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Climate Risk Profile

CLIMATE RISKS TO FOOD SECURITY IN FOOD FOR PEACE GEOGRAPHIES

HAITI

DOCUMENT OVERVIEW

Food security is essential to advancing sustainable development, strengthening resilience, improving nutrition, and reducing the need for humanitarian assistance in Haiti. (1) This Climate Risk Profile assists the United States Agency for International Development (USAID)/Haiti Mission to:

1. Better understand how climate change-related stressors—including extreme events—threaten Haiti's food security.
2. Identify potential measures that the USAID/Haiti Mission and emergency assistance might undertake in order to break the cycle of recurring food insecurity in Haiti.

This document consists of four main sections:

- **Country Overview**, which provides context on food insecurity in Haiti, and the major climate-related stressors that threaten food security.
- **Climate Summary**, which describes recent and expected near-term changes in climate.
- **Livelihoods in Food for Peace Program Areas**, which describes Food for Peace (FFP) programming in Haiti, as well as Haiti's livelihood zones. 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.
- **Sector Impacts and Vulnerabilities**, which describes the major climate-related risks facing key sectors that affect food security:
    - Crop Production, including pesticide use and the spread of invasive species
    - Livestock
    - Food Processing and Storage
    - Food Purchases and Imports
    - Human Health: Nutrition; Water, Sanitation, and Hygiene (WASH); and Health Services
    - Ecological Sensitivity and Endangered Species

COUNTRY OVERVIEW

Haiti is one of the most food-insecure countries in the world: more than half of its population is food insecure and more than one-fifth of its children are chronically malnourished. (2, 3, 4) Around 6 percent of the country was classified in the Integrated Phase Classification (IPC) food insecurity Emergency Phase and 27 percent in the Crisis Phase as of February 2019. (5)

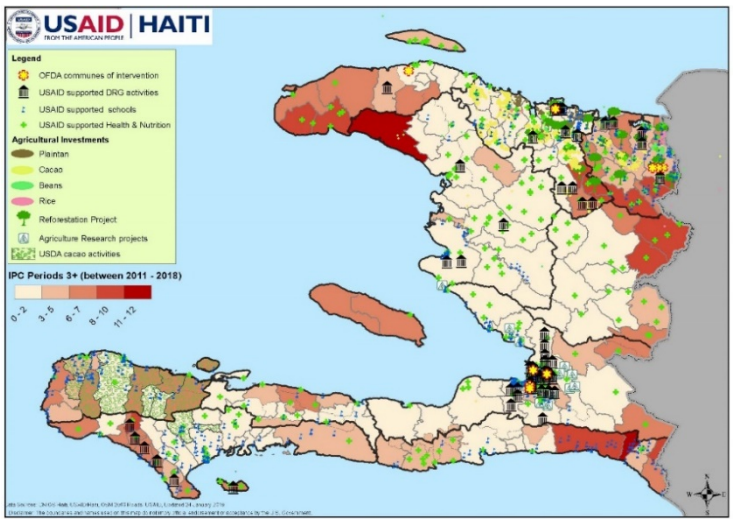

Figure 1. Haiti commune food insecurity 2011–2018 (red indicates the most food insecure communes). Source: USAID Haiti Mission.

Haiti experiences structural food insecurity, driven by widespread poverty and environmental degradation, and exacerbated by frequent natural disasters. (1, 2, 6, 7) In Haiti, 25 percent of the population lives on less than $1.90 per day and 59 percent of the population, approximately 6 million people, lives below the national poverty line of $2.41 per day. (8) Environmental degradation in the form of deforestation and poor agricultural practices has compromised ecosystem services and substantially heightened the country's vulnerability to erosion, landslides, and flooding due to intense rainfall events. (1, 2, 7) Natural disasters—such as the 2010 earthquake, a prolonged El Niño drought (2014–2016), and seven named storms since 2000—severely affect Haiti's economy and exacerbate food insecurity. (2, 3, 8) The damage from Hurricane Matthew in 2016 alone was equivalent to 32 percent of the country's gross domestic product (GDP). (8) This state of continual crisis has left the country weak in its ability to prepare for, mitigate, and respond to disasters. Furthermore, the Haitian government provides little to no direct emergency activities and lacks a strong vision for long-term development and poverty reduction. As a result, the country has a need for international support and emergency interventions. (3, 4, 7, 9, 10, 11)

Climate change is beginning to drive more extreme drought and flood conditions, as well as more intense hurricanes, and is contributing to increased salinization of coastal aquifers and estuaries, which are expected to continue to compromise food security. (10, 12) Climate change is also expected to exacerbate current climate impacts on health and water, sanitation, and hygiene (WASH) infrastructure and services, which are already in poor condition.

CLIMATE STRESSORS AND PROJECTIONS

Hotter and longer heat waves; 1.0°C increase in maxima of daily maximum temperatures.

Projected increase in flood and storm—including hurricane—intensity.

Projected reduction in dry season precipitation; projected increase in intensity and severity of droughts.

