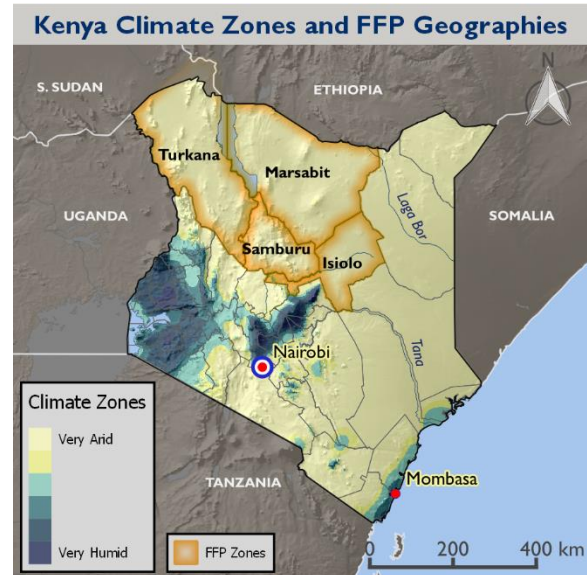




CLIMATE RISK IN FOOD FOR PEACE GEOGRAPHIES KENYA

COUNTRY OVERVIEW

Northern Kenya's arid and semiarid lands (ASALs) are food- and water-insecure regions dependent on limited and highly variable rainfall. Rising temperatures, heat waves, changes in seasonal rainfall and extreme rainfall events intensify risks to livestock and crop production, and to human health through heat and water stress, disease, damage to crop and grazing lands and diminished water quality. The recurrent drought events of recent years (i.e., 2009, 2011 and 2017) have affected millions, increasing food insecurity and reliance on emergency food aid among the region's pastoralists and agropastoralists. Floods caused by heavy rainfall, such as those in 2018, have also led to extensive displacement, loss of livestock and crops and periodic health impacts such as cholera outbreaks. Years of agricultural losses, combined with limited livelihood alternatives and market engagement have forced more Kenyans to rely on the purchase of staple foods, increasing vulnerability to regional and global food price fluctuations. Rapid population growth, insecure tenure systems, the privatization of land and water sources, and intercommunity conflict further constrain adaptive capacity in the region. As the combination of climate and non-climate impacts continue to increase, they exacerbate tensions over already limited land and water resources and augment the social consequences of climate variability. While poverty rates are falling nationally, they remain above 80 percent in the arid north. Poor households' repeated exposure to drought and other weather-related shocks, depletion of assets, and continuing ecological decline leave them less able to cope with shocks and stresses. (7, 8, 44, 53)



Source: [WorldClim 2005](#); [Hijmans, R.J., et al. 2005](#)

CLIMATE PROJECTIONS

- Rising temperature of 1.2°C to 2.2°C by 2050
- Uncertain precipitation trend of -3 to +28 percent by 2050
- Increased frequency and intensity of heavy rainfall
- More heat waves; changes in rainfall seasonality

KEY CLIMATE IMPACTS

Agriculture and Livelihoods

- Reduced livestock and crop productivity
- Increased livestock losses and crop failure
- Increased erosion and land degradation
- Increased pest and disease outbreaks
- More conflict over natural resources

Health, Nutrition and WASH

- Increased food insecurity
- Increased water- and vector-borne disease
- Increased heat stress
- Increased flood mortality/morbidity
- Reduced water availability/quality

April 2019

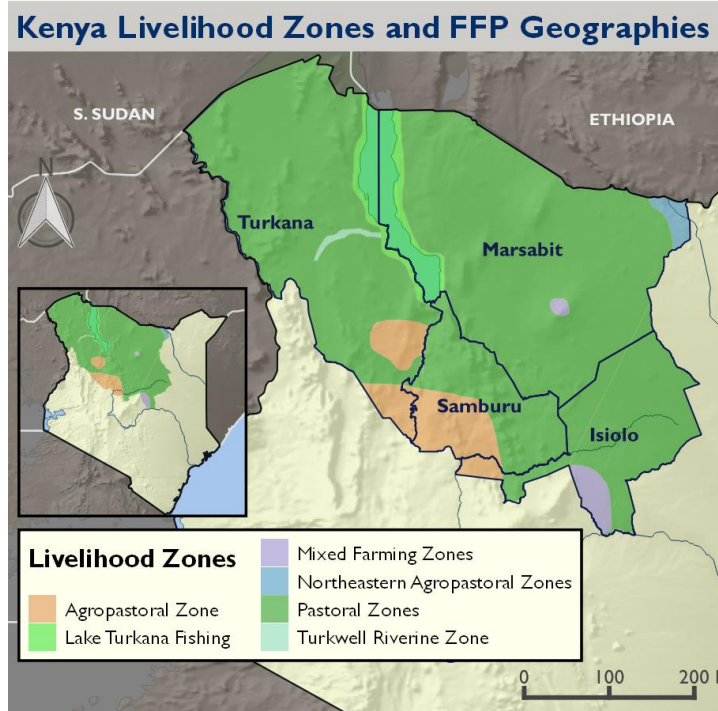
This document was prepared under the Adaptation Thought Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00014 and is meant to provide a brief overview of climate risk issues. The key resources at the end of the document provide more in-depth country and sectoral analysis. The contents of this report do not necessarily reflect the views of USAID.

