CROP PRODUCTION—Climate sensitivities of key crops	
Crop	**Climate sensitivities**
Maize	• Very susceptible to rain failure • Small changes in rainfall patterns/amounts and temperatures lead to appreciable yield loss • Sensitive to temperatures over 35°C • Sensitive to drought during flowering period • Warmer temperature leads to faster growth but lower yields
Sorghum	• Sensitive to moisture stress during grain-filling stage when dry periods of 2 weeks or more significantly diminish yields • Poor performance if rainfall is less than 450 mm • Temperatures more than 35°C can reduce yields • Hot, dry conditions increase risk of damage from khapra beetle and *Striga* (purple witchweed); hot, wet conditions increase risk of sorghum midge, anthracnose, sorghum downy mildew and zonate leaf spot
Millet	• Poor performance if rainfall is less than 275 mm; excess rain during flowering can cause crop failure • Sensitive to temperatures over 34°C • Sensitive to longer periods of drought during seedling stages • Longer midseason stress in grain-filling and post-flowering periods leads to lower yields • Requires evenly distributed rainfall during growth period; does not go into dormancy during drought like sorghum

Sources: USAID 2013; van Oort 2017; Reynolds et al. 2015; Steward et al. 2018; ICRISAT 1984; USAID Sector Environmental Guidelines 2014; USAID 2017; USAID 2014.

Table 4: CROP PRODUCTION	Climate stressors, risks and responses
Climate stressors	**Climate risks**
Rising temperatures **Erratic rainfall**	• Water scarcity, reduced soil moisture and increased erosion
Longer and more intense dry spells	• Crop failure and reduced yields; increased food prices
Increased intensity and frequency of droughts	• Increased incidence of pests (e.g., locusts, fall armyworm)
Increased intensity and frequency of floods	• Waterlogging/crop damage

Source: USAID Sector Environmental Guidelines Agriculture 2014; USAID Sector Environmental Guidelines Crop Production 2014

LIVESTOCK

Livestock are an important source of food, income, capital and draught, and also serve as a financial safety net for Zimbabwean households in times of heightened climate-related stress or other shocks. The livestock sector in Zimbabwe is dominated by cattle, sheep, goats, poultry, and pigs. While typically more resilient to climate variability and shocks than crops, livestock are susceptible to heat stress, and their viability is affected by the productivity and availability of pasture, feed production, water availability, and pest and disease dynamics. Geographically, livestock are more important in the drier, more climate-sensitive southern and western regions, including the FFP program areas of Matabeleland North, and parts of Manicaland and Masvingo. Masvingo Province has the highest proportion of households with cattle in the country. (22, 50, 49, 58, 62)

Cattle are critical for livelihoods: 60–75 percent of households own cattle; 90 percent of these households are smallholder farmers. Ownership of cattle in rural areas, in particular, is important for the resilience of smallholder farmers as it reduces vulnerability to climate shocks and stressors. Cattle offer a fallback option for both better-off and poorer households to fill food gaps caused by crop failure and a rebound measure from climate shocks through cash sales or, primarily for middle and better-off households, through the consumption of meat and milk. However, recurrent droughts, increased temperatures and water stress are likely to negatively impact livestock production. These stressors could decrease forage, fodder and water availability and degrade the productivity and quality of pasturelands, leading to disease, malnutrition and loss of livestock. During the 2015–2016 drought season, 27 percent of reported cattle deaths were drought-related due to poor grazing and lack of water. This demonstrates that increased heat and water stress will continue to affect livestock production, food security and poverty in the country's semi-arid regions. (13, 18, 20, 22, 26, 49, 53)

Poultry (e.g., chickens, ducks, turkeys, guinea fowls and pigeons) and small ruminants (goats and sheep) are also key assets that households consume or sell for cash income. Chickens are the most important, in number and in terms of social and economic significance—over 55 percent of households own chickens and/or ducks. Small ruminants are more tolerant of dry conditions and higher temperatures than chicken and cattle, and poultry production has a quick turnover and low investment needed. While these conditions make owning both poultry and small ruminants attractive adaptation options, climate stressors also pose added challenges to the production of these assets. However, chickens are sensitive to rising temperatures, which are likely to impact the range, transmission rate and outbreak of certain livestock diseases (e.g., Newcastle disease, *coccidiosis* and anthrax). The increased frequency of drought has led households to "de-stock" and sell their productive assets to cope with these shocks. However, research demonstrates that during times of high stress and food insecurity, households are paid far below the normal market price for livestock. Notably, during the 2015–2016 drought the price of cattle in high rainfall areas ranged from $350–$450, but communities in low rainfall districts were selling cattle for as little as $20 to buy food. (22, 26, 62)