KEY CLIMATE IMPACTS

Agriculture
Reduced soil fertility.
Reduced water supply and longer dry seasons.
Shifts in timing of planting and growing seasons.
Change in prevalence of pests and pathogens.

Human Health, Nutrition, and WASH
Reduced availability of health services and clean drinking water.
Increased risk of water-borne diseases.
Increased difficulty of accessing medical treatment.
Reduced nutrition.

July 2019
This document was prepared under Environmental Compliance Services (ECOS) Task Order No. DCHA-004 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

Haiti has a tropical climate, with the South-East, West, Central, and North-East departments generally classified as equatorial savannah, and the northwestern and southwestern departments generally classified as equatorial rainforest; the northwestern tip of Grande'Anse is classified as equatorial monsoon (Figure 2). (2, 13) In Haiti, daily temperatures typically range from 19°C to 28°C (66°F to 82°F) in the winter and 23°C to 33°C (73°F to 91°F) in the summer. (14)

The country experiences two rainy seasons, one in April to June and a second in August to November. (7, 15) Annual rainfall varies substantially between livelihood zones, ranging from 400 millimeters (mm) (livelihood zone HT01) to 2,000 mm (HT08), with most livelihood zones receiving 800 to 1,500 mm/year. (7) Inter-annual variations in precipitation are largely affected by El Niño and La Niña events; the former is associated with hotter, drier conditions, while the latter is associated with cooler, wetter conditions. (7, 14) The North-West, Artibonite, North-East, Central, and West departments experience frequent, recurrent drought due to a combination of erratic rainfall patterns and limited water management infrastructure. (14, 16) In particular, the driest regions are the Plaine du Gonaïves (HT01, North-West Department) and the Plaine du Cul-de-Sac (HT07, West Department). (14) Rising temperatures combined with reductions in annual rainfall—particularly summer month rainfall—are projected to worsen drought, particularly in the North-East, North-West, Artibonite, Central, and West departments. (14, 16)

Hurricanes and tropical storms regularly hit Haiti, with the strongest hurricanes passing over the West and South departments. (16) Hurricane season spans nearly half the year, from June through November, and brings rainfall of up to 40 mm/day, triggering fast-flowing runoff and flooding. (14, 16) Low plains (West and Artibonite departments) and coastal zones (South, South-East, Grande'Anse, and Nippes departments) are particularly vulnerable to flood events. (14) More intense rainy seasons and hurricanes are expected to bring more intense flooding and rain-triggered erosion. (14, 16) Sea level rise is expected to exacerbate flooding and erosion along the coast, particularly in the South and South-East departments. (16)

Table 1 summarizes these recent and expected climate trends.

Table 1. Climate conditions and projections (projections are based on Representative Climate Pathways (RCP) 4.5 and RCP 8.5).

Parameter	Current Conditions and Recent Trends (since the 1960s)	Projected Changes (2030)
Temperature 	• Mean temperatures have risen by 0.45°C (0.81°F), with the greatest warming occurring in the warmest season (June to November). • Annual numbers of hot days and hot nights increased by 63 and 48 days, respectively.	• Mean temperatures are projected to increase by 0.64°C to 1.24°C (1.2 to 2.23°F) by 2030, with the greatest warming occurring from December to February. • Monthly maximum daily maximum temperatures are projected to increase by 1.0°C (1.8°F). • Annual numbers of hot days and hot nights are projected to increase.
Drought 	• Mean monthly rainfall has dropped by 5 mm per decade.	• Average annual rainfall is projected to decrease by 68 mm by 2030. • Dry season (June to August) is expected to experience reductions in precipitation. • Drought is projected to intensify.

Parameter	Current Conditions and Recent Trends (since the 1960s)	Projected Changes (2030)
Extreme Events 	• Atlantic hurricane intensity has increased substantially since 1980.	• Hurricane intensity is projected to increase by 5% to 10%, and related precipitation is projected to increase by 2% by 2050. • Rainfall is projected to become more intense during the wet season.
Sea Level 	• Sea level rose, on average, 1.8 mm/year.	• Sea levels are projected to increase by 0.13 to 0.40 meter (m) by 2030.

Source: USAID 2017, USAID 2015, World Bank 2019

LIVELIHOODS IN FOOD FOR PEACE PROGRAM AREAS

FFP PROGRAMMING

The USAID/Haiti Strategic Framework (2018–2020) aims to develop the foundation for resilience and stability, and reinforce inclusive growth. (1) This framework is centered around four development objectives, including advancing economic and food security, and improving health outcomes. (1) To achieve these objectives, USAID/Haiti focuses on several programmatic priorities:

- **Governance:** Poor governance has been identified as an impediment to development; governance is a key programmatic priority in all projects and activities.
- **Resilience:** Haiti is especially vulnerable to shocks and stresses, creating a chronic dependency on humanitarian aid. To integrate resilience into programs across all objectives, USAID will improve social safety nets, mainstream disaster risk reduction, bolster health systems, and create farm and off-farm economic opportunities.
- **Economic Growth:** There is widespread unemployment in Haiti, with official rates at 40.6 percent and more than two-thirds of Haitians without formal jobs. USAID will focus on increasing access to finance and enhancing economic opportunities.
- **Local Solutions to Increase Self-Reliance:** Working with local partners to increase their capacity, USAID will improve sustainability and decrease dependency on aid.