LIVELIHOODS AND CLIMATE IN FOOD FOR PEACE PROGRAM AREAS

In Kenya, the USAID Food for Peace (FFP) program aims to sustainably prevent acute malnutrition among vulnerable groups. The initial target FFP geographies that are the focus of this profile include Isiolo, Marsabit, Samburu and Turkana counties in northern Kenya’s ASALs.

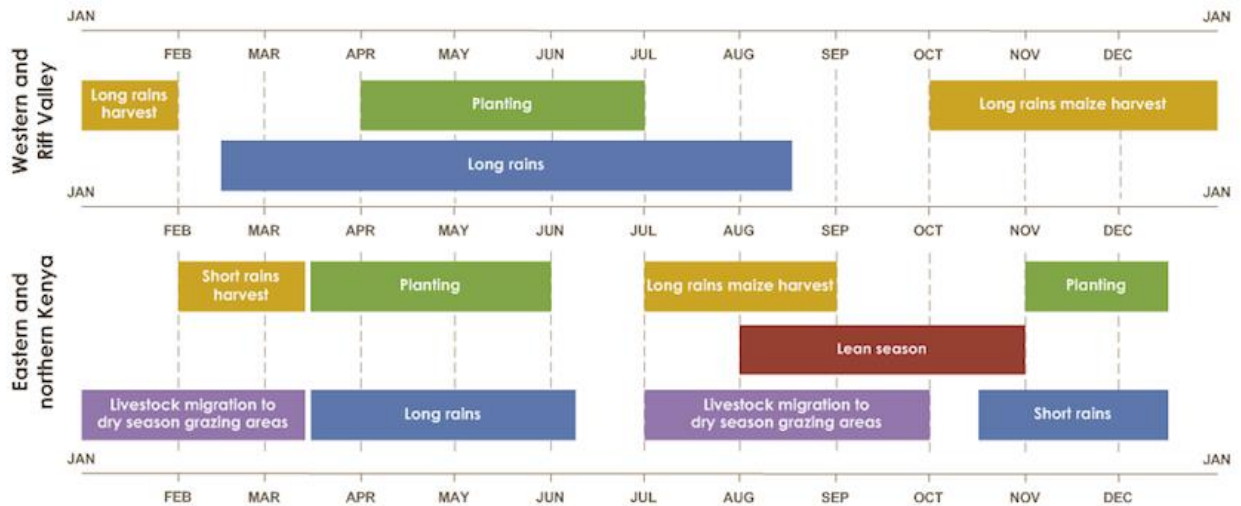
LIVELIHOOD ZONES

In the FFP program areas in northern Kenya, the vast majority of household wealth and income comes from livestock (Table 1). Livestock production in Kenya’s ASALs accounts for an estimated 90 percent of employment and household income. The ASALs are the most food insecure parts of the country and experience high levels of poverty, limited economic opportunities, poor access to basic infrastructure and social services and a harsh climate. Drought, which involves a deficiency of precipitation resulting in reduced soil moisture and diminished plant growth over prolonged periods of time, is the main threat to livestock and pastoral/agropastoral livelihoods and leads to dramatic increases in food insecurity and livestock and crop losses. (5, 7, 8, 32, 52)



Livelihood activities are centered around two rainy seasons: the “long rains” (*akiporo*) from March to May/June (accounting for about 70 percent of total annual rainfall) and the “short rains” (*akecheres*) from October to November/December (Figure 1). Differentiated from drought, the program areas are expected to see an increased intensity and severity of dry periods during the dry season, which leads to early drying or loss of seasonal water sources and has consequences for crop production and yield (e.g. maize, millet, sorghum).

