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Climate Risk Profile

CLIMATE RISKS IN FOOD FOR PEACE GEOGRAPHIES

MALI

DOCUMENT OVERVIEW

Food security is essential for advancing sustainable development, strengthening resilience, improving nutrition, and reducing the need for humanitarian assistance in Mali. This Climate Risk Profile assists the United States Agency for International Development (USAID)/Mali Mission and Food for Peace (FFP) program to:

1. Better understand how climate-related stressors threaten Mali's food security, and
2. Identify potential measures that the USAID/Mali Mission, FFP, and development assistance might undertake to ensure that climate risks do not exacerbate the cycle of recurring food insecurity in Mali.

This document consists of four main sections:

- **Country Overview**, which provides context on food insecurity in Mali, and the major climate-related stressors that threaten food security.
- **Climate Summary**, which describes current and expected changes in climate by mid-century.
- **Livelihoods and Climate in Food for Peace Program Areas**, which describes FFP programming in Mali, as well as Mali's livelihood zones within FFP geographies. The section also includes a table (Table 2) that characterizes each livelihood zone's climate, crop production, main sources of food and income, and primary climate and non-climate hazards to food security. Notably, the descriptions of zones 1 through 9 are drawn from the 2010 Famine Early Warning Systems (FEWS) Livelihood Profile, therefore they do not capture changes that arose following the 2012 Tuareg Rebellion.
- **Sector Impacts and Vulnerabilities**, which describes the major climate-related risks facing key sectors that impact food security:
    - Agriculture
        - Crop Production
        - Invasive Species
        - Pesticide Use and Storage
        - Food Processing and Storage
        - Livestock
    - Sensitive Ecosystems
    - Human Health: Nutrition; Water Supply, Sanitation, and Hygiene (WASH); and Health Services (Appendix A)

COUNTRY OVERVIEW

Food insecurity and malnutrition have been persistent challenges in Mali. (1, 2, 3) More than 29 percent of the population is malnourished. (4) Since 2006, stunting has affected nearly 40 percent of children under five. (1) In 2018, acute malnutrition (measured by wasting) also affected 13 percent of children under five. (1) Food insecurity has historically been particularly problematic in the Mopti, Tombouktou, Gao, and Segou regions (Figure 1).

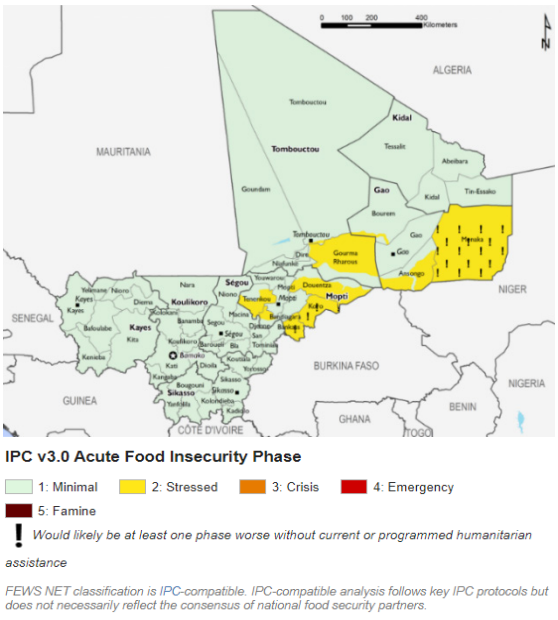

Figure 1. IPC Acute Food Insecurity Phase for Mali, August–September 2019. Source: FEWS NET 2019

Food insecurity in Mali is driven by recurrent severe poverty, conflict, interannual variability in rainfall, and frequent and intense drought. (1, 2, 3) Nearly 44 percent of Malians live below the national poverty line, creating challenges for meeting basic needs, including food needs. (2) Civil conflict since 2012 has worsened food insecurity and spurred population displacement; as of June 2019, nearly 148,000 Malians were internally displaced. (1, 5) More recently, ongoing conflict has undermined livelihood opportunities and increased food prices in areas with conflict, preventing households from meeting basic food needs, particularly poorer households in central and northern Mali. (5) Interannual variation in precipitation and extreme rain and drought have historically undermined agricultural productivity, thereby undermining food security and nutrition. (3, 6, 7) Three-quarters of Malians rely on agriculture for food and income, much of which is small-scale, rainfed subsistence agriculture and pastoralism, and is highly sensitive to climate stressors. (8, 9) Poor water quality, sanitation services, hygiene practices, and health services have also adversely affected nutrition levels.

Projected changes in climate have the potential to further aggravate food insecurity, malnutrition, and poor health. Reduced wet season rainfall in the Inner Niger Delta, more frequent and intense extreme drought and rainfall, and shifting and increasingly unpredictable rainfall patterns are projected to continue to harm agricultural and pastoral livelihoods and water supply, sanitation, and hygiene (WASH) services and infrastructure. Rising temperatures may also harm crops and livestock and increase the range of malaria vectors.

CLIMATE STRESSORS AND PROJECTIONS

Hotter and longer heat waves; 0.9°C–1.5°C increase in average annual temperatures by 2050

Projected increase in extreme rain and flood frequency and intensity

Projected increase in the frequency and intensity of drought, and accelerated desertification

KEY CLIMATE IMPACTS

Agriculture

Drought and reduced rain in the Inner Niger Delta harming crops and livestock
Desertification limiting the availability of agricultural land
Extreme rains damaging crops, livestock, and infrastructure

Human Health: Nutrition, WASH, and Health Services

Reduced nutrition
Reduced availability of clean drinking water
Increased risk of diseases
Reduced ease of accessing health services

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This document was prepared under Environmental Compliance Support (ECOS) Task Order No. DCHA-007 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.

CLIMATE SUMMARY

Northern Mali is dominated by the arid Saharan desert, which transitions into the semiarid Sahel to the south, and then into the humid savannahs further down (Figure 2). (7, 10) The Niger River's seasonally flooded delta and alluvial plain run through the Sahelian band. Average annual temperatures range from 27°C to 30°C annually, with more temperature variation in the north. (7) As of 2015, maximum temperatures had reached 51°C, while the minimum temperatures have reached 10°C. (11)