FFP supported several key projects in fiscal year (FY) 2018, as described below.

- FFP supported the UN WFP in providing around 10,000 food-insecure individuals with conditional cash transfers for food, in return for their participation in disaster risk-reduction activities, including rehabilitation of schools, communal irrigation systems, and riverbanks.
- In partnership with World Vision, FFP provided 26,000 food-insecure individuals in the North-East and Central departments with conditional food and seed vouchers in return for their participation in communal asset creation and rehabilitation activities.
- Together with CARE and the Government of Haiti, FFP is developing a social safety net program to improve vulnerable households' access to local, nutritious foods; in FY 2018, the program benefited close to 86,000 food-insecure individuals.

Underlying these cross-cutting priorities is a focus on supporting key populations—including vulnerable communities and agricultural workers—to improve food security, nutrition, and economic growth.

USAID's Office of Food for Peace (FFP) currently provides support in six departments—North-East, North-West, Central Plateau, Artibonite, South, and South-East—and on Ile de la Gonâve. Activities include a food voucher-based safety net activity in order to improve food security and achieve several co-benefits, such as improving households' income and resilience to natural disasters, and reducing malnutrition, as well as emergency response activities to address critical food security emergencies in Haiti, such as ongoing programming in the North-East Department to address El Niño-driven drought. Finally, as the Government of Haiti does not currently maintain a national stock, FFP also provides support to the UN World Food Program (WFP) for a contingency stock of food capable of feeding 150,000 people in the event of a rapid-onset emergency. Figure 1 on page 2 highlights communes that have experienced chronic food insecurity over the past decade (light tan areas indicating where fewer incidences of IPC 3 or higher have occurred and red

indicating areas where IPC 3 or higher have occurred most frequently between 2011 and 2018). As shown on the figure, the most food-insecure areas are in the northwest, northeast, and portions of the south. The figure also highlights USAID activities, and USAID and U.S. Department of Agriculture agricultural investments in the country. These agricultural investments are largely concentrated in the northern departments of North and North-East and in the southwestern department of Grande'Anse, with much of the agricultural investment focused on cacao crops.

LIVELIHOOD ZONES

Agriculture is central to the Haitian economy, employing 66 percent of the population. (17) However, it generates less than 25 percent of GDP, and only 50 percent of the country's food needs are met by local production, while the deficit is covered by imports. (18, 19) Wealth is linked to access to and ownership of arable land, capital available to hire labor and purchase farming inputs (e.g., seeds, fertilizer), and livestock holdings. (7) Better-off households meet a larger proportion of their basic caloric needs through crop production; in three livelihood zones (HT03, HT04, and HT05), half of households' food needs are primarily met through rice, maize, tubers, and/or banana cultivation, depending on the livelihood zone. (7) Poorer rural households primarily purchase their food, tying their food security to their income, which is mainly generated by labor for wealthier landowners, petty trade, crop sales, and wood and charcoal sales. Very poor households have the greatest difficulty meeting the minimum caloric requirements in livelihood zones HT03 and HT07. (7)