Figure 1. Seasonal calendar for Kenya



Source: FEWS NET 2011

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

Livelihood zone	Main economic activities	Annual rainfall	Main climate-related hazards
Pastoral and Agropastoral Zones (Isiolo, Marsabit, Samburu, Turkana)	<p>Livestock production, a combination of goats, sheep, cattle and camels, is the main income for the nomadic, seminomadic and settled households in the pastoral and agropastoral zones.</p> <p>Agropastoral areas have greater economic diversification, with more household income from crops, such as sorghum, maize and tomatoes, and small businesses that sell firewood, charcoal, bush products and other products.</p>	200–400 mm; up to 1,000 mm in the highlands of the Northern Pastoral Zone	<p>Drought, restricted dry season water and grazing, livestock pests and disease, and increased conflict/livestock theft</p> <p>Additional climate-related hazards by zone:</p> <ul style="list-style-type: none"> • Northwestern Pastoral Zone: access to clean drinking water and waterborne disease • Northwestern Agropastoral Zone: crop disease, crop damage, flooding and landslides • Western Agropastoral Zone: drinking water shortages
Mixed Farming Zones (Isiolo and Marsabit)	<p><u>Southeastern Marginal Mixed Farming Zone</u>: The mainly settled households of this zone rely on food crops (maize, sorghum and pulses), cash crops (pulses, cotton, tobacco and khat) and livestock (cattle, goats and sheep).</p>	1,300 mm	Drought, waterborne diseases (e.g., cholera, dysentery), crop and livestock pests and diseases, and flooding
	<p><u>Marsabit Marginal Mixed Farming Zone</u>: Livestock production (goats, sheep and cattle) is the main contributor to income and food for this mainly settled population. Khat, maize, beans, bananas and mangoes are sold and sorghum, maize and millet are grown for food.</p>	200–1,000 mm	Drought and crop pests (e.g., armyworm, stem/stalk borers) and disease
Lake Turkana Fishing Zone (Marsabit and Turkana)	<p>This zone is a narrow strip along the shores of Lake Turkana where fishing and livestock (goats, sheep and camels) are the main contributors to household income.</p>	300–1,000 mm	Drought and restricted access to dry-season water and grazing, increased conflict, increased water temperature and salinity
Turkwell Riverine Zone (Marsabit and Turkana)	<p>Crop production that is both rainfed and irrigated by surface canals is the main activity in this zone; goats, sheep, cattle and camels are also important for food and income.</p>	300–400 mm	Drought, crop and livestock pests and diseases, flooding and waterborne diseases

Source: [FEWS NET 2011](#)

CLIMATE SUMMARY

The FFP program areas fall within Kenya's desert, semiarid and tropical savanna climate zones. This geography is dominated by arid and semiarid plains with a few temperate highland areas mainly along the country's western border and south of Lake Turkana. High temperatures and low total and highly variable rainfall characterize the region. Daytime temperatures average more than 30°C and climb to 40°C in some desert areas. (8)

Located both along the equator and in low elevations (between 360 and 2235m), the program areas experience little seasonal temperature variation. However, the hottest temperatures occur in February and March and cooler temperatures in July and August. Annual rainfall averages 200–400 mm in the lowlands; highland areas receive up to 1,000 mm. In contrast to other areas of Kenya, in the ASALs, the short rains typically provide more reliable rainfall than the long rains. While more reliable, the short rains are influenced by the El Niño Southern Oscillation (ENSO), which can alternate between periods of above- and below-average rainfall. Droughts and floods are frequent. (8, 9, 10, 18, 35)

CLIMATE TRENDS AND PROJECTIONS

Table 2 summarizes recent trends and projected changes in temperature and rainfall across the country; data specific to the FFP program areas are scarce. There has been an observed decline in total rainfall during the long rains in central Kenya and some evidence that overall annual rainfall may be increasing in the north. The majority of climate models project increased rainfall across East Africa.

Table 2: Climate trends and projections for Kenya		
Parameter	Observed trends	Projected changes (2040–2069)
Temperature	<ul style="list-style-type: none"> Increased average temperature of 0.34°C per decade from 1985 to 2015; greatest increases March to May and in arid and semiarid regions Increased average maximum temperature including from 34.4°C to 35.7°C from 1960 to 2005 in Lodwar, Turkana 	<ul style="list-style-type: none"> Increase in average temperatures of 1.2°C to 2.2°C, with warming greatest in the west Increased maximum and minimum temperatures of 1.2°C to 2.2°C and 1.2°C to 2.5°C, respectively Increased duration of heat waves by 9–30 days
Rainfall	<ul style="list-style-type: none"> Little change in average annual precipitation but declines in the long rains (by more than 100 mm since the 1970s in central Kenya) and possible increased rainfall in the north 	<ul style="list-style-type: none"> Uncertain trend for average rainfall (models range from -3 percent to +28 percent, with the majority pointing to increases), mainly from October to May and principally in the highlands; a likely decrease in the long rains Decline in annual average precipitation by 50 to 150 mm throughout central Kenya by 2025 Changes in seasonal rainfall with projected increases during the October–December short rains and decreases during the March–May long rains and the June–September dry season Increased frequency and intensity of heavy rainfall events Likely no change or a small decrease in duration of dry spells by up to 3 days, but possibly increased severity, with lower rainfall projected from June to September combined with increased evaporation rates

Source: [FEWS NET 2010](#); [GERICS 2015](#); [Government of Kenya 2015](#); [Government of Kenya 2012](#); [REGLAP 2012](#); [UNDP 2012](#); [USAID 2017a](#); [USAID 2017b](#); [World Bank n.d.](#)