Climate variability and change will pose added challenges to the health of Zimbabwe's livestock. The risk of livestock disease is likely to increase with lower mean annual precipitation, which combined with heat stress and more intense rainfall events is expected to create conditions conducive to the increased incidence and range of pests and diseases. Examples include Newcastle disease in chickens, Rift Valley fever, Theilerioses (January disease) and zoonoses, including anthrax and foot and mouth disease, which are already common in the FFP program areas. Low rainfall conditions during the 2015–2016 drought, for example, caused livestock disease rates to skyrocket, accounting for 61 percent of reported cattle deaths, of which Manicaland and Masvingo experienced the highest proportion. Between November 2017 and May 2018, a combination of late, heavy rains and a shortage in cattle dip led to over 3,000 cattle perishing from tick-borne diseases, primarily Theileriosis. In addition, severe floods can contribute to significant losses in livestock by destroying key infrastructure, including dip tanks and paddocks. As a result, livestock become more susceptible to malnutrition, pests and disease. Stressors and risks for livestock are listed in Table 5. (18, 26, 38, 45, 51)

Table 5: LIVESTOCK – Climate stressors and risks	
Climate stressors	**Climate risks**
Rising temperatures **Erratic rainfall** **Longer and more intense dry spells** **Increased intensity and frequency of droughts** **Increased intensity of extreme events**	• Increased incidence of pathogens, including parasites
	• Reduced livestock reproduction and growth rates due to heat stress
	• Increased rate of livestock loss due to heat and water stress impacting fodder and pastureland quality
	• Changes in the distribution and presence of disease vectors (e.g., mosquitoes, ticks, fleas)
	• Drying pasture, decreasing grazing potential
	• Early drying of seasonal water or diminishing water points

Source: USAID Sector Environmental Guidelines Livestock 2015

HUMAN HEALTH, NUTRITION AND WATER, SANITATION AND HYGIENE (WASH)

The increased frequency and/or intensity of floods, storms, fires and droughts are expected to impact human health, nutrition, and WASH across Zimbabwe. The most recent drought in 2015–2016, which was followed by intense floods, rendered more than 25 percent of Zimbabwe's population in need of food assistance. These climate shocks are expected to expand the geographical range of malaria and dengue and increase the burden of waterborne and diarrheal diseases (e.g., cholera). Table 6 lists stressors and risks for human health, nutrition and WASH. (1, 39, 60, 62)

Human Health and Nutrition

Even though malaria transmission decreased by 81 percent between 2003 and 2015, the country continues to experience a perennially high number of malaria cases. It is the third leading cause of morbidity and mortality in Zimbabwe, with over one-half of the population at risk of contracting malaria annually. By 2050, changes in temperatures and precipitation will likely alter malaria transmission and distribution limits; most of the country could be affected by the disease. Previously unsuitable areas with dense human populations are expected to become suitable for transmission, with increased intensity and frequency of floods creating breeding grounds for malaria parasite-carrying mosquitoes. Floods can either reduce or increase malaria incidence, depending on the nature of the flood itself. Rapid flooding can wash out mosquito breed areas, reducing larval numbers. However, slower moving floods that linger for extended periods of time, create stagnant water that is a breeding ground for mosquito larvae. The highest malaria risks will be concentrated in the Zambezi River Valley and southeastern low-lying regions, including Masvingo and Manicaland. The increasing geographic range of infectious disease vectors will also affect people living with other health risks such as HIV/AIDS. (1, 4, 7, 37, 60)

While Zimbabwe's population has seen notable reductions in HIV/AIDS, from 25 percent of the population afflicted in 2002 to 13.3 percent in 2017 (the average in Sub-Saharan Africa is 6.1 percent), HIV/AIDS prevalence is likely to exacerbate the negative effects that more frequent droughts and longer dry spells will have on nutrition, especially in low-lying, chronically food insecure regions. These areas include the FFP target province of Matabeleland North, which has the second highest HIV/AIDS incidence nationally. With heightened food insecurity, HIV/AIDS treatment may become increasingly difficult, as those with the disease have higher nutritional requirements for those with the disease. This creates a vicious feedback loop, with inadequate nutrition weakening the immune system and undermining overall nutrition status, leading to more disease-related deaths. The disease burden also reduces labor force productivity, which increases food insecurity. (4, 14, 59, 68, 91)