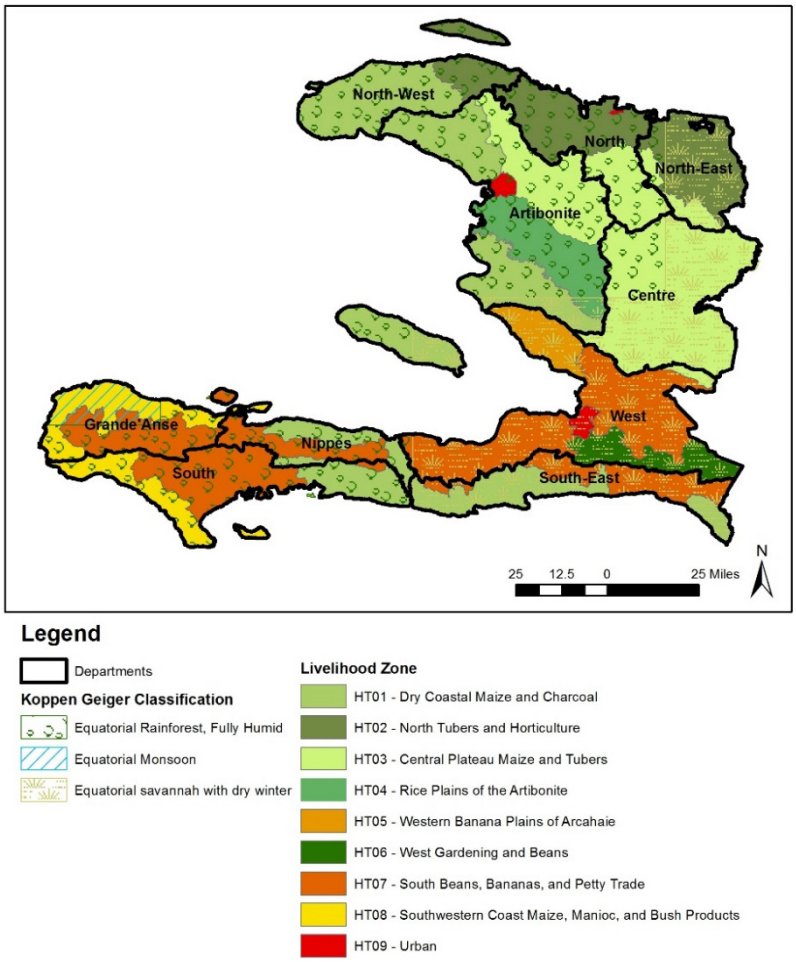

Figure 2. Haiti departments, Köppen Geiger climate classifications, and livelihood zones. Data sources: OCHA, n.d., Köppen-Geiger Climate Classification, n.d., FEWS NET 2015

Livestock production is mainly done on a small scale, and livestock and animal product sales supplement incomes, particularly when crop harvests are smaller than normal or economic conditions at the household level result in a need to raise cash to meet household needs. (7) Fishing contributes to household food supply in some coastal areas, although Hurricane Matthew in 2016 destroyed significant fishery vessels and infrastructure. (20) Haiti imports large volumes of meat, fish, eggs, and milk, indicating that expanding the livestock sector and fish farming could help meet domestic demand. (7)

Table 2 summarizes each livelihood zone, including climate and terrain, crops produced and primary sources of food and income, and climate and non-climate hazards that impact food security.

Table 2. Livelihood zones and climate in Haiti, as well as main climate and non-climate hazards, affect food security. The information in this table is largely based on the FEWS NET 2015 Haiti Rural Livelihoods Profile, much of which draws on interviews with key informants in select Haitian villages representative of the broader livelihood zones; interviews were conducted in fall 2014.

Livelihood Zone	Climate and Terrain	Zone Description	Main Hazards to Food Security
HT01 – Dry Coastal Maize and Charcoal	Coastal plains, dry brush, and savanna grass-covered plateau; substantial dry corridors, particularly in the upper Artibonite, Northwest, and Isle de la Gonâve Annual rainfall ranges from 400 to 1,000 mm, with the northwest coast getting the least amount of rain	**Food production:** Crops: maize, beans, peas, and pearl millet; Livestock: goats, cattle, and pigs **Main sources of food:** Market purchases (80–90%[1] very poor and poor households, 60% middle-income and better-off households); local crop production (10–20% poor households, 40–80% middle-income and better-off households) **Main sources of income:** For middle-income and better-off households, major sources of income include wood and charcoal sales, crop sales, petty trade, and animal sales. For poorer households, major sources of income include wood and charcoal sales, labor, petty trade, transportation services, and crop sales. Variable rainfall and limited cropland are causing households to switch from farming to charcoal production and sales, and wood sales.	**Crops:** arid zones, drought, hurricanes, wind, predatory birds, locusts, and other crop pests **Livestock:** adverse health effects from extreme events (hurricanes, floods, drought, and heat waves), livestock diseases (especially porcine enterovirus encephalomyelitis [Teschen disease]) **Market purchases:** rising prices (especially for imported rice)
HT02 – North Tubers and Horticulture	Dry, humid plains; rolling hills and mountains; and plateau Areas high in the Massif du Nord (mountains) get more rain (1,000 to 1,500 mm or more of rain per year) than lower plain areas (with 800 to 1,000 mm of rain per year)	**Food production:** Cash crops: sugarcane, coffee, cacao, and fruit (pomegranate, orange, grapefruit); Crops for household consumption: tubers (cassava, yams, and potatoes), maize, and peas and beans; Livestock: goats, cattle, and pigs **Main sources of food:** Market purchases (70–80%, mainly rice and flour, animal products for middle-income and better-off households), local crop production (20–30%). Crop failures in the area have increasingly led households to use wild plant food to meet their caloric needs. Very poor households receive 10% of their food from in-kind payments for farm and domestic work. **Main sources of income:** Better-off households earn the majority (70%) of their income from selling crops; this is supplemented by animal sales, petty trade, and sales of wild plant products. Middle-income and poorer households earn around half of their income from crop sales, and receive the rest from labor (in Haiti and the Dominican Republic), wood/charcoal sales, and	**Crops:** drought, floods, and hurricanes (including strong winds) **Livestock:** adverse health effects from extreme events (hurricanes, floods, drought, and heat waves), livestock diseases **Market purchases:** rising prices (especially for imported rice)

[1] Percentages represent minimum daily energy needs (2,100 kilocalories [kcal]). In some cases, middle-income and better-off households consume more than 2,100 kcal; therefore, the combined percentages exceed 100 percent.