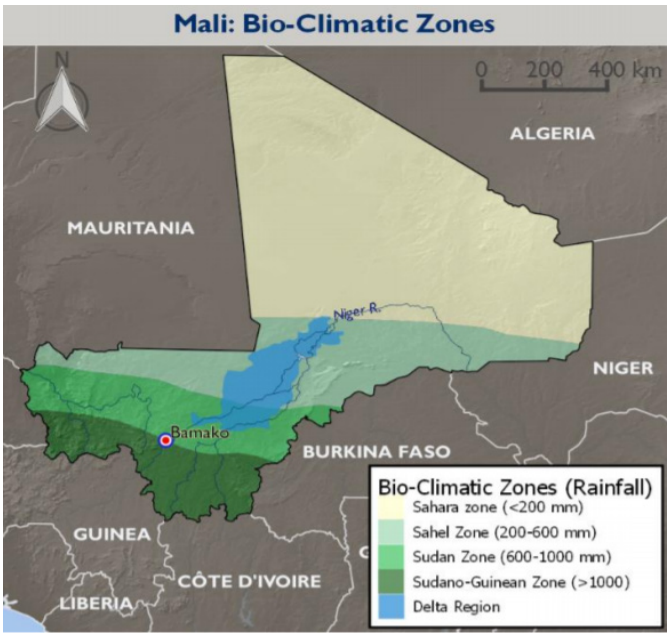

Figure 2. Bio-climatic zones of Mali. Source: USAID 2017

In the north, the rainy season lasts for only three months, from July through September. Meanwhile, in southern Mali, the rainy season stretches for six months, with most of the rain falling from June through October. Southern Mali's dry season lasts from October through May, and is cool from October through January, driven by the Harmattan winds, and becomes hotter from February through May. Average annual rainfall increases moving south; the Sahara receives merely 50 mm, while the Sahel receives 100–1,100 mm, and southern Mali receives up to 1,100 mm. (7) Notably, most FFP areas are in the Sahel Region, where rainfall typically does not exceed 700 mm.

Year to year, rainfall varies substantially, due to Mali's location in the Intertropical Conversion Zone (ITCZ), which causes the annual West African monsoon. (11) As a result, Mali regularly experiences severe floods and drought, which sometimes occur within the same year (7, 12)

Between 1960 and 2015, average annual temperatures increased by 1.2°C. (7) Mali is expected to become even hotter in the future, with average annual temperatures projected to rise by 0.9°C–1.5°C by 2050 relative to the historical baseline of 1986–2005. Increases are expected to be greatest in the southwest (Kayes) and central (Mopti and Gao) regions. (7) Mali experiences a multi-decadal rainfall cycle; on average, the country experienced rainfall reductions from 1950 through 1983 (an average of -4.4 mm/year), and increases from 1983 through 2015 (an average of +2.6 mm/year). On average, rainfall has decreased since the 1960s. (13) Climate model projections disagree on whether average annual precipitation will increase or decrease in Mali by mid-century. The model ensemble average indicates a small (1 percent to 3 percent) increase in average annual rainfall by mid-century,[1] although the model ensemble averages project a decrease in the north. (7) On a seasonal scale, models indicate that rainfall will become less evenly distributed across the wet season, as the beginning of the wet season (June and July) is projected to become slightly drier (4 percent to 5 percent reduction in rainfall), while the latter portion of the wet season (August through October) is projected to become wetter (6 percent to 10

[1] Range reflects projections for Representative Concentration Pathway (RCP) 4.5 and RCP 8.5 for the average of all 32 Coupled Model Intercomparison Project Phase 5 (CMIP5) climate models. Projected change reflects the difference between the most recent 30-year baseline period (1986–2015) and the 30-year projected period centered around 2050 (2036–2065). Source: KNMI Climate Explorer

percent increase in rainfall).[2] Additionally, drought and heavy rainfall events are projected to become more frequent and more intense. (7) Desertification—driven by drought, population growth, and destructive land uses—has also accelerated in recent years; the Sahel experiences some of the fastest rates of desertification in the world. (7, 12) Climate change is projected to accelerate desertification due to warmer oceans affecting ITCZ migration and causing drought-like conditions over the Sahel, and warmer temperatures driving increased evaporation. (7, 10, 12)

Changes in rainfall and temperature will also impact water resources supply, including groundwater resources that are critical for domestic use, crops, and livestock. (14) Drought may simultaneously reduce groundwater recharge rates and increase the need to rely on groundwater as surface water availability declines, while increasing temperatures and evapotranspiration rates and non-climate factors (e.g., population growth) drive increases in water demand. (14) More research is needed to better understand the potential impacts on Mali's groundwater. Table 1 summarizes recent climate conditions and trends as well as projected changes in climate by mid-century.

Table 1. Climate conditions and projections

Climate Parameter	Current Conditions and Recent Trends (since the 1960s)	Projected Changes by 2050[3]
Temperature 	• Between 1960 and 2015, average annual temperature has increased by an average of 1.2°C, an average of 0.23°C per decade • Hot nights have increased in frequency and cold nights have decreased in frequency	• Increase in average annual temperatures of 0.9°C–1.5°C by 2050, with larger increases in the southwest and central regions • Increase in the duration of heat waves and decrease in the duration of cold spells
Drought 	• High interannual variability in rainfall • Mali experiences a multi-decadal rainfall cycle; on average, the country experienced rainfall reductions from 1950 through 1983 (average of -4.4 mm/year), and increases from 1983 through 2015 (average of +2.6 mm/year) • Mali has experience severe drought years since the 1970s, which have progressively become more frequent and longer lasting	• More frequent and intense drought • Accelerated desertification due to increased heat and drought • Increased evapotranspiration
Extreme weather 	• Increase in frequency of Harmattan dust storms in northern and central Mali • Recurrent floods	• More frequent and intense heavy rainfall events and floods
Precipitation 	• Reductions in average annual rainfall since the 1960s • Substantial interannual variability in average annual rainfall • Poorly distributed rainfall in some areas • Erratic and unpredictable rainfall patterns at the seasonal level, leading to early or delayed rains	• Projected change in average annual rainfall is uncertain, although most models indicate a projected decrease in rainfall in the north • Increase in interannual variability in average annual rainfall • Less evenly distributed wet season rainfall, with reductions (4%–5%) during the beginning and increases (6%–10%) during the end of the season

Sources: 7, 10, 12, 13, 15, 16, and 17

[2] Range reflects projections for RCP 4.5 and RCP 8.5 for the average of all 32 CMIP5 climate models. Projected change reflects the difference between the most recent 30-year baseline period (1986–2015) and the 30-year projected period centered around 2050 (2036–2065). Source: KNMI Climate Explorer

[3] Ranges reflect projections for RCP 4.5 and RCP 8.5 for the average of all 32 CMIP5 climate models. Projected change reflects the difference between the most recent 30-year baseline period (1986–2015) and the 30-year projected period centered around 2050 (2036–2065). Source: KNMI Climate Explorer

LIVELIHOODS AND CLIMATE IN FOOD FOR PEACE PROGRAM AREAS

FFP PROGRAMMING

USAID/FFP Mali Development Food Security Activity (DFSA) aims to enable communities to strengthen local systems to manage shocks and improve food security and resilience in the central and northern portions of the country.