Although Zimbabwe has made progress toward reducing malnutrition, it remains a widespread concern in Zimbabwe, especially for children. The national acute malnutrition rate in Zimbabwe is 2.5 percent, which is classified as *"acceptable"* by the World Health Organization. Food prices are highly volatile, especially during the lean season, when the country can see price increases of 30–40 percent. High micronutrient deficiencies exist across all age groups; nearly 33 percent of all children below the age of five experience high stunting and 3 percent are wasted (weight-for-height). Boys are more likely to be more malnourished than girls. Manicaland has the highest overall prevalence of stunting among boys and girls nationally (26.2 percent), while wasting is highest in Matabeleland North. Recurrent drought and variable precipitation are expected to continue to be main drivers of stunting and wasting among children. Droughts decrease household food production, especially of staples, and reduce income and the ability to purchase food. These factors particularly affect households' ability to provide children with adequate nutrition. Finally, research points to an association between reduced malnutrition and both improved sanitation (reduction in open defecation) and hygiene practices (breastfeeding, complementary feeding, handwashing, deworming). (12, 13, 27, 64, 65, 84)

Water, sanitation and hygiene (WASH)

WASH remains a challenge nationwide; only 30 percent of the population has access to improved water and sanitation and over one-quarter of all households practice open defecation; Matabeleland North has the lowest access at 33 percent. Additionally, water availability and quality are also increasingly impacted by highly variable climatic conditions; national per capita water availability is projected to decrease by 38 percent to 1.52 milliliters per capita per year by 2050. Zimbabwe's groundwater resources are limited, and the country relies overwhelmingly on surface water for its water resources (about 90 percent). These challenges combined with more variable precipitation patterns, drought, and extreme weather events increase the risk of disease and water scarcity, hampering rural economic growth. (1, 9, 25, 86, 96, 97, 98)

Zimbabwe currently experiences recurrent outbreaks of cholera, typhoid, and other diarrheal diseases. The country experienced one of the world's largest recorded cholera outbreaks in 2008, that had a national morbidity rate of 4.3 percent, affected over 100,000 people and killed over 4,000. Diarrhea is also one of the top ten diseases affecting children in Zimbabwe, occurring in about 10 percent of children and causing around 4,000 deaths annually among children under 5 years of age. Increased temperatures and climate-related shocks (e.g. heavy rainfall events and floods), an unreliable potable water supply from surface and groundwater sources, and poor sanitation and hygiene practices are likely to increase the exposure to water-borne pathogens and the outbreak of epidemics. (2, 5, 7, 23, 99, 100, 98, 97)

Despite efforts to develop rural infrastructure, there is a striking imbalance in WASH services between urban and rural areas, Rural poverty and lack of infrastructure maintenance have resulted in a decline in WASH services; for example, more than 75 percent of hand pumps in rural areas are broken. Maintenance and repairs of supply systems especially in rural areas have virtually ceased. Increased precipitation intensity can overwhelm existing infrastructure, such as drainage, and lead to flooding that can contaminate drinking water (e.g., surface water, groundwater, and distribution systems). Septic systems and other waste management infrastructure may also become dysfunctional after extreme weather events, increasing the potential for disease outbreaks. (2, 5, 7, 23, 62, 90, 96, 97, 100)

Groundwater, albeit limited in quantity compared to surface water, is the main source of both clean drinking water for more than 70 percent of the rural population as well as for communal and commercial sectors. However, the planning, development and management of groundwater has received little attention from the government since the mid-1980s. The government has focused its attention on the provision of clean water from surface water resources, so almost no monitoring of groundwater levels or quality occurs. A decline in mean annual precipitation could reduce groundwater recharge, with potentially severe effects on rural populations, given their dependence on groundwater as a source of clean water. The Southern Africa Development Community (SADC) found that the population at high risk from groundwater drought could rise from 32 percent to 86 percent by 2100 as a result of climate variability and change. In the FFP program areas of Masvingo and Matabeleland North, groundwater extraction potential is already low, given their location within Zimbabwe's semi-arid agroecological natural zones. The arid conditions in these areas, exacerbated by projected higher temperatures, reinforce a drying climatic outlook with diminished water availability. (23, 26, 44, 80)