SECTOR IMPACTS AND VULNERABILITIES

LIVESTOCK PRODUCTION

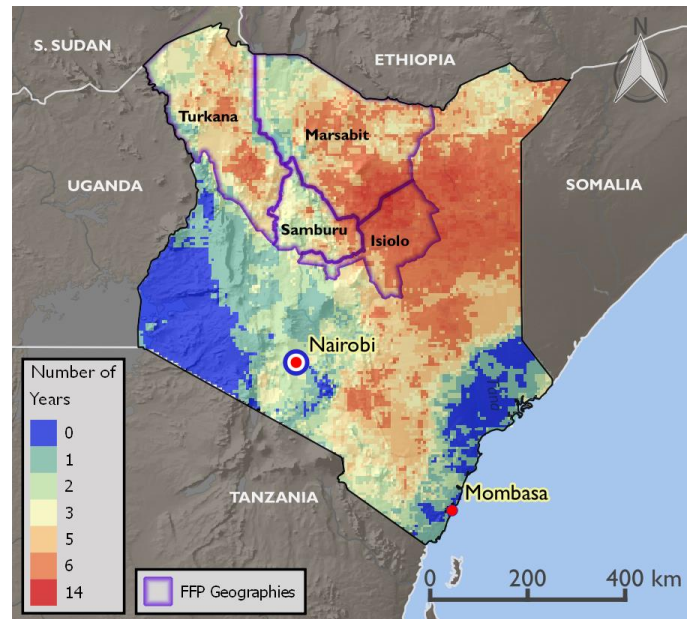
Climate is a key driver of drought, disease, water scarcity, flooding and conflict. Thus, changes in temperature and rainfall and the associated impacts on natural resource availability and quality present major risks to livestock production in Kenya’s FFP program areas. Livestock are typically more resilient to climate variability and shocks than crops; however, recurrent climate-related stressors, mainly drought, flood and outbreaks of livestock disease, have led poor and very poor households in the ASALs to abandon their livelihoods and migrate to neighboring high potential livelihood zones in search

of labor opportunities in urban and semi-urban areas. Livestock losses beyond a critical threshold, often 8–16 tropical livestock units,¹ tend to tip households into economic collapse. (5, 8)

Nationally, livestock accounts for 11–12 percent of GDP. Nearly half of this production occurs in the ASALs, where an estimated four million pastoralists raise livestock worth \$800 million per year. While the ASALs lack higher-value dairy production found in west-central Kenya, extensive livestock keeping accounts for an estimated 70 percent of the nation’s cattle, 90 percent of the sheep and goats and all of the camels. Livestock production in the ASALs is constrained by non-climate factors such as poor market access, low market value for animals, ongoing conflict and the risk of livestock raids, poor access to veterinary services, low-yielding genetic stock and endemic livestock pests and disease. The historic and ongoing conversion of dry season grazing areas to settlement and cultivation, as well as land leasing for mining, oil, and other commercial development, continue to raise tensions and limit dry-season grazing and water access for pastoralists. (2, 8, 9, 22, 33, 34)

Drought, which poses the greatest climate stressor for livestock, is common in the FFP program areas (Figure 2 and Table 3).² From 1980 to 2011, Kenya experienced 13 years of widespread drought (11 separate drought events), three of which were categorized as “extreme.” Drought trends have not had a fixed pattern. However, four out of 11 drought events since 1987 have been most severe during the short rain season. At the regional level, the IPCC projects a modest increase in rainfall in Eastern Africa by 2100. However, there is some uncertainty in longer-term projections for downscaling projections for drought frequency at the local level, including in the ASALs, in part due to incomplete understanding of the influence of cyclic drivers (e.g. ENSO) at the local level and gaps in local historical weather data. Projections for a potential increase in rainfall (Table 2) are unlikely to offset the droughts, given the simultaneous decrease in long rains during the dry season and rising temperatures and evaporation rates. The results of one herd dynamic model indicate that with an increased probability of drought in the ASALs to once every three years, 1.8 million animals would be lost by 2030. (7, 19, 22, 23, 27 34, 35, 43)

Figure 2. Number of years below 70 percent of average rainfall, 1981–2010



Source: [USGS FEWS NET 2013](#)

Even in the absence of changes in temperature and rainfall patterns, people within the FFP program areas are becoming more vulnerable to drought as a result of persistent socioeconomic trends, including rapid population growth and intensifying land use (e.g. cultivation, expansion of cultivated land, overgrazing, and tree harvesting). Climate variability coupled with these trends also could increase price volatility and make livestock feed and fodder less affordable.

¹ Tropical livestock units are livestock numbers converted to a common unit (in 2005). Conversion factors are: camels = 1.0, cattle = 0.7, pigs = 0.2, sheep = 0.1, goats = 0.1, chickens = 0.01.

² Isiolo, Marsabit, Samburu and Turkana counties are among those in Kenya most affected by drought. Figure 2 indicates that pockets of these counties experienced 5–14 droughts between 1981 and 2010.