The focus geography of the FFP DFSA includes the Sahelian band regions of Mali, including the Mopti Region, Tombouctou Region, Gao Region (Gao and Ansongo cercles), and Segou Region (Niono Cercle). Figure 3 highlights these areas.

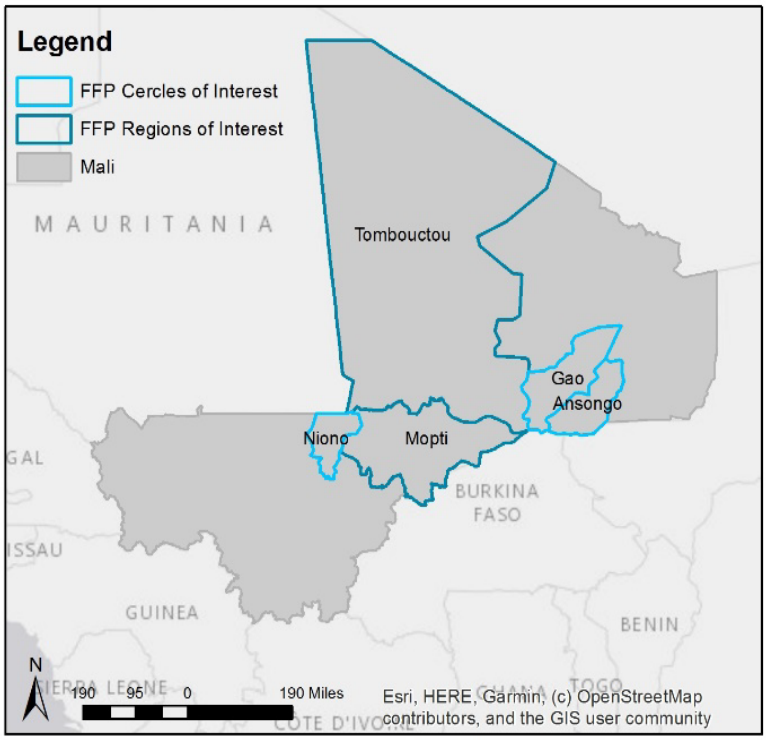

Figure 3. FFP Mali target areas.

The FFP DFSA has several efforts aimed at ameliorating food insecurity in Mali, including: (2)

- Collaborating with the United Nations (UN) World Food Program (WFP) to address vulnerable populations' urgent food needs through cash or in-kind assistance. FFP's fiscal year 2019 contributions supported WFP in assisting around 300,000 people by distributing food, providing nutrition assistance, and supporting asset construction.
- Collaborating with a nongovernmental organization to provide food assistance to around 59,000 Malians who were recently displaced or affected by natural disasters.
- Collaborating with the UN Children's Fund (UNICEF) to provide therapeutic food to treat around 33,000 severely malnourished children.
- Collaborating with CARE to implement a long-term development activity to benefit around 124,000 Malians in the Mopti Region, aiming to strengthen the food security of poor households by promoting nutrition and hygiene, livelihood diversification and support, and conflict resolution.

LIVELIHOOD ZONES IN FFP PROGRAM AREAS

Agriculture employs nearly three-quarters of Mali's labor force. (7) In the more arid and less populated north (ML01 and ML02), pastoralism dominates, while in the wetter central and southern parts of the country, mixed crop and livestock production dominate. (7) The Sahelian band in the central part of the country (ML04) has sufficient precipitation to allow the cultivation of some cereal crops; however, the rainfall is still low in amount and unreliable, making agriculture risky. Thus, pastoralism is still a principal livelihood in this zone. (6) Notably, Mali has a single growing season, therefore climate impacts—such as floods or below average or delayed rains—during this season have an outsized impact on agricultural production. Figure 4 depicts the FEWS livelihood zones within the FFP target geographies.

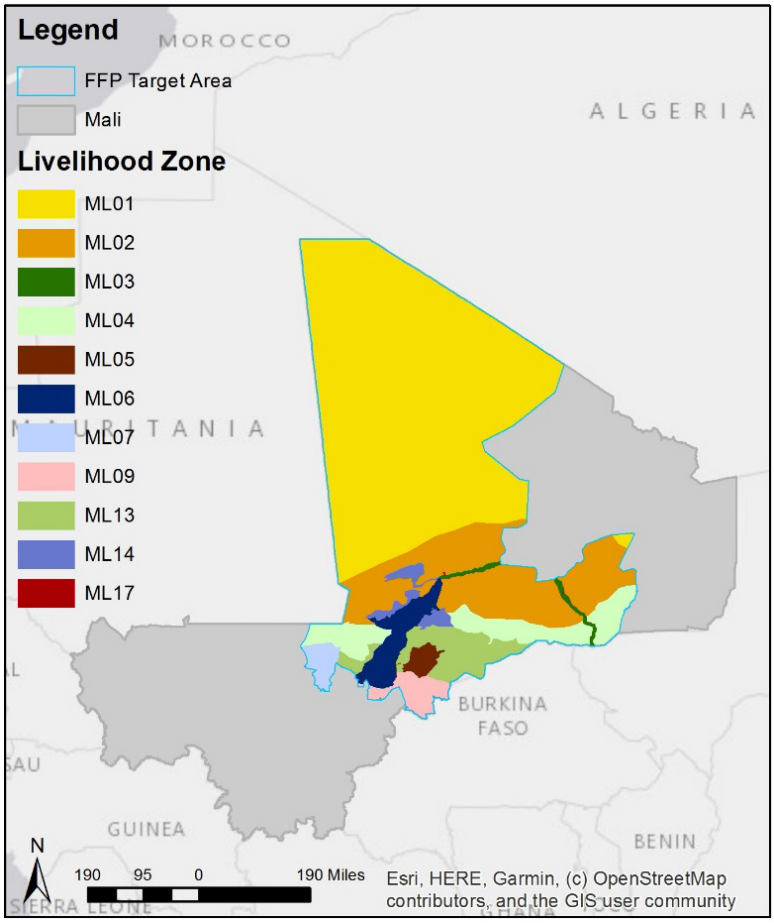

Figure 4. Livelihood zones in FFP Mali target geographies.

Rainfall largely dictates differences across livelihood zones and determines the use of arable land and dependence on livestock. (6) Because 95 percent of agriculture is rainfed, the timing and amount of rainfall plays a major part in crop production. (7) Much of Mali sees a cycle of good years followed by bad. In the Sahelian band, good years allow some households to prepare for, and recover from, bad years. (6) Geomorphology and relief also affect productive potential; for example, the delta and floodplains surrounding the Niger River (ML06 and ML07) allow rice cultivation despite low rainfall in the area, and offer more diverse livelihoods for the Bozo fishermen who live among its banks. (6) Other zones (ML08) have populations that receive significant remittances from relatives abroad, or can make most of their money from selling handicrafts and wild foods (ML05 and ML09). (6) Notably, these are historical patterns that have likely been impacted by conflict over the past seven years.