On average, 22 percent of households in Zimbabwe still lack access to basic water service for domestic use. Ninety-eight percent of those without basic water service live in rural areas. In 2009, 82 percent of households used basic drinking water at the household level (by boiling, using water tablets or bleaching); and over one-third of the country's children lacked basic water and basic sanitation services. According to the Sphere Standards, the maximum distance that any household should travel to access the nearest safe water source is 500 m. In Zimbabwe, more than 54 percent travel more than 500 m; 25 percent travel more than 1 km (kilometer). In rural areas, specifically, 28 percent of households require travel of 30 minutes or longer to obtain drinking water (Zimbabwe Demographic Health Survey ZDHS 2010/11). The FFP program areas of Masvingo and Matabeleland North have the highest proportion of households traveling more than 1 km to access safe water. Women in Zimbabwe's rural areas are predominantly responsible for collecting water and firewood. As droughts lengthen, women will have to travel longer distances to access water, exposing them to crime, theft, gender-based violence, and health risks related to high temperatures and heat waves. Stressors and risks for human health, nutrition, and WASH are listed in Table 6. (26, 62, 64, 89, 90)

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

Climate stressors	Climate risks
Rising temperatures	• Increased food insecurity, hunger and malnutrition from heat stress, flood and drought

Table 6: HUMAN HEALTH, NUTRITION AND WASH– Climate stressors and risks	
Climate stressors	**Climate risks**
Longer and more intense dry spells **Increased intensity and frequency of droughts** **Erratic rainfall** **Heavy rains, storms and floods**	• Expanded ranges of disease-carrying vectors (e.g., mosquitoes) and increased transmission of infectious diseases such as malaria, Rift Valley fever and dengue
	• Increased incidence of infectious diseases from reduced water quality, flooding and standing water
	• Increased incidence of diarrheal and other waterborne diseases (e.g., cholera)
	• Reduced water availability and quality

Source: USAID Sector Environmental Guidelines Small Healthcare Facilities 2014; USAID Sector Environmental Guideline: Water Supply and Sanitation 2015

PESTICIDE USE

Increasingly erratic rainfall patterns, warmer temperatures, and an increase in the intensity and frequency of mid-season dry spells may increase the risk of higher pest populations and consequently, of increased pesticide use and contamination in Zimbabwe. Since the 1980s, farmers in Zimbabwe have reported an uptick in pesticide use, specifically insecticides, which also corresponds to an increase in pest populations. Cotton is the most pesticide-intensive crop grown nationwide. It is the second most important cash crop and is primarily cultivated by smallholder farmers in four main regions, including Manicaland, Masvingo and Matabeleland North Provinces. Cotton growers make intensive use of pesticides to control major pests including aphids, *Heliothis* bollworm, stainers and red spider mites. Aphid populations in particular have been reported to explode during the rainy seasons following prolonged dry spells, increasing farmers' use of insecticides. Cotton farmers also use higher amounts of pesticides during dry conditions to sustain production levels, as lack of continuous rainfall results in higher aphid populations. The aphids weaken the cotton plants, so farmers increase fertilizer to counter this adverse impact of plant growth. (40, 72, 78, 94)

Additionally, as demand rises for fruits and vegetables to feed growing urban populations, small-scale, rural farmers located around urban centers intensively use pesticides to maximize yields. Regionally, pesticides are frequently applied without sufficient safety precautions being taken. Resource-poor farmers are often unwilling or unable to buy the appropriate safety equipment. Therefore, it is important to be aware of climate risks that may increase pesticide use in the agriculture sector, as well as the risks to human health that this increased use precipitates. Stressors and risks for pesticide use are listed in Table 7. (5, 93)

Table 7: PESTICIDE USE – Climate stressors and risks	
Climate stressors	**Climate risks**
Erratic rainfall **Longer and more intense dry spells** **Increased intensity and frequency of droughts** **Rising temperatures**	• Increased surface runoff
	• Increased percolation/groundwater infiltration
	• Increased threat from current pests/introduction of new pests
	• Reduced effectiveness of pesticides applied topically
	• Reduced effectiveness of pesticides that are activated/distributed by water

Source: USAID Sector Environmental Guidelines 2014; USAID Sector Environmental Guidelines 2015