Major drought event	El Niño events	Number of people affected
2017	2015–2016	3.96 million
2011	2009–2010	3.75 million
2009	2006–2007	3.79 million
2006	2004–2005	2.97 million
2003/04	2002–2003	2.23 million
1998–2001	1997–1998	2.36 million

Source: [NOAA CPC 2018](#); [REGLAP 2012](#); [UNICEF 2018](#)

Current climate variability already has significant consequences for livestock production. In 2011, drought in Kenya’s ASALs resulted in an estimated 10–15 percent increase in livestock deaths, with the largest losses for cattle. Between 2008 and 2011 across the Rift Valley Province, drought-related livestock loss and damage was \$3.2 billion; in Samburu Central district, households lost 57 percent of cattle and 65 percent of sheep. During a drought, livestock prices plummet to 15–90 percent below normal years. Following a drought, it takes households a minimum of two to four years to rebuild their herds, and during this recovery time, households have reduced assets, leaving them highly vulnerable to other shocks. The repeated and increased incidence of droughts across the ASALs in recent years has meant that communities have less time to recover and rebuild their assets, weakening coping mechanisms and impairing resilience to future shocks. (7, 19, 22, 23, 34, 35, 43)

Mobility is a critical drought adaptation strategy. However, compounding the risks associated with drought, the mobility of pastoralists is increasingly restricted as migratory corridors are lost to settlements, cultivation, subdivision and privatization of communal lands. If rainfall increases, expansion of cultivated areas is likely to increase, further restricting pastoral mobility. Compared with normal years, families have to move livestock about three times farther in search of water and grazing in drought years, and livestock losses are exacerbated when mobility is restricted. Increased mobility during drought also raises the risk of conflict among neighbors. Intercommunity conflict over access to and ownership of land in northern Kenya is long-standing and leads to interrupted livelihood activities, displacement and loss of life and property. During the drought in July 2009, violent conflict over pasture and water resources among Samburu, Turkana, Borana and Somali groups led to 32 deaths, thousands displaced and extensive livestock theft. (4, 8, 22, 31)

Apart from droughts, rising temperatures have implications for heat stress, rangeland productivity and disease outbreaks (see box below). Heat stress in livestock can reduce feed consumption, reproduction and growth rates, longevity, milk production and disease resistance. At temperatures more than 30°C, cattle, sheep and goats reduce their feed intake by three to five percent for each 1°C increase. Temperature increases may lead to changes in rangeland productivity, species composition and the quality of plant material, each affecting nutrient availability for livestock. By the 2050s, rangeland productivity is projected to decline by 37 percent across Kenya. Declining maize productivity in the ASALs will also diminish the availability of maize crop residue (stover) for livestock.

Increased flooding due to more frequent and intense rainfall events is also a threat to livestock. In April and May 2018, flooding led to the loss of nearly 20,000 livestock across Kenya, many of these in Turkana County. In addition to livestock death and injury, heavy rainfall events further increase rates of runoff and soil erosion, both processes that degrade rangelands. Table 4 summarizes the climate stressors and risks for livestock. (19, 33, 39, 41, 47)

Table 4: LIVESTOCK — Climate stressors and risks

Climate stressors	Climate risks
Rising temperatures	Reduced livestock reproduction, growth rates and milk production due to heat stress
Increased duration of heat waves	Increased milk spoilage
Increased evaporation rates	Drying rangelands lead to degradation and loss of perennial grasses, diminishing dry season grazing potential (gradually evolving risk)
Increased frequency of drought	Reduced rangeland and crop productivity and quality lead to reduced livestock weight and livestock losses during drought (climate shock)
Increased intensity of dry periods	Increased evaporation or more severe dry periods lead to early drying or loss of seasonal water sources
Increased frequency and intensity of heavy rainfall	Altered pastoral mobility and increased conflict over scarce natural resources
	Expansion and increased outbreaks of certain livestock diseases

Source: [USAID Sector Environmental Guidelines 2015](#)

Disease risks to livestock

Source: USAID. 2014. *Agricultural Adaptation to Climate Change in the Sahel: Expected Impacts on Pests and Diseases Afflicting Livestock*

Climate change will influence occurrence of vector-borne diseases and animal parasites. While particular impacts on livestock disease are difficult to predict, past drought followed by heavy rainfall has led to widespread outbreaks of Rift Valley Fever and blue tongue in East Africa. Research from the Sahel, which has a similar climate, shows that increased temperatures may exacerbate certain diseases during wetter-than-normal conditions and others during drier-than-normal conditions. (16, 41, 42)

Under warmer and wetter conditions, risks include:

- Increased Rift Valley Fever outbreaks and expansion into new areas (sheep and cattle; lower risk for goats),
- Increased gastrointestinal helminths burden leading to increased losses (sheep, goats; lower risk for cattle),
- Increased occurrence of lumpy skin disease (cattle),
- More severe sheep and goat pox and orf (pustular dermatitis) (sheep, goats), and
- More common foot rot (sheep, goats).