Livelihood Zone	Climate and Terrain	Zone Description	Main Hazards to Food Security
		animal and wild plant product sales. The city Cap-Haitien and the industrial zone in the North-East department also provide economic opportunities.	
HT03 – Central Plateau Maize and Tubers	Mountainous, with altitudes from 500 m to > 2,000 m above sea level Average annual rainfall is 1,000 mm, although the High Plateau gets less rain than the Lower Plateau (approximately 500 mm/year)	**Food production:** Cash crops: beans (black beans and pigeon peas), peanuts, bananas, citrus fruits, and sugarcane; Crops for household consumption: maize and tubers (sweet cassava, yams, and sweet potatoes); Livestock: goats and cattle **Main sources of food:** Rely heavily on market purchases (60–65%), local crop production (30–35%), school meal programs, in-kind payments for crop harvest (for poorer households) **Main sources of income:** Better-off and middle-income households generate a large portion (~40%) of their income from crop sales (mainly pigeon peas and black beans, peanuts, bananas, and avocados); this is supplemented by self-employment (leasing land, oxen, and motorcycles) and animal and animal product sales. Poorer households generate around half of their income from labor (in neighboring areas and the Dominican Republic), and supplement this with petty trade, crop sales, and wood and charcoal sales.	**Crops:** drought and late start of rains or inadequate rainfall during planting season (increasingly an issue over the past decade); limited supply of seeds; predatory birds, locusts, and other crop pests; deforestation; loss of soil fertility **Livestock:** adverse health effects from extreme events (hurricanes, floods, drought, and heat waves), livestock diseases, poultry diseases, lack of veterinary services **Market purchases:** rising prices (especially for imported rice) **Labor:** security problems at border crossings, informal nature of work contracts, insecure status of migrant workers in the Dominican Republic, low pay in the Dominican Republic
HT04 – Rice Plains of the Artibonite	Irrigated plains surrounding the Artibonite River; most favorable zone for agriculture Annual average rainfall is 1,400 mm	**Food production:** Crops: rice, garden produce, sweet potatoes, beans, cassava, maize, and bananas; Livestock: cattle, goats, horses, donkeys, pigs, and poultry **Main sources of food:** Crop production (65–75% for middle-income and better-off households, 10–20% for very poor and poor households); market purchases (25–35% for middle-income and better-off households, 10–20% for very poor and poor households; mainly rice, maize, and beans) **Main sources of income:** Middle- and better-off households generate the majority (~80%) of their income from crop sales (mainly rice, pulse, maize, and sorghum), while the rest comes from petty trade, animal sales, and animal product sales. Poor households generate nearly half of their income from crop sales and receive the rest from petty trade and self-employment (selling phone cards, driving motorbike taxis, and selling wood/charcoal). Very poor households receive the majority (> 50%) of their income from labor, supplemented by crop sales, petty trade, and animal sales.	**Crops:** drought; late start to the rainy season reducing irrigation; parasites/pests attacking rice crops; higher fertilizer prices and less local fertilizer reducing rice crops; poor government and community canal maintenance; soil degradation; rice production depends on inputs imported from the United States, therefore affected by U.S. dollar exchange rate; competition with imported rice (which is about half the price of local rice); very poor households must work at other farms, preventing them from tending to their own crops **Livestock:** adverse health effects from extreme events (hurricanes, floods, drought, and heat waves), theft, reducing herd sizes and investment in livestock rearing