INVASIVE SPECIES

Invasive species, both plants and pests, can reduce crop and livestock production, encroach on native biodiversity and increase production costs. Considerable evidence globally suggests that climate change will further increase the likelihood of invasive species gaining a foothold and/or expanding their range in areas where they are currently present (Table 7). Warmer conditions in Zimbabwe are already creating conducive environments for new crop pests and diseases. Many invasive species are, by nature, highly adaptable and are more likely than native species to thrive in a more variable climate. Food shortages resulting from fluctuations in temperatures and rainfall could stimulate significant movement of agricultural produce within and between continents, consequently leading to the increased risk of invasive species' encroachment and/or expansion. (23, 68)

The fall armyworm, tomato leafminer, cotton mealybug, larger grain borer and other newcomer pests, some of them adapted to shifting weather patterns, have arrived in Zimbabwe and are impacting already embattled farmers. The invasion of the fall armyworm in 2016 caused extensive maize yield losses in Zimbabwe, estimated at 263,000 tons and valued at approximately $83 million. If proper control measures are not implemented, more frequent and intense droughts could continue to expand the fall armyworm's reach and cause severe damage to maize production. Table 8 describes the most common invasive species in Zimbabwe and their link to climate. (38)

Table 8: INVASIVE SPECIES – Characteristics and link to climate		
Species	**Characteristics**	**Link to climate**
Tomato leafminer *Tuta absoluta*	Flourishes in relatively warm and short rainy season. Feeds primarily on tomato plants, tobacco and cassava and can lead to significant yield losses if uncontrolled.	High basal thermal tolerance. Thrives in temperatures ranging from 30–37°C; temperatures between 37–43°C limit spread and establishment
Fall armyworm *Spodoptera frugiperda*	A transboundary, fast-multiplying pest that, in its larval stage, feeds on more than 80 plant species, including maize, rice and vegetable crops.	Uncertain; however, more than 50 years of data on the closely related African armyworm indicate that its population explodes after droughts

Table 8: INVASIVE SPECIES – Characteristics and link to climate		
Species	**Characteristics**	**Link to climate**
Cotton mealybug *Phenacoccus solenopsis*	A sap-sucking insect that feeds on more than 200 plants but causes economic damage mainly to cotton and vegetable crops. Feeds mainly on leaves and branches that join stems.	Attains maximum population increase during May–June and October–November (e.g., cotton-growing and -picking seasons)
Blue gum chalcid *Leptocybe invasa*	First detected in Zimbabwe in 2015, this gall-inducing wasp species native to Australia weakens eucalypt trees and nurseries by attacking leaves and stems of young trees and seedlings.	Thrives under temperatures from 14–18°C; peak tolerance is at 22°C
Aphids *Aphis gossypii (Glover)*	An herbivorous sap-sucking insect often found in terrestrial habitats, mainly in temperate regions. Host plants include cotton, vegetables and weeds.	Sensitive to changes in temperature; expected to increase with higher mean temperatures; optimal temperature for generation is 30°C
Water hyacinth *Eichhornia crassipes (Martius)*	A fast-growing flowering plant; populations can double in 12 days; this weed obstructs waterways.	Adapted to temperature range of 12–35°C; seeds can germinate in a few days or remain dormant for 15–20 years to survive variable conditions
Cherry pie (Black cherry) *Lantana camara*	An aromatic, flowering, prickly plant that forms impenetrable thickets, reducing the quantity and quality of crops and pasturelands. Leaves are toxic to livestock.	High suitability to warming temperatures and further inland expansion is projected through 2070 for Africa
Larger grain borer *Prostephanus trancatus*	First detected in Zimbabwe in the 1980s, this fast-multiplying insect feeds internally on maize grains, sorghum and dried cassava, with most damage occurring in storage.	Flourishes in temperatures around 30°C in high humidity areas

Sources: Machekano 2018; De Souza et al 2018; Moyo 2016; Fand et al 2014; Zinyemba et al 2018; Sankaran, n.d.; Jones 2016; Gerson and Applebaum 2014; USAID 2019; Hyde et al 2007; Taylor et al 2012; BioNET-EAFRINET, n.d.; Farrell 1999; USAID Sector Environmental Guidelines 2009