Under warmer and drier conditions, risks include:

- Increased anthrax due to longer periods spent grazing on infected pastures (cattle, camels, sheep, goats),
- Expansion of tropical theileriosis (cattle), and
- More frequent foot-and-mouth disease outbreaks (cattle).

CROP PRODUCTION

Crops, mainly sorghum, maize and millet, account for about 30 percent of food needs in agropastoral zones. The combined impacts of increasing temperatures, heat waves, heavy rainfall events and changes in seasonal rainfall are expected to decrease crop yields in Kenya's ASALs (Table 5). Crop production is already marginal, with just 20 percent of the region considered arable, and yields are low (e.g., 1.1 tons/ha for maize). Rainfed crop failure is frequent due to unreliable rainfall and poor soils. (7, 8, 31, 38)

Table 5: CROP PRODUCTION — Climate stressors and risks	
Climate stressors	Climate risks
Rising temperatures, including max and min temperatures	Increased crop failure and reduced grain quality and yields due to heat stress, heavy rainfall, flooding, erosion and waterlogging
Increased duration of heat waves	
Increased evaporation rates	Reduced soil moisture; water stress
Increased intensity of dry periods	Increased incidence of pests and disease
Increased frequency of drought	
Increased frequency and intensity of heavy rainfall	Increased postharvest spoilage

Source: [USAID Sector Environmental Guidelines 2014](#)

Crops will be affected by heat stress, some pests and diseases, flood damage and erosion, and land degradation, all of which are expected to increase in frequency and intensity. Climate trends are expected to reduce crop productivity and make the already limited arable land unsuitable for crop production. Across Kenya’s ASALs, maize yields are projected to decrease 8–20 percent by the 2050s because temperatures above 40°C cause crop development to cease. Warmer temperatures are also expected to push new crop pests into the region, such as the maize stalkborer (*Busseola fusca*), which is linked to yield losses of 20–40 percent across East Africa. Meanwhile, the

increasing frequency and intensity of heavy rainfall can damage crops and erode and degrade fragile soils. While projections for drought occurrence are inconclusive, drought resulting from low or irregularly timed rainfall is the single largest threat to crops. Research in the Sahel, with its similar climate and topography to northern Kenya, has evaluated climate sensitivities and adaptive characteristics for common crops (Table 6). In contrast to projections for FFP program areas, in the cooler high-elevation areas of Kenya, maize and bean production are expected to increase with warming temperatures. (7, 31, 38, 45, 48)

Non-climate constraints on crop production—losses from pests and disease (e.g., maize lethal necrosis, larger grain borer), low levels of irrigation, declining soil fertility, postharvest losses, small and decreasing farm size and insecure land tenure—increase vulnerability to climate risks. (8, 50)

Table 6: Climate sensitivities and adaptive characteristics of key crops		
Crop	Climate sensitivities	Adaptive characteristics
Maize	<ul style="list-style-type: none"> • Temperatures over 35°C can destroy pollen, leading to dramatically reduced yields • Sensitive to dry periods greater than 7–10 days, particularly during germination and seedling stages • Sensitive to waterlogging • Hot dry conditions increase risk of damage from maize stalkborer, pink stemborer (<i>sesamia inferens</i>) and maize streak virus • Hot wet conditions increase risk of gray leaf spot 	<ul style="list-style-type: none"> • Many varieties that together cover a broad range of climate conditions; important to match variety with conditions • Fast-maturing varieties are suited to annual rainfall of 200–500 mm • Performs well in most soil types and conditions but poorly in heavy, dense clay and infertile sandy soils
Millet	<ul style="list-style-type: none"> • Cannot tolerate waterlogging or immersion • Requires evenly distributed rainfall during growth period; does not go into dormancy during drought, like sorghum • Excess rain during flowering can cause crop failure 	<ul style="list-style-type: none"> • Most reliable grain in hot drought-prone areas with sandy soils • Only rainfed grain that is productive in areas with less than 400 mm of rainfall • Plants are photoperiod sensitive such that development is triggered by day length rather than planting date, temperature or rainfall,

Table 6: Climate sensitivities and adaptive characteristics of key crops		
Crop	Climate sensitivities	Adaptive characteristics
Millet	<ul style="list-style-type: none"> Hot dry conditions increase risk of witchweed infection and damage; hot wet conditions increase risk of downy mildew 	making it resilient to variable climate conditions
Sorghum	<ul style="list-style-type: none"> Sensitive to moisture stress during grain-fill 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 	<ul style="list-style-type: none"> Drought tolerant (although less so than millet); goes dormant during water stress and resumes growth when conditions improve Tolerates waterlogging of up to 2 weeks Does well on most soils; moderately tolerant to soil salinity Plants are photoperiod sensitive

Source: [USAID Sector Environmental Guidelines 2014d](#); [USAID 2014a](#); [USAID 2014c](#)