Livelihood Zone	Climate and Terrain	Zone Description	Main Hazards to Food Security
			Market purchases: rising prices (especially for imported rice)
HT05 – Western Banana Plains of Arcahaie	Tropical, semi-arid climate between the coast and mountains Annual average rainfall is 1,200 mm	**Food production:** Crops: bananas, papayas, melon, cassava, beans, and sorghum; Livestock: goats, pigs, and cattle **Main sources of food:** Market purchases (65–77%; mainly rice and maize); crop production (15–30%; mainly bananas, cassava, beans, and sorghum). Wild plant foods, animal products, and food are received in exchange for farm labor (applies to poorer households). **Main sources of income:** Crop sales (mainly fruit) make up the majority of income for better-off (> 95%), middle-income (85%), and poor (76%) households; these households supplement income with animal sales, animal product sales, and petty trade. Poor households generate around a third of their income from crop sales and the rest from petty trade, labor, animal product sales, animal sales, and gathering.	**Crops:** diseases affecting banana plantations, hurricanes, lower banana prices linked to competition with bananas from the Dominican Republic **Livestock:** adverse health effects from extreme events (hurricanes, floods, drought, and heat waves) **Market purchases:** high prices (especially for imported rice)
HT06 – West Gardening and Beans	Humid climate, mountainous forest, brush, and prairies Average annual rainfall is 1,600 mm	**Food production:** Cash crops: potatoes, leeks, carrots, cabbages, onions, maize, and beans; Crops for household consumption: maize and beans; Livestock: goats and cattle **Main sources of food:** Market purchases (80–95%; mainly rice, maize, wheat, and maize flour); crop production (5–10% very poor and poor households, 15–20% middle-income and better-off households); animal products **Main sources of income:** Crop sales generate the majority of income for better-off (~95%) and middle-income (~75%) households; this is supplemented by animal sales and petty trade. Poor households generate ~40% of income from crop sales, ~30% from labor, and the rest from petty trade and animal sales. Very poor households generate around half of their income from labor, supplemented by petty trade, crop sales, and animal sales.	**Crops and labor reliant on crops:** drought, late start to rainy season in rain-fed agricultural zones, hurricanes (especially in August and September), crop pests (especially caterpillars affecting maize and beans, and marocas affecting maize and tubers), disturbances to agricultural input supply channels, increased fertilizer prices, excessive increase in staple food prices **Livestock:** adverse health effects from extreme events (hurricanes, floods, drought, and heat waves) **Market purchases:** rising prices (especially for imported rice)
HT07 – South Beans, Bananas, and Petty Trade	Mountainous and plains terrain Annual average rainfall is 900 mm	**Food production:** Cash crops: coffee, peppers, and bananas; Crops for household production: maize, sorghum, peas, pigeon peas, yams, bitter cassava, and sweet potatoes; Livestock: goats and pigs **Main sources of food:** Market purchases (60–70%; mainly rice, pasta, sugar, oil, peas, and maize); crop production (40% better-off households, 28% middle-income households, and 20% very poor and poor households; mainly maize, peas, bananas, sorghum, and tubers)	**Crops:** flooding that causes soil leaching, drought from a late start to the rainy season or insufficient rainfall during planting, birds and locusts, scarcity and poor quality of seeds **Livestock:** adverse health effects from extreme events (hurricanes, floods, drought, and heat waves), livestock diseases, poultry diseases,

Livelihood Zone	Climate and Terrain	Zone Description	Main Hazards to Food Security
		Main sources of income: Better-off households generate nearly half of their income from trade, nearly a third from crop sales, and the rest from animal and animal product sales. Middle-income households generate around one-third of income from trade, around one-third from crop sales, and the rest from animal and animal product sales, labor, and wood and charcoal sales. Poor households generate around one-third of their income from trade, around one-quarter from labor, and the rest mostly from wood, charcoal, and crop sales. Very poor households generate nearly half of their income from labor, and the rest comes mostly from trade, wood and charcoal sales, and crop sales.	lack of veterinary equipment/ medicines **Market purchases:** higher prices (especially of imported foods), low market supplies (poor road conditions) **Labor:** limited labor availability driven by periods of intense farming needs (March–August) coinciding with high incidence of mosquito-borne diseases (e.g., malaria, dengue fever, chikungunya)
HT08 – Southwestern Coast Maize, Manioc, and Bush Products	Plains, foothills, and semi-humid plateaus Average annual rainfall ranges from 1,200 to 2,000 mm	**Food production:** Crops: grasses (maize and rice), legumes (peas, beans, and peanuts), roots and tubers (yams, sweet potatoes, and cassava), plantains, and fruits (figs, bananas, coconuts, mangoes, pomegranates, citrus fruit, and breadfruit); Livestock: pigs **Main sources of food:** Market purchases (55–80%); crop production (15–40%); breadfruit gathering (10–20%); animal products (5–15%) **Main sources of income:** Better-of households earn income primarily from crop, animal, and wild product sales. Middle-income households earn income primarily from crop sales, trade, and animal sales. Poor and very poor households earn income primarily from crop sales, trade, animal sales, labor, and wood and charcoal sales. Poor households generate nearly half of their income from crop sales and receive the rest from petty trade and self-employment (selling phone cards, driving motorbike taxis, and selling wood/charcoal.	**Crops:** hurricanes, drought, and small tidal waves (up to 75 **cm** high) **Livestock:** adverse health effects from extreme events (hurricanes, floods, drought, and hea twaves), livestock diseases (especially those affecting pigs) **Market purchases:** rising prices (especially for imported rice)

Source: FEWS NET 2015, FEWS NET 2018

SECTOR IMPACTS AND VULNERABILITIES

CROP PRODUCTION

The majority of Haiti's population relies on crop production for income and to supplement household food supply, meaning that crop productivity largely dictates food security. (2, 10, 14) Crop productivity is limited by several key types of stressors, including the following:

- **Environmental degradation.** Widespread deforestation, a mountainous topography, fragile soils, extreme rainfall, and erosion-intensive agriculture on slopes have, in combination, caused and continue to cause severe soil fertility degradation. (10, 15) More than 85 percent of soils are either already severely degraded or are degrading rapidly. (7) This degradation has increased the sensitivity to climate stressors and reduced the capacity to cope with climate impacts (e.g., denuded slopes are more likely to erode when exposed to extreme rains). It has also disrupted ecosystem services, such as water filtration, flood protection, coastal protection, and sustenance of pollinator populations. (21)