KEY RESOURCES

1. Brazier, Anna. 2015. Climate Change in Zimbabwe: Facts for Planners and Decision Makers.
2. Bickton, F. 2016. Climate Change as the Biggest Threat to Public Health in Southern Africa and Measures to Reduce its Impacts.
3. BioNET-EAFRINET. n.d. Prostephanus truncatus Horn - Larger Grain Borer (LGB).
4. Brown, D., Chanakira, R.R., Chatiza, K., Dhliwayo, M., Dodman, D., Masiiwa, M., Muchadenyika, D., Mugabe, P., Zvigadza, S. 2012. Climate Change Impacts, Vulnerability and Adaptation in Zimbabwe.
5. Centre for Agriculture & Biosciences International (CABI). 2018. Fall Armyworm: Impacts and Implications for Africa.
6. Chagutah, Tigere. 2010. Climate Change Vulnerability and Adaptation Preparedness in Southern Africa: Zimbabwe Country Report.
7. Chigwada, Johannes. 2009. Case Study 6: Zimbabwe Climate Proofing Infrastructure and Diversifying Livelihoods in Zimbabwe.
8. University of East Anglia Climatic Research Unit. 2016. Zimbabwe: Historical Climate Data.

9. Davis, Richard and Hijri, Rafik. 2014. Climate Change and Water Resources Planning, Development and Management in Zimbabwe.
10. De Souza, J.R., Barbosa, L.R., Souza, A., and a Castro B.M. 2018. Longevity and survival of Leptocybe invasa (Hymenoptera: Eulophidae), an invasive gall inducer on Eucalyptus, with different diets and temperatures.
11. Development Alternatives International. n.d. Zimbabwe—Agricultural Competitiveness Program.
12. Famine Early Warning Systems Network (FEWS NET). 2014. Zimbabwe Food Security Brief.
13. FEWS NET. 2018. Zimbabwe – Food Security Outlook December 2018 to May 2019.
14. FEWS NET. 2010. Zimbabwe Livelihood Zones Profiles.
15. FEWS NET. 2013. Zimbabwe Seasonal Calendar: Typical Year.
16. Fand, B., Tonnang, H., Kumar, M., and Bal, S.K. 2014. Predicting the impact of climate change on regional and seasonal abundance of the mealybug Phenacoccus solenopsis Tinsley (Hemiptera: Pseudococcidae) using temperature-driven phenology model linked to GIS.
17. Farrell, G. 1999. Dispersal, Phenology and Predicted Abundance of the Larger Grain Borer in Different Environments.
18. Food and Agricultural Organization of the United Nations (FAO). 2018. FAO in Southern Africa Prepares for the looming 2018/19 El Niño Occurrence.
19. FAO. 2008. FAO/WFP Crop and Food Supply Assessment Mission To Zimbabwe.
20. FAO. 2018. Forecasting Threats to the Food Chain Affecting Food Security in Countries and Regions.
21. FAO. 2000. Special Alert No. 307 Concerns Over Food Security Mount as Economic Problems Deepen and Disturbances Affect Food Production.
22. FAO. 2013. The State of Zimbabwe's Biodiversity for Food and Agriculture.
23. FAO. 2016. Zimbabwe Regional Report.
24. Gerson and Applebaum. 2014. Aphis gossypii (Glover)
25. Government of Zimbabwe (GoZ). 2009. Zero Draft – Medium Term Plan January 2010–December 2015.
26. Government of Zimbabwe. 2016. Zimbabwe Vulnerability Assessment Committee (ZimVAC) 2016 Rural Livelihoods Assessment.
27. Hoddinott, J. and Kinsey, B. 2001. Child Growth in the Time of Drought.
28. Human Rights Watch. 2002. Fast Track Land Reform in Zimbabwe.
29. Hyde, M., Wursten, B., Ballings, P. and Coates, M. 2007. Flora of Zimbabwe: Lantana camara L.
30. International Crops Research Institute for the Semi-Arid Tropics. 1984. Climate of the Sorghum and Millet Cultivation Zones of the Semi-Arid Tropical Regions of West Africa.
31. International Federation of the Red Cross and Red Crescent Societies. 2017. DREF Operations Update No. 2: Zimbabwe Flooding.
32. IFRC. 2017. Cyclone Dineo: IFRC Releases Emergency Funds to Zimbabwe.
33. Jayne, T.S., Chisvo, M., Rukuni, M., and Masanganise, P. 2006. Zimbabwe's Food Insecurity Paradox: Hunger Amid Potential.
34. Jones, R.A.C. 2016. Chapter Three - Future Scenarios for Plant Virus Pathogens as Climate Change Progresses.
35. Machekano, H., Mutamiswa, R., and Nyamukondiwa, C. 2018. Evidence of rapid spread and establishment of *Tuta absoluta* in semi-arid Botswana
36. Makadho, Johannes. 1996. Potential Effects of Climate Change on Corn Production in Zimbabwe.
37. Malar, J., Sande, S., Zimba, M., Mberikunashe, J., Tangwena, A., Chimusoro, A. 2017. Progress Towards Malaria Elimination in Zimbabwe with Special Reference to the Period 2003–2015.
38. Mambondiyani, Andrew. 2017. Zimbabwe's Farmers Brace for Return of Destructive New Pests.
39. Markandya and Chiabai. 2009. Valuing climate change impacts on human health: empirical evidence from the literature.
40. Maumbe, B. and Swinton, S. 2000. Why do Smallholder Cotton Growers in Zimbabwe Adopt IPM?
41. Monjane, Boaventura. 2018. Zimbabwe: Farmers Practice Agroecology To Overcome The Adversities Of Climate Change.
42. Moyo, J. 2016. Zimbabwe's parched forests fall prey to new pests.
43. Mtetwa, Rumbidzai Patience. 2018. Assessing Socio-Economic Impacts of Drought and Coping Mechanisms: A Case Study on Musikavanhu Area, Chipinge District, Zimbabwe.
44. Ngwawi, J. 2018. SADC Braces for Another El-Niño-Induced Drought.
45. Norval, R.A. 1979. Tick Infestations and Tick-Borne Diseases in Zimbabwe Rhodesia.
46. OEDA and IEA. 2014. Electricity Production from Hydroelectric Sources (% of total).
47. Pereira, Laura. 2017. Climate Change Impacts on Agriculture across Africa.
48. Reynolds, T.W., Waddington, S.R., Anderson, C.L., Chew, A., True, Z., Cullen, A. 2015. Environmental impacts and constraints