HUMAN HEALTH, NUTRITION AND WATER RESOURCES

The most concerning impacts of climate change on human health, nutrition and water resources in Kenya's FFP program areas include projected increases in food and nutrition insecurity, infectious diseases, heat stress and waterborne diseases (Table 7). Health indicators in Kenya have improved in recent years, but life expectancy is still low at just 66 years, and under-five mortality rates are high (71 per 1,000 live births). In Kenya, pastoralists have the highest incidence of poverty, and health issues are exacerbated by very limited access to health care, low immunization coverage, a dispersed population and precarious living conditions. (33, 50, 51)

Nutrition and food security

Climate-related impacts on livestock, crops, water, and disease are expected to increase food and nutrition insecurity. Malnutrition in Kenya is most severe in the ASALs, where nutrition is closely linked to livestock and crop production. Acute malnutrition is highest in the north of the country, affecting more than 11 percent of children under five in Marsabit and Samburu and 23 percent in Turkana. Twenty-five percent of children under five are underweight in Marsabit, Samburu and Turkana. During the 2017 drought, acute malnutrition rates in areas of Marsabit and Turkana rose to 30 percent, more than double the emergency threshold. (8, 16, 22, 42)

Vector and waterborne diseases

A warmer, wetter climate is expected to increase the intensity and duration of the transmission season in the ASALs for malaria, Rift Valley Fever and dengue. Countrywide, malaria is responsible for five percent of deaths in children under five and accounts for significant health-related expenses and burden on caregivers, who are typically women. Past years of above-average rainfall have led to malaria outbreaks, which are particularly challenging in the ASALs, where immunity is low.

Outbreaks of waterborne diseases such as typhoid, cholera, bilharzia and diarrhea are projected to increase with more heavy rainfall events and are particularly dangerous in the ASALs, where just 10–30 percent of people have access to improved water sources. Diarrheal diseases are a leading cause of mortality, and cases tend to surge after flooding; warmer temperatures further exacerbate this threat. Extremely low sanitation coverage (e.g., 7 percent access to improved sanitation in Turkana County) increases the risk of water contamination during floods or droughts. In Marsabit County, *E. coli* contamination was found in 100 percent of sampled boreholes, 91 percent of taps, 63 percent of dams/pans and 58 percent of wells. (6, 14, 17, 18, 52)

Heat Stress

Heat stress from warmer temperatures will particularly affect the elderly, among whom heat-related deaths are projected to increase from 2 per 100,000 people annually in 1990 to 45 by 2080. (16, 18, 41, 52)

Water Resources

Increasing temperatures, evaporation rates and changes in seasonal rainfall could strain chronically scarce water resources in the ASALs. Kenya's per capita water availability is in the bottom eight percent of countries globally, with just 526 m³ per person annually (well below the internationally accepted threshold of 1,000 m³). Availability is expected to drop to as low as 393 m³ by 2050, mainly due to population increase. The reduced quantity and quality of water, coupled with the increasing frequency of floods and droughts, is expected to increase competition and resource conflicts between agriculturalists and pastoralists in both upstream and downstream areas (e.g., in the Ewaso Ng'iro North River). The ASALs are characterized by high evaporation rates, generally two times the annual rainfall, and in certain areas, as much as ten times. These conditions, compounded with higher temperatures, reinforce a drying climatic trend and diminished per capita water availability. Only roughly 3% of Kenya's surface water storage is available for domestic, livestock and irrigation use; the remaining majority is used for hydroelectric generation. In the ASALs, data indicate that surface water serves 79% of the two lowest socioeconomic population quintiles, but proximity is a barrier to easy access; approximately 43% of people in the ASALs take more than one hour to reach water sources during the dry season. Upstream water usage and natural seasonal flow patterns limit the surface water availability for domestic use and watering. Lastly, the annual runoff height of renewable surface water is less than 10mm per year, and faced with declining surface water service levels in rural Kenya, people rely on collecting groundwater. Mainly women and girls typically spend three to five-and-a-quarter hours per day collecting groundwater, and more during droughts; a survey in central Kenya found that households spend an average of 6.1 hours per day collecting water, and each water collector spends an average of 3.4 hours per day (7, 13, 14, 15, 26, 32)

Additionally, Lake Turkana is an important and increasingly at-risk water resource at the center of the Lake Turkana Fishing and Turkwell Riverine Livelihood zones. The lake was recently designated as an endangered World Heritage Site by the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Committee, owing to its geological, anthropological, and ecological significance. It is home to migratory bird species and breeding grounds for the Nile crocodile, hippopotamus and several snake species. As a closed basin, it is also a sensitive proxy for precipitation in northern and eastern [Kenya](#). Climate variability, including rising temperatures and high evaporation rates, erratic rainy seasons, and flooding place increased pressure on the lake ecosystem. Upstream activities, including run-off from fertilizer and pesticide use and the construction of reservoirs and dams, contaminate the lake's water and create substantial fluctuations in water and salinity levels. The climate and non-climate stressors endanger the lake and the livelihoods of those in the surrounding program areas. (1)