Livelihoods also differ among wealth groups, with wealthier households more likely to earn their income from crop and livestock sales and poorer households earning more of their income through labor and self-employment. (6) This labor is in the form of agricultural labor during peak farming seasons and local labor, such as construction, during drier seasons. (6) Self-employment normally consists of selling fuels, such as firewood and charcoal, wild foods, and handicrafts to wealthier households. (6) Both poorer and wealthier households also generate income through labor migration, particularly in the north where pastoral lifestyles dominate. (6) Furthermore, there is a slight difference between poor and very poor households, with poor households more likely to be farmers and generating income from crop production and very poor households more likely to be laborers. (6)

Notably, the Inner Niger Delta and the Sourou floodplain support the livelihoods of many households in the southwestern FFP target geographies, namely the Mopti and southern Tombouctou regions. The floodplain supports livelihoods by providing suitable habitat for fisheries; arable land and water for crops, particularly rice; and pasture for livestock grazing. Because of its importance, the floodplain has been designated as a Ramsar site. (18, 19)

The descriptions of zones 1 through 9 are drawn from the 2010 FEWS Livelihood Profile; therefore they do not capture changes that arose following the 2012 Tuareg Rebellion (e.g., youth were recruited into criminal and radical groups as opposed to engaging in rural livelihoods). (20) Notably, the rebellion was driven, in part, by climate-related factors. Droughts preceding the rebellion (in 2005, 2010, and 2011–2012) in part underpinned the rebellion, as they led to mass livestock die-off, harming livelihood opportunities and increasing unrest. (21) The government's marginalization of pastoralist communities through policies that limit their access to land and water (favoring access by crop producers) also drove the rebellion. (21, 22)

As described in Table 2, many of these livelihoods are vulnerable to climate-related hazards. In developing interventions to address food insecurity, it is important to consider how a given population's livelihoods and food sources are vulnerable to climate impacts.

Table 2. Livelihood zones, climate and terrain, economic activities and sources of food and income, stressors on food security, and poorer household strategies for coping with food insecurity in Mali FFP program areas

Livelihood Zone	Climate and Population	Zone Description	Main Hazards to Food Security
ML01: Nomadism and Trans-Saharan Trade	Desert, thinly populated Annual rainfall: 0–200 mm	**Main sources of income** • Nomadic livestock rearing • Trade with Algeria **Sources of food** • Date palm, onions, tomatoes, cheese, and dried meat	**Food production** • Limited water availability **Socioeconomic** • Poor market access • High food prices • Conflict
ML02: Northern Livestock	Sahel (semiarid transition zone between Sahara and southern savannas), thinly populated Annual rainfall: < 200 mm	**Main sources of income for poorer households** • Primarily (50%–65%) local labor (e.g., looking after herds, watering animals, bringing livestock to market, constructing and repairing houses and wells) **Sources of food for poorer households** • Primarily (70%) market purchases, followed by animal products and in-kind payment	**Livestock rearing** • Limited water availability • Limited pasture (due to limited rainfall) • Bushfires • Livestock diseases (e.g., anthrax, liver fascioliasis, bovine pleuropneumonia) • Theft • Wild animals kill livestock • Crickets destroy pastures **Socioeconomic** • Poor trade terms (high millet prices, low livestock prices) • Conflict, exacerbated limited water availability in drought years
ML03: Niger Loop Rice and Fishing	Fluvial Sahel, thinly populated Annual rainfall: 150–200 mm	**Main sources of income for poorer households** • Highly diversified; agricultural labor, crop sales, labor migration, fish sales, remittances, and livestock sales **Sources of food for poorer households** • Primarily (40%–50%) market purchases, followed by crop production, labor migration, wild foods, and in-kind payment	**Crops** • Drought, limited rainfall, delayed rainfall, and erratic rainfall • Broken dikes • Crop pests, especially crickets, grain-eating birds, and rice-eating fish **Livestock rearing** • Limited pasture (due to limited rainfall)

Livelihood Zone	Climate and Population	Zone Description	Main Hazards to Food Security
			• Livestock diseases (e.g., liver fascioliasis, bovine pleuropneumonia, anthrax) **Socioeconomic** • High cereal prices **Human health** • Malaria
ML04: Central Livestock, Millet, and Remittances	Sahel, thinly populated Annual rainfall: 300–500 mm	**This zone is the Sahelian band, and is the focus of Development Food Security Activities** **Main sources of income for poorer households** • Mostly (30%–40%) local labor, followed by local agriculture, self-employment, livestock sales, and crop sales **Sources of food for poorer households** • Primarily (50%–60%) market purchases, followed by in-kind payment, crop production, loans and in-kind gifts, and milk	**Crops** • Crop pests (e.g., termites, locusts) • Grain-eating birds • Lack of rain, shortened rain season, and poorly distributed rains • Pests (e.g., grasshoppers) • High winds that cover fields with sand or damage germinating seeds, forcing households to resow their crop • Floods **Livestock rearing** • Livestock diseases (e.g., foot-and-mouth disease, anthrax) • Wild animals preying on livestock • Lack of rain, shortened rain season, and poorly distributed rains
ML05: Dogon Plateau Millet and Shallots	High plateau, small water sources Annual rainfall: 400–600 mm	**Main sources of income for poorer households** • Primarily (40%–60%) self-employment (selling wild foods [more than 30% of income], firewood, and handicrafts), followed by agricultural and other labor **Sources of food for poorer households** • Primarily (50%–70%) market purchases, followed by crop production, in-kind payment, and loans and in-kind gifts	**Crops** • Poorly distributed rains, lack of rains, and late-starting rains • High winds that damage germinating seeds, forcing households to resow their crop • Crop pests (e.g., crickets, grasshoppers) • Floods **Livestock rearing** • Livestock diseases (e.g., trypanosomiasis) **Socioeconomic** • Conflict • High cereal prices **Human health** • Malaria
ML06: Niger Delta Rice, Cattle, and Fishing	River delta and floodplain, large pastures Annual rainfall: 300–600 mm	**Main sources of income for poorer households** • Highly diversified; local agricultural labor, livestock sales, crop sales, other local labor and remittances, self-employment, and trade • Bozo fishermen earn most of their income from labor, selling fish, and trade **Sources of food for poorer households** • Primarily (40%–60%) market purchases, followed by crop production, in-kind payment, and loans and in-kind gifts • Bozo fishermen primarily get their food (60%) from market purchases or by exchanging their fish for cereals	**Crops** • Insufficient rains, late-starting rains, and poorly distributed rains • Floodwater receding too early • Overly strong floods • Pests (e.g., rice-eating fish, grain-eating birds) **Livestock rearing** • Livestock diseases **Socioeconomic** • High cereal prices **Human health** • Malaria