- **Natural disasters.** Natural disasters, such as earthquakes, drought, hurricanes, and floods, have disrupted farming and triggered periods of food insecurity. (4, 7, 10, 15, 22) In particular, recurrent drought substantially hindered Haiti's crop production. Haiti has experienced drought conditions most years since 2014, contributing to losses of 80 million U.S. dollars in 2012, and reducing local production by up to 70 percent in 2015–2016. (12, 23, 24) Hurricanes also create substantial damage to crops and infrastructure. (12, 25, 26, 27)

- **Social stressors.** Crop productivity has been further limited by the following:
    - **Political instability, poor governance, and poor government accountability** have also hindered the Haitian government's ability to meet the basic needs of its people, and limited the reliability and accessibility of extension services.
    - There are **farm labor shortages** due to migration from rural areas to cities, the Dominican Republic, and elsewhere.
    - There is **lack of mechanization** to replace labor losses.
    - **Shrinking farm sizes** prevent large-scale production.
    - There is a lack of adequate **production infrastructure and supporting services**, such as credit; quality agricultural inputs, such as seeds, fertilizers, and pesticides; irrigation; and weather and market price data.
    - **Poverty and a lack of access to credit and other financial services** also limit farmers' ability to purchase the necessary inputs, cope with input price fluctuations, mechanize agriculture, and otherwise invest time and resources in farming their land. (6, 7)

Changes in climate—including warmer temperatures, drier dry seasons, more frequent and intense droughts, shorter but more intense wet seasons, more intense hurricanes, and sea level rise—are expected to put additional stress on crop production.

Table 3 summarizes the main climate sensitivities and adaptive characteristics of the staple crops grown in Haiti. Table 4 summarizes the major climate-related risks facing the agricultural sector, and potential adaptation responses to address these impacts. The potential adaptation measures identify strategic options for both addressing emergency conditions and enhancing long-term agricultural development in order to promote climate resilience. In particular, providing agricultural extension services could help farmers improve their crop productivity and resilience to climate-

related hazards. Notably, the Government of Haiti does not currently deliver extension services, rather these are delivered by the private sector and nongovernmental organizations (NGOs), and supported by the international community, limiting their sustainability and reach. In addition, in order to undertake these adaptation measures, it would be beneficial to identify synergies and collaborate with other USAID programs (e.g., Sustainable Landscapes, FAA 118/119 Biodiverseity and Tropical Forestry), NGOs (e.g., World Wildlife Fund, Nature Conservancy), and other programs and projects (e.g., the Natural Capital Project).

Table 3. Crop production: Climate sensitivities and adaptive characteristics of staple crops produced in Haiti.

Crop	Climate Sensitivities	Adaptive Characteristics
Maize	• Yields sensitive to drought (during flowering/tasseling/ filling periods) and erratic rainfall. Crops in HT01 have been adversely affected by drought in the past. (6, 7, 22) • Sensitive to damage from hurricanes. (22) • Yield sensitive to heat waves and hot temperatures. • Prices sensitive to supply reductions due to drought or extreme event impacts.	• Temperature and drought-resilient, highly productive, and high-protein certified seeds (e.g., Hugo Plus, a new variety of maize seeds) can help tackle malnutrition. (28)
Rice	• Sensitive to low rainfall, requires significant water. • Sensitive to hot temperatures. • At the flowering stage, even 1 day of extreme heat can cause sterility.	
Sorghum	• While sorghum is relatively drought-tolerant, Haiti's crops have been adversely affected by shifts in rainfall leading to late rains and drought in the past. (7, 22) • Sensitive to moisture stress during grain development.	• Less sensitive to erratic rainfall than maize and pulse. (22)
Pulse (beans and peas)	• Haiti's pulse crops have historically been adversely affected by droughts and storms, including hurricanes. (7) • Very sensitive to excess precipitation and humidity. (22) • Some varieties, including the common bean, are much less drought-tolerant. (7)	• Some varieties of pulse, including cowpea, are particularly drought-tolerant and pest/disease-resistant. (15) • Some varieties, such as the pigeon pea, have residues high in nitrogen and bioavailable phosphorous, enabling them to improve soil fertility. (15)
Bananas and Plantains	• Sensitive to drought due to high water demand, particularly concerning where growing conditions have been changing recently, such as in the North-East Department. (7) • Sensitive to hurricanes, floods, and high winds. (22)	

Table 4. Crop production: Climate risks and potential adaptation responses.