Table 7: HEALTH, NUTRITION AND WASH — Climate stressors and risks	
Climate stressors	Climate risks
Rising temperatures	Increased mortality and morbidity related to heat wave and heat stress (i.e., cardiovascular and respiratory diseases, heat exhaustion, heatstroke)
Increased duration of heat waves	Expanded ranges of disease vectors (e.g., mosquitoes) and increased transmission of infectious diseases such as malaria, Rift Valley Fever and dengue
Increased frequency and intensity of heavy rainfall	Increased flood-related mortality and morbidity, including an increase in infectious diseases from degraded water quality; increased damage to water and sanitation infrastructure Potentially reduced water availability
Increased intensity of dry periods	Diminished nutrition and food security from flood and drought
Increased frequency of drought	

Source: [USAID Sector Environmental Guidelines 2014](#); [USAID Sector Environmental Guidelines 2015](#)

PESTICIDE USE

Pesticide use is low in northern Kenya’s ASALs. Some pesticides are available to pastoralists and small farmers, and while they support crop and livestock production, they also pose a threat to human, livestock, and environmental health. Assessment in Kenya’s southern ASALs has shown that pesticide use poses risks to the environment, pest and disease resistance and safety of the farmer and food (Table 8). There is greater use and knowledge of pesticides among commercial farmers than subsistence farmers and pastoralists; however, a cross-cutting lack of awareness about the risks of improperly handling pesticides persists. Increasing population in the ASALs, combined with the crop impacts from climate trends, could increase the demand for pesticide use and use of counterfeit pesticides by farmers. Increased frequency and intensity of heavy rainfall could further increase contamination risks and reduce pesticide effectiveness. (20, 21, 49)

Table 8: PESTICIDE USE — Climate stressors and risks	
Climate stressors	Climate risks
Increased heavy rainfall frequency and intensity	Increased surface runoff
	Increased percolation/groundwater infiltration
Increased intensity of dry periods	Increased threat from current pests/introduction of new pests
	Reduced effectiveness of pesticides applied topically and/or that are activated/distributed by water
Rising temperatures	Farmers’ reduced willingness to use personal protective equipment due to increased temperatures

Source: [USAID Sector Environmental Guidelines 2009](#)

INVASIVE SPECIES

Many invasive species are adaptable to increased temperatures and variable climate conditions. Many invasive plants are early maturing; capture a larger share of nutrients, water and pollinators; and outcompete crops and native species. Invasive species can establish in (and sometimes even prefer) degraded lands, which are likely to expand under climate pressures. Converting native vegetation to cultivated land disturbs the soil and disrupts plant communities, giving invasive species additional opportunities to proliferate. Problematic invasive species in Kenya's ASALs (Table 9) reduce livestock and crop production, displace native biodiversity and increase production costs. More than 100 invasive species pose threats to native plant species and agricultural production across Kenya. In the ASALs, *Prosopis juliflora* (mesquite) is particularly problematic because it is widespread, difficult to manage and forms dense thickets that prevent growth of other plants. The plant has spread rapidly around Lake Turkana and along the Turkwell River, where large areas of shoreline have been covered, impeding lake and river access for pastoralists and farmers. Other species that pose risks to ASAL grasslands, shrublands and waterways include *Imperata cylindrica* (cogongrass), *Eichorniae crassipes* (water hyacinth) and *Lantana camara* (tick berry). (3, 24, 28, 29, 36)

Species	Characteristics	Link to climate
<i>Prosopis juliflora</i> (mesquite)	Perennial, deciduous, fast-growing, nitrogen-fixing shrubs or trees with deep tap roots; salt- and drought-tolerant; grows in arid and semiarid environments; forms dense stands and outcompetes native vegetation	Has shown increased distribution under increasing temperature and long dry periods in Kenya's drylands
<i>Imperata cylindrica</i> (cogongrass)	A rhizomatous grass that grows up to 1.5 m tall; 60 percent of biomass is below ground; considered one of the top 10 worst weeds in the world, as it displaces native species and alters fire regimes	Adapted to a range of habitats, including degraded grasslands; prefers rainfall >500 mm per year and would thrive under increased rainfall in the ASALs
<i>Eichorniae crassipes</i> (water hyacinth)	Aquatic species that can grow from a few centimeters to over a meter in height; forms dense floating mats that impede water flow and create mosquito breeding areas	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
<i>Lantana camara</i> (tick berry)	An aggressive plant, it spreads rapidly to form dense and impenetrable thickets in pasture and natural and degraded areas	Resilient to dry conditions and continues to spread and adapt in drylands and riparian zones

Source: [USAID Sector Environmental Guidelines 2009](#); BioNET-EAFRINET n.d.; Global Invasive Species Database 2010; [Kyuma et al. 2016](#).

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