Livelihood Zone	Climate and Population	Zone Description	Main Hazards to Food Security
ML07: Office du Niger Rice and Market Gardening	Fully irrigated agricultural zone, Sahelian, densely populated Annual rainfall: 300–500 mm	**Main sources of income for poorer households** • Mostly local agricultural labor (40%–50%), followed by crop sales (20%–40%), self-employment, labor migration and remittances, other labor, and livestock sales **Sources of food for poorer households** • Market purchases (40%–60%), crop production (20%–50%), loans and in-kind gifts, in-kind payment, and milk	**Crops** • Pests (e.g., boring caterpillar, rice viral infections, grain-eating birds) **Livestock rearing** • Livestock diseases (e.g., botulism, foot-and-mouth disease) **Socioeconomic** • Conflict due to dense population **Human health** • Malaria • Diarrhea • Cholera
ML09: Central Sorghum and Millet	Plains, hills, and woodland with moderately fertile clay soil, rainfed agriculture, and moderate population density Annual rainfall: 600–800 mm	**Main sources of income for poorer households** • Local agricultural labor and self-employment (e.g., selling handicrafts), each of which make up 20%–30%; labor migration, other labor, and livestock sales **Sources of food for poorer households** • Market purchases (40%–50%), crop production (30%–50%), loans and in-kind gifts, in-kind payment, and milk	**Crops** • Insufficient rains and drought • Pests (e.g., caterpillars) • Floods (July–September) • Bushfires (January–April) **Livestock rearing** • Lack of pasture • Livestock diseases (e.g., anthrax) • Poultry diseases (e.g., Newcastle disease) • Livestock theft **Human health** • Malaria
ML13: Center-Eastern Millet and Livestock (2015 Profile)	Production deficits that barely cover half a year of food, some ponds and wells that can feed gardens depending on July–September rainfall	**This zone is the Sahelian band, and is the focus of Development Food Security Activities** **Main sources of income for poorer households** • Livestock sales, migration, farm and non-farm labor, self-employment, and crop sales **Sources of food for poorer households** • In-kind payments are a significant source of food, with some market purchases, crop production, and wild food gathering	**Crops** • Drought and poorly distributed rainfall • Crop pests • Floods **Livestock rearing** • Animal diseases
ML14: Lakes Recessional Millet and Sorghum (2015 Profile)	Multiple lakes whose water level determines production potential	**Main sources of income for poorer households** • Livestock sales, migration, farm and non-farm labor, self-employment, and crop sales **Sources of food for poorer households** • Mostly in-kind payments and market purchases, some crop production and wild food gathering	**Crops** • Drought (low rainfall and low water levels in rivers) • Crop pests • Floods **Livestock rearing** • Animal diseases **Socioeconomic** • Civil insecurity

Source: FEWS NET 2010, FEWS NET 2015

SECTOR IMPACTS AND VULNERABILITIES

AGRICULTURE

Three-quarters of Malians rely on agriculture for food and income, much of which is small-scale subsistence agriculture and pastoralism. (8, 9) As a result, climate shocks and stresses to agriculture can greatly impact livelihoods. (11) The following sections describe food insecurity drivers, including climate-related drivers, in various agricultural components, including crop production, invasive species, pesticide use and storage, livestock, and food processing and storage.

Crop Production

Many households grow much of their own food and/or generate income either by selling crops or by performing agricultural labor. (6) The following stressors have posed and will continue to pose the greatest threats to crop production:

- **Drought, limited rainfall, and shortened rain seasons.** The vast majority of crops (95 percent) are rainfed; thus, limited rainfall, drought, and increasing temperatures have been a major constraint on crop production. (7, 12) For example, many farmers grow rice in the Inner Niger Delta and Sourou floodplain, and annual flooding helps to irrigate rice fields. (18, 19) In the past, reduced wet season rainfall drove lower river levels and floodwaters that receded too early reduced the rice harvest. (6, 23) Rainfed crops—including those in the Inner Niger Delta and Sourou floodplain—are particularly vulnerable during the dry season, when they rely on shallow groundwater or ephemeral water sources. A lack of monsoon rains and an elongated dry season can cause crop stress and failure. (14)

- **Extreme events, such as floods or high winds.** Strong winds blow sand over fields, covering or damaging crops. These winds have also damaged germinating seeds, reducing potential productivity and forcing households to resow their fields. (6) In the rice cultivation areas along the Niger River, floods drown rice plants. Many farmers build dikes along their rice fields to protect them from this hazard; however, heavy floods and strong winds often break the mud dikes, flooding crops and destroying harvests. (6, 24)

- **Environmental degradation and desertification.** Desertification is a widespread issue in Mali, threatening 98 percent of the country. (10, 25) Driven by deforestation, intensive cultivation and poor soil management, overgrazing, and drought, desertification degrades soil quality and renders it unsuitable for agriculture. (10, 25) Rapid population growth—Mali had a fertility rate of six children per woman in 2017—has been a major driver of deforestation for agricultural expansion and reduced fallow periods, intensifying pressure on the land. (26, 27, 28)

- **Crop pests.** The staple crops grown in Mali suffer from a variety of crop pests and diseases, including insects, grain-eating birds, rice-eating fish, and, more recently, the fall armyworm. (6, 29) This especially affects the main grain crops, such as millet, sorghum, maize, and rice.

- **Socioeconomic factors.** Conflict and political instability, particularly in the North and Central regions of Mali, have displaced people and hindered crop production by interrupting supply routes and the ability to reach agricultural land. (7) Insecure land tenure and lack of training for agro-food jobs further hinder crop production. (3) In addition, Mali's policies—including misaligned subsidies—adversely affect trade and weaken private sector incentives to invest in crop production and extension services. (3) Limited access to finance

and insurance, and limited market access and high transport costs are also major constraints on agribusiness. (30, 31)

Climate-related hazards are expected to further threaten future crop production. In particular, more frequent and intense drought; greater interannual variability in total annual rainfall; and shifts in rainfall distribution, leading to early or delayed seasonal rainfall, have the potential to limit crop productivity. The productive potential of many of the nation's staple crops, such as millet and sorghum, can drop significantly if annual rainfall does not exceed a certain threshold. (11) Increasing temperatures in Mali may also begin to exceed crop tolerance thresholds and reduce soil moisture, reducing crop yield and available land for cultivation. (7) More frequent and intense rainfall events also have the potential to exacerbate flood damage to crops. Due to projected temperature increases and precipitation decreases, crop yields are expected to change by -17 percent to +6 percent. (11) More frequent and intense drought may further accelerate desertification in the Sahel and increase the risk of brush fires, destroying crops and diminishing land suitable for agriculture and pastoralism. Furthermore, changes in rainfall may reduce water and pasture availability for livestock, which can, in turn, lead to conflict with crop farmers that reduce agricultural yields. (32) Growing populations and increasing food demand may put further pressure on crop production. (26) Most models indicate reductions in wet season rainfall and resulting flooding in the Inner Niger Delta, which may adversely affect farmers who are dependent upon the floodplain and increase conflict over and competition for land. (18, 33) Drought may also cause increases in groundwater withdrawals and reduce the groundwater available for crops, which may become particularly problematic during the dry season when groundwater is a key resource. (14)

Table 3 summarizes climate sensitivities of Mali's staple crops, while Table 4 summarizes the major climate-related risks facing the agricultural sector.