associated with the production of major food crops in Sub-Saharan Africa and South Asia.

49. Rurinda, Jairos. 2014. Vulnerability and Adaptation to Climate Variability and Change in Smallholder Farming Systems in Zimbabwe.
50. Ruset, J.M. and Ruset, T. 2013. Climate Change and Livestock Production: A Review with Emphasis on Africa.
51. Sango, Ishumael. 2014. An Investigation of Communal Farmer's Livelihoods and Climate Change Challenges and Opportunities in Makonde Rural District in Zimbabwe.
52. Sankaran, K.V. n.d. Blue Gum Chalcid Pest Fact Sheet.
53. Shewmake, S. 2008. Vulnerability and the Impact of Climate Change in South Africa's Limpopo River Basin.
54. Spong, P.J., Booth, V., and Walmsley, B. 2002. Zimbabwe.
55. Steward, P.R., Dougill, A.J., Thierfelder, C., Pittelkow, C.M., Stringer, L.C., Kudzala, M., Shackelford, G.E. 2018. The adaptive capacity of maize-based conservation agriculture systems to climate stress in tropical and subtropical environments: A meta-regression of yields.
56. Taylor, S., Kumar, L., Reid, N. and Kriticos, D. 2012. Climate Change and the Potential Distribution of an Invasive Shrub, Lantana camara L.
57. Thomas, Alice and Hollingsworth, Ann. 2016. From Bad to Worse: Deepening Impacts of Zimbabwe's Drought.
58. Thornton, P., Herrero, M., Freemand, A., Okeyo, A.M. 2007. Vulnerability, Climate Change and livestock – Research Opportunities and Challenges for Poverty Alleviation.
59. United Nations Programme on HIV/AIDS (UNAIDS) and National AIDS Council and Ministry of Health and Child Care. 2018. Global AIDS Response Progress Report 2018.
60. United Nations Development Programme (UNDP). 2012. Malaria Grant 2012 Annual Report.
61. UNDP. 2016. Mapping of Selected Hazards Affecting Rural Livelihoods in Zimbabwe.
62. UNDP. 2017. Zimbabwe Human Development Report 2017.
63. United Nations Framework Convention on Climate Change (UNFCCC). 2015. Zimbabwe's Intended Nationally Determined Contribution (INDC) Submitted to the UNFCCC.
64. UNICEF. 2012. Climate Change Adaptation and Disaster Risk Reduction in the Education Sector.
65. UNICEF. 2017. Zimbabwe Situation Report January – December 2017.
66. United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA). 2009. Zimbabwe: Agro-ecological Zones Map.
67. United Nations Office of the Resident Coordinator. 2017. Zimbabwe: Floods Situation Report No. 1.
68. United States Agency for International Development (USAID). 2019. Climate Risks in Food For Peace Geographies: Malawi
69. USAID. 2012. Country Specific Information: Zimbabwe.
70. USAID. 2018. Fall Armyworm in Africa: A Guide for Integrated Pest Management.
71. USAID. 2019. Food Assistance Fact Sheet: Zimbabwe.
72. USAID. 2013. Malawi Climate Change Vulnerability Assessment Report.
73. USAID. 2014. Pesticide Evaluation Report and Safer Use Action Plan.
74. USAID. 2017. United States Drought Response Reduced Suffering for Over 2 Million Zimbabweans as Malnutrition Declines.