Table 3. Climate sensitivities of staple crops and crops with the greatest gross production value in FFP program areas

Crop	Climate Sensitivities
Rice	• High river levels and strong winds can break the mud dikes protecting rice fields from excess flooding, destroying the harvest (ML03) (6) • Floodwaters that recede too early result in not enough water for rice cultivation (ML06) (6) • Overly strong floods can drown rice plants (ML06) (6) • Rice viral infections (6)
Millet **Sorghum** **Maize** **Cotton**	• Bushfires (January–April) (ML09) • Drought and limited rainfall, temporally and spatially irregular rainfall (6); annual rainfall totals under 400 mm for millet, 500 mm for sorghum, 600 mm for maize, and 750 mm for cotton will significantly reduce productivity (11) • Low water levels in rivers (ML14) (6) • Floods (ML04, July–September in ML09, ML13, and ML14) (6) • High winds that cover fields with sand or damage germinating seeds (ML04 and ML05) (6)

Table 4. Crop production climate risks

Climate Risks
Drought, early or delayed rains, greater interannual variability in total annual rainfall reducing water availability and increasing unpredictability and challenges in agricultural planning, and drought and increasing temperatures reducing soil moisture (6)
Accelerated desertification limiting the availability of crop land
Rising and extreme temperatures damaging crops

Climate Risks
Bushfires (January–April) destroying crops (6)
More frequent and intense extreme rain events resulting in flooding and crop damage (6)
High winds that cover fields with sand or damage germinating seeds (6)

Invasive Species

The fall armyworm is the primary invasive species that threatens Mali's crops, namely maize, sorghum, and millet. (29, 34, 35) More frequent and intense drought and delayed rainfall have the potential to increase the likelihood of armyworm infestation as plant moisture stress creates conditions that are favorable to insects. (36, 37) On the other hand, more frequent and intense heavy rainfall may alleviate armyworm infestation as these events can kill armyworm larvae. (36) In addition, changes in temperature, drought, or precipitation may increase the spread of certain weeds that are parasitic to staple crops such as millet and sorghum. (38) Drought may also weaken crops, making them more susceptible to attacks by parasitic plants or less able to compete with hardier weeds. (38)

Table 5 summarizes notable climate-related invasive species risks facing Mali's agricultural sector.

Table 5. Spread of invasive species climate risks

Climate Risks
Increasing temperatures may increase the prevalence of witchweed. Witchweed can prevent root development and nutrient uptake for millet plants and germinates best in warm conditions (38)
Increasing temperatures may increase the prevalence of Striga purple witchweed. Striga purple witchweed can attack sorghum at all plant stages and parts, and germinates in high temperatures (38)
More frequent and intense drought and delayed rainfall exacerbating fall armyworm infestation

Pesticide Use and Storage

Farmers currently use insecticides and pesticides, although this is most prevalent in the southern part of Mali where there are higher moisture levels. (38) A focus study in Mali found that nine villages reported a 70 percent pesticide adoption rate in their fields. The pesticides are most commonly used on millet, sorghum, rice, and maize. (38) While pesticides save time, reduce labor, and increase agricultural productivity, they can be expensive or difficult to obtain, and they also bring health and environmental hazards. (38)

Climate change may exacerbate staple crop pest infestation. (38) Hot climates generally stimulate the growth of pest populations, with different pests thriving more under different (wet or dry) conditions. As the frequency of both extremely wet and extremely dry years are projected to increase in the future, Mali may experience more pest outbreaks. (38) Historically, locusts have been particularly harmful to Mali's crops; locusts require moist soil and warm temperatures to breed, therefore future changes in temperature and precipitation may affect the prevalence of locusts. (39, 40, 41)

Table 6 summarizes the primary pests that impact Mali's major crops. Table 7 summarizes the major climate risks with the potential to exacerbate the prevalence of pests, limit pesticide effectiveness, and increase environmental contamination from the use of pesticides.

Table 6. Major crop pests affecting Mali's major crops

Crop	Major Pests and Livelihood Zones Affected
Millet	• Termites (ML04) (6) • Locusts (ML04) (6) • Grain-eating birds (ML03, ML04, ML06, and ML07) (6) • Grasshoppers (ML04 and ML05) (6) • Caterpillars (ML09) (6) • High risk of infestation of millet stem borer in hot/dry weather (38)
Sorghum	• Termites (ML04) (6) • Locusts (ML04) (6) • Grain-eating birds (ML03, ML04, ML06, and ML07) (6) • Grasshoppers (ML04 and ML05) (6) • Caterpillars (ML09) (6) • High risk of infestation of Khapra beetle, sorghum head bug, and Striga purple witchweed in hot/dry weather (38)
Rice	• Grain-eating birds (ML03, ML04, ML06, and ML07) (6) • Rice-eating fish (ML03 and ML06) (6) • Boring caterpillar (ML07) (6) • Crickets (6) • High risk of infestation of African rice gall midge in hot/wet weather (38) • High risk of severe infestation of yellow stem borer in hot/dry weather (38)
Maize	• Termites (ML04) (6) • Locusts (ML04) (6) • Grain-eating birds (ML03, ML04, ML06, and ML07) (6) • Grasshoppers (ML04 and ML05) (6) • Caterpillars (ML09) (6) • High risk of infestation of maize stalk borer and pink stem borer in hot/dry weather (38)
Cotton	• Caterpillars (ML09) (6) • High risk of infestation of cotton aphid, cotton bollworm, pink bollworm, red bollworm, spiny bollworm, and Egyptian cotton leafworm in hot/dry weather (38)

Table 7. This table includes (1) climate risks that may (a) increase the prevalence of pests, (b) reduce the effectiveness of pesticides, or (c) increase human or environmental health risk from pesticides

Climate Risks
Increasing temperatures and higher frequency and severity of extreme precipitation events can increase the spread of pests, requiring more pesticide use
Reduced effectiveness and/or shelf life of pesticides due to climate stressors (42)
Increased environmental contamination due to increases in intense winds (42)
Increased health hazards due to rising temperatures (e.g., farmers may be less willing to use personal protective equipment, tissue irritation may worsen) (42)
Warming temperatures and changes in precipitation that alter the risk of locust invasion

Food Processing and Storage

Food storage is especially important for families with migrating members. While herders travel with their cattle from pasture to pasture, their remaining family members must plan to cover cash and food needs by stocking up on grain. (6) Migrating laborers may also earn food as in-kind payments while traveling and bring this back to their families at home; this also requires proper food storage. (6)

Post-harvest losses of crops in Mali is high at 20 percent to 25 percent. (43) The lack of a robust energy network means that large-scale food processing is difficult, so even if agricultural production increased, the processing infrastructure is not enough to keep up with food demand.

(11) Political instability, particularly in the northern parts of the country, can also disrupt supply routes, preventing harvested crops from reaching more food-insecure regions. (11) Delays may occur in getting food from one point to another due to poor road conditions, roadblocks, and bribes that incur time and money. (43)

Climate stressors also contribute to post-harvest losses. High temperatures can accelerate spoilage of fresh foods, such as dairy products and vegetables. (44, 45) Flooding during the rainy season can also make roads impassable, thus delaying the transport and distribution of harvested crops. (6) In the future, higher temperatures and more frequent and intense extreme precipitation events have the potential to further exacerbate spoilage and inhibit food transport. (7) In addition, increasingly erratic rainfall patterns may lead to unexpected rains during the dry season, which could damage crops left outside for drying.

Table 8 summarizes the risks of climate change to post-harvesting processes.

Table 8. Post-harvest climate risks

Post-Harvest Component	Climate Risks
Storage	• Hot weather can lead to post-harvest food spoilage (44) • Warm weather can cause milk to spoil (45) • Unexpected rains during the dry season can cause spoilage of crops left outside to dry
Transportation & Distribution	• Heavy rainfall may cut off roads, particularly rural roads, most of which are sand and dirt (6) • In some parts of the desert, floods may isolate areas (6)

Livestock

Livestock makes up about 10 percent of Mali's gross domestic product (GDP) and beef is the third largest export; as a result, climate impacts on the livestock sector can have a severe impact on Mali's economy. (11) The livestock sector is particularly important in the north where a transhumant pastoral lifestyle dominates, and livestock and livestock products are key food sources. (6) Middle-income and better-off households often generate a substantial portion of their income from livestock-related sales, and employ poorer households to manage their cattle. (6) Poorer households also rely on livestock as a savings mechanism as livestock can be sold during lean times. (6)

Climate hazards can pose risks to the livestock sector. Drought and desertification have already altered pastoralists' range and access to pastures, driving conflict with farmers. More frequent and intense drought is likely to further accelerate desertification and the associated challenges of rearing livestock. (7) Due to reduced rainfall, pastures are expected to decrease by 5 percent to 36 percent. (11) The limited availability of pastures and water is especially stressful just before the arrival of the rains, when most cows give birth. These limited resources put newborn animals at increased risk of disease and death. (6) Because climate change may delay the start of the rainy season, newborn cattle may have to endure these conditions for even longer. (7) Decreased precipitation can also reduce general vegetation growth, affecting fodder production. Climate change may also bring about higher temperatures, which can create heat stress and reduced production in livestock. A hotter climate may also expand the range of some livestock pests and diseases, such as Rift Valley fever (which can especially affect sheep), African swine fever, Newcastle disease (for poultry), avian flu, and anthrax. (7)

Climate change also threatens the transhumant pastoral lifestyle. In 2012, extreme drought in the Sahel Region contributed to the displacement of 100,000 people to neighboring countries and the

movement of 95,000 people within Mali to escape drought-ridden regions. (11) Moreover, more people may shift to livestock-dominated livelihoods as climate hazards continue to decrease the productive potential of crops, increasing the number of livelihoods at risk from climate change. (11) Climate change-driven drought in the Inner Niger Delta may further limit available pasture and increase conflict over, and competition for, land. (18, 33)

Other factors can exacerbate climate impacts on livestock, such as cropland merging into pastures, deforestation, intentional burning, and conflicts between herders and farmers. (26) Armed groups in the northern part of Mali have altered pasture access and the range of areas to which pastoralists may travel. (7)

Table 9 summarizes the risks of climate change to livestock.

Table 9. Livestock climate risks

Climate Risks
Limited pasture due to limited rainfall, drought, and desertification (ML02) (6)
Livestock diseases (e.g., anthrax, liver fascioliasis, bovine pleuropneumonia, foot-and-mouth disease, trypanosomiasis, botulism), which can be exacerbated by extreme heat (6)
Limited pasture due to pests (e.g., crickets) (ML02, ML03, and ML05) (6)
Limited water availability due to drought and decreased precipitation (5)
Hot season (March–June) causing high livestock mortality (6)
Bushfires (ML02) that burn pastures (6)

SENSITIVE ECOSYSTEMS

The FFP geographies of focus contain two Ramsar wetland sites: the Inner Niger Delta—which is one of the largest Ramsar sites in the world—and the Sourou floodplain. The delta supports more than 1 million people who use it for food needs, such as rice cultivation, fishing, and livestock grazing. (7) However, wetlands in Mali—including the delta—already face threats from soil erosion, desertification, drought, salinization, and desiccation, all of which may be exacerbated by climate change. (7) Due to climate change, the Inner Niger Delta is projected to experience less wet season rainfall and flooding, which may adversely affect the livelihoods and species reliant on the delta. (23) For example, lower tributary levels prevent seasonal fish migrations that are important for feeding and breeding. (7) Low rainfall years leading to poor agricultural harvests may put additional pressures on wetlands as pastoralists and farmers try to capitalize on the water source. Rising temperatures may change water quality and dissolved oxygen content in lakes, which would harm fish reproduction and survivability. (7) The Sourou floodplain—which also supports livelihoods, serves as habitat, and provides flood control and groundwater recharge—may also be adversely affected by increasing interannual variability in rainfall and increasingly erratic seasonal rainfall patterns. (14)

Malian forests, primarily consisting of savanna, contribute 4.9 percent to the country's GDP and 25 percent to exports through forest products. (46) The trees provide soil and water conservation services, food, fodder, medicinal products, and more than 90 percent of Mali's energy in the form of firewood and charcoal. (12) Wild animals in forests also contribute to the economy by providing medicinal drugs, food security, trade, and handicrafts. (46) These forests already face climate-related and non-climate-related hazards, including land clearing, overgrazing, pruning, poaching, illegal fishing, mining, excessive wild food harvesting, and the introduction of non-native species.