75. USAID. 2018. United States Works With 350,000 Zimbabwean Farmers to Tackle Dangerous Pest Targeting Maize Crop.
76. USAID. 2017. Vulnerability Impacts and Adaptation Assessment in the East Africa Region.
77. USAID. 2015. Zimbabwe Country Development Cooperation Strategy 2016-2021.
78. United States Department of Agriculture (USDA) Foreign Agricultural Service. 2017. Cotton Production and Consumption in Zimbabwe.
79. USDA. 2017. Grain and Feed Annual Report.
80. Villholth, K., Tottrup, C., Stendel, M., Maherry, A., Claassen, M., Chikozho, C., and Colvin, C. 2011. SADC Regional Groundwater Drought Vulnerability Mapping.
81. Van Oort, P.A.J., Zwart, S. 2017. Impacts of climate change on rice production in Africa and causes of simulated yield changes.
82. Voice of America. 2017. Cyclone Dineo Pounds Zimbabwe's Southern Regions.
83. Wild, Sarah. 2017. African Countries Mobilize to Battle Invasive Caterpillar.
84. World Bank, CCAFS, CIAT. 2018. Climate-Smart Agriculture in Zimbabwe.
85. World Bank. 2019. Climate Change Knowledge Portal Zimbabwe: Impacts on Agriculture.
86. World Bank. 2019. Climate Change Knowledge Portal Zimbabwe: Impacts on Water.
87. World Bank. 2019. Climate Change Knowledge Portal Zimbabwe: Vulnerability.
88. World Bank. 2019. Zimbabwe: GDP Share of Agriculture.

89. World Bank. 2014. Zimbabwe - Multiple Indicator Cluster Survey 2014.
90. World Bank and UNICEF. 2012. Consolidated Recommendations on a National Water Policy for Zimbabwe.
91. World Food Programme. 2017. United States Provides $4 Million to Alleviate Impact of Drought on People Living with HIV.
92. Zambezi River Authority. 2016. Lake Kariba Weekly Levels in Meters.
93. Zimba, M. and Zimudzi, C. 2016. Pesticide Management Practices Among Rural Market Gardening Farmers Near Harare, Zimbabwe.
94. Zinyemba, C., Archer, E., and Rother, H.A. 2018. Climate Variability, Perceptions and Political Ecology: Factors Influencing Changes in Pesticide Use Over 30 years by Zimbabwean Smallholder Cotton Producers.
95. Irigoyen, C. 2017. Center for Public Impact: Fast Track Land Reform in Zimbabwe.
96. Zimbabwe National Statistics Agency. 2015. Zimbabwe Multiple Indicator Cluster Survey 2014, Final Report.
97. UNICEF, FAO, and World Food Programme. 2018. Zimbabwe National Nutrition Survey.
98. UNICEF. 2013. Rural WASH Fast Facts on Water and Sanitation.
99. Alexander, K., Carzolio, M., Goodin, D., and Vance, E. 2013. Climate Change is Likely to Worsen the Public Health Threat of Diarrheal Disease in Botswana.
100. UNDP. 2017. Zimbabwe Human Development Report 2017: Climate Change and Health.
101. Phiri, M. 2016. Swap maize for millet? Zimbabwe's farmers just say no.
102. GoZ. 2013. Zimbabwe National Climate Response Strategy.
103. Marima, T. 2019. Cyclone Idai destroys Zimbabwe farms, deepening food crisis.
104. UNOCHA. 2019. Cyclones Idai and Kenneth.