(12) In Malian forests, higher temperatures, decreased rainfall, and brush fires may kill more trees. (7, 12) Adverse climate impacts on crop production and pastoralism may also drive more Malians to turn to deforestation in order to generate income through charcoal sales.

Other than providing food and resources to humans, Mali's sensitive ecosystems also support significant habitats. More than 640 bird species (140 in the Inner Niger Delta alone), 140 fish species, and 130 mammal species (70 of which are large mammals) exist in Mali, and savanna forests provide habitats for a range of endangered species. (7, 12, 46) However, climate change also poses a risk to these species as decreased rainfall can reduce biodiversity and increased occurrence of brush fires can kill more animals. (12) Increased population pressures and development may also further stress sensitive ecosystems.

Table 10. Sensitive ecosystems climate risks

Climate Risks
Limited precipitation, higher temperatures, and brush fires killing more trees
More dry season river flows and flooding expanding the range of invasive species
Drought and decreased rainfall lowering tributary levels and preventing fish breeding and fattening
Rising temperatures changing water quality and biochemistry, harming fish reproduction
Brush fires killing more animals

APPENDIX A. HUMAN HEALTH: NUTRITION, WASH, AND HEALTH SERVICES

Nutrition

Chronic malnutrition has been a persistent challenge in Mali. Since 2006, stunting has affected nearly 40 percent of children under five. (1) Acute malnutrition (measured by wasting) also affects 13 percent of children under five. (1) Malnutrition is particularly acute in the Mopti (47 percent), Segou (41 percent), and Sikasso (40 percent) regions. (1) Children of poorer, younger, and less educated mothers are more likely to be stunted. (1) Early motherhood and poor child feeding practices worsen malnutrition. (1) Malnutrition can compound other health risks by increasing susceptibility to disease. (7) Poor water supply, sanitation, and hygiene (WASH) infrastructure and services, vector-borne diseases, and poor health services also aggravate malnutrition, as described below.

Climate impacts on agricultural production, as described previously in this document, may further harm human health and nutrition, particularly among the poorest households. In addition, rising carbon dioxide levels may cause crops to become less nutritious. (47) Climate impacts on WASH, vector-borne diseases, and health services also have the potential to adversely affect human health.

Water Supply, Sanitation, and Hygiene (WASH)

Nearly three-quarters of Malians—62 percent in rural areas, 91 percent in urban areas—had access to at least basic improved drinking water services as of 2015. (48) However, population growth and highly variable precipitation, which alternates between extremely wet and periods of extreme drought, create water supply challenges for Mali. (49) The country also faces water quality challenges; poor water quality has been linked to diarrhea and other infectious diseases, aggravating nutrition levels. (50)

In addition, sanitation services and hygiene challenges persist. Mali has high rates of diarrheal disease, which is largely attributed to poor sanitation and hygiene services and practices. (51, 52) As of 2015, only 31 percent of the population (22 percent in rural areas, 46 percent in urban areas) had access to at least basic improved sanitation facilities, and 16 percent of Malians (16 percent in rural areas, 18 percent in urban areas) had access to basic handwashing facilities with soap and water. (48)

Climate change has the potential to aggravate poor WASH infrastructure, services, and practices, thereby adversely affecting health and nutrition. More frequent and intense extreme rainfall events and flooding may limit access to clean water by damaging water supply and sanitation infrastructure; reducing the ability to travel to water supplies; and increasing the contamination of water supplies, driving an increase in cholera and other waterborne diseases. Conversely, drought may reduce the availability of water sources and discourage handwashing and improved hygiene practices, increasing the spread of infectious diseases such as gastrointestinal illness. Higher temperatures may also increase the prevalence of waterborne pathogens that cause diarrhea. (7)

Disease

Two key diseases occur at high rates in Mali and thus pose human health concerns:

- **Malaria** is the leading cause of death in Mali; more than half of children carry malaria parasites during the seasonal high-transmission period. (7, 50) Of the FFP target geographies, malaria is particularly prevalent in the Mopti Region, where 60 percent of

children under five were found to have malaria in 2015. (53) Malaria incidences generally rise during warmer temperatures and following heavy rains and floods. (52) Because malaria can disrupt an able-bodied person's ability to work and force family members to spend money on medication, it can significantly impact household finances. (6)

- **Meningitis** is particularly prevalent in parts of the country that lie in the "meningitis belt"—including the FFP target geographies of Niono Cercle, the Mopti Region, and the southern tips of the Tombouctou Region and the Gao and Ansongo cercles—where meningitis epidemics occur during the dry season. Meningitis tends to be more prevalent when there is dust and low humidity. (7)

Because Mali already experiences high temperatures, climate change may decrease malaria transmission. Temperatures are projected to rise above the thermal threshold for survival of the mosquito vector that carries malaria, thereby shortening the transmission season. (7, 54) However, rising temperatures may accelerate the development of malaria parasites within mosquitos, increasing the likelihood of malaria transmission. (46) More frequent drought may also accelerate desertification, creating dustier and less humid conditions that promote meningitis. (7) Rising temperatures may also increase the prevalence of bacteria and viruses that cause meningitis. (52)

Health Services

Mali faces serious health sector challenges, with poor performance across a range of health indicators, including high infant and child mortality and high malnutrition. (55) Poor health systems performance is one of the main drivers of Mali's low health indicators. (50) Major weaknesses include insufficient coverage of quality health services, particularly for those who live far from health centers; insufficient inputs (e.g., commodities, staff) at the local level; and inadequate health management information systems. (50) Furthermore, health service infrastructure in the north is in particularly bad condition, as in 2012, under terrorist occupation, nearly all northern Mali health facilities were destroyed or damaged and many health staff fled. (50)

Climate change has the potential to further aggravate the challenges facing health services. Extreme rains and flooding may damage health service infrastructure and roads, limiting health professionals' ability to provide health services, and limiting patients' ability to access services. (12) In addition, climate impacts may increase the pressure on health services. More frequent and intense heat waves may cause heat rash, heat stroke, and other cardiovascular diseases. (7, 12) Changes in climate may also increase the amount or impact of air pollution, such as pollen and spores, which can aggravate existing asthma, allergy, and respiratory disorders. (12) Furthermore, climate impacts on livelihoods may strain household income and resources, potentially reducing the willingness and ability to seek health services.

Table 11. Human health: Nutrition, WASH, and health services climate risks

Climate Risks
Reduced nutrition levels
Increased risk of waterborne illnesses, including diarrheal illnesses due to rising temperatures, extreme events contaminating water sources, and drought limiting handwashing
Increased risk of meningitis
Change in malaria transmission rates
Extreme events, such as heavy rain and flooding, destroying roads and medical facilities, making it more difficult for people to receive care
Heat waves causing heat rash, heat stroke, and other cardiovascular diseases
Air quality issues aggravating existing medical conditions

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