Climate Risks	Potential Adaptation Responses

Soil erosion and reduced soil fertility. Extreme rainfall triggers soil erosion and leeching of soils, reducing soil fertility, particularly on hillsides. Erosion	• Support farming practices that develop and conserve soil fertility (7, 29, 39) (especially in HT02, HT03, HT04, and HT07).
	  ○ Indigenous *Taino* soil management practices:
	  ▪ Promote tree-based perennial agriculture on slopes (e.g, fruit trees, especially those that lend themselves to production alongside crops important to farm families). This strengthens soil structure, promotes microbial activity, and provides soil organic matter. Co-benefit of reducing labor requirements. (10, 15, 39)

Climate Risks	Potential Adaptation Responses
is exacerbated when drought precedes extreme rainfall because it causes soil crusting and reduces water infiltration. Erosion and reduced soil fertility are also exacerbated by deforestation and Haiti's soil types. High winds from hurricanes also drive erosion. (7, 10, 14, 15)	▪ Encourage use of *conucos* (mounds of dirt in rows). This improves water drainage and aeration, increases storage of mature tubers, facilitates easier weeding and harvesting, and reduces erosion (1–8 million). (10, 15) ○ Modern farmer-derived practices: ▪ Support ramp pay (or *rampe de paille* or *fascinage*), where crop residue piles are placed along a contour, covered with soil, and held in place by stakes. This conserves moisture, traps sediment, and is affordable. (15) ▪ Support canal diversion, where ditches are constructed perpendicular to the slope to trap runoff and transport water to drainage channels. This increases corn and sorghum yields, even during rainfall shortages. Can be combined with ramp pay or another sediment-trapping mechanism. (15) ▪ Support zare (using soil and stubble to form micro-catchments that hold water for rice) and *sakle en woulo* (hoeing weeds into contoured ridges that trap runoff). (15) ○ Soil fertility practices: ▪ Supply or subsidize fertilizer and disseminate information on appropriate use (e.g., composting, storage, field-application). Fertilizers might include manure (in areas with livestock), vermiculture (in small home gardens), composting toilets (although this requires high capital costs), and commercial inorganic fertilizers (although these can be expensive when applied across a field; microdosing may be a more effective strategy. (15, 39) ▪ Encourage build-up of soil organic matter by supporting farmers in keeping crop residues on fields (especially legume and green manure plants), avoiding over-tilling, and applying sufficient mulch and manure. (15, 39) ○ Pay farmers for ecosystem services that enhance agricultural productivity and household resilience to climatic shocks (e.g., reduce erosion, improve soil fertility, plant trees, wait until trees are more mature [credit to Conservation Mercy Corps program]). (10, 30, 36, 39) • Reduce erosion: ○ Apply erosion controls on depleted hillside garden plots through strategies such as rock walls, hedgerows, tied ridges, contour and terrace farming, no-tillage agriculture, cover crops, perennial plants, and alley cropping (where food crops are cultivated between hedgerows of leguminous trees or shrubs). It is also important to provide funds for management and upkeep. Notably, this practice is already widely implemented through donor-funded projects in Haiti. (10, 15, 31, 32) • Prevent deforestation, particularly in highly denuded areas, to prevent further erosion and reduction of soil fertility. (7, 10, 29) Currently, tree cover is estimated at around 30% of land surface; under ideal conditions, 35–55% of land surface would be covered in forests. Currently, agricultural clearing is the main driver of deforestation. (33) ○ Prevent agricultural clearing and encourage agroforestry. ○ Prevent non-tree based agriculture on steep slopes to prevent erosion, and identify crops appropriate for steeply sloped land, such as in Cap-Haitien, Fort-Liberité, and the Artibonite Basin. (10, 29, 39) ○ Reduce the use of wood for cooking fuel by supporting (1) fast-growing trees such as bamboo, (2) sustainable tree-harvesting practices such as coppicing (tree regeneration from the base), (3) more efficient cooking stoves (e.g., Kenya Ceramic Jiko stove), (4) solar cookers using parabolic reflectors focused on a pot, (5) access to cooking oil produced from local crops (e.g., peanuts and palm nuts), and (6) pressure cookers to minimize cooking time. Efforts should be focused on priority watersheds. (15)

Climate Risks	Potential Adaptation Responses
	• Reduce soil leeching: ○ Implement flood management practices to prevent soil leaching (especially in HT02 and HT07). (7) Where possible, focus on natural and nature-based flood management practices, such as those outlined in the World Wildlife Fund and USAID Flood Green Guide.

Reduced water supply. Drought and reduced rainfall during the summer season, plus higher evapotranspiration from higher temperatures limit the water supply for crops (an issue in all livelihood zones but HT05). Compounding drought impacts, 92% of the country's agriculture is rain-fed, and most irrigation infrastructure is in poor condition. (7, 14, 34)	• Improve irrigation and water storage:
	  ○ Rehabilitate and maintain water canals to increase water availability. Constructing concrete-lined channels would allow for more efficient movement of water and reduce the time needed to irrigate fields (especially in HT04). (7, 12, 29, 35, 39)
	  ○ Improve communication about the timing of water release into a canal to enable farmers to more effectively take advantage of available water (especially in HT04). (7)
	  ○ Conduct a needs assessment for irrigation infrastructure, focusing on agricultural areas in the east and west of Port-au-Prince, Saint-Marc, and Gonaïves. (29)
	  ○ Implement rainwater storage and water-efficient and less time-consuming irrigation systems (e.g., pump, sprinkler, center-pivot systems) to reduce crop water supply needs. This would be particularly helpful in areas where these systems are lacking but needed, such as in HT03 and HT06. (7, 12, 29, 35, 39)
	• Distribute seeds and planting material of early maturing and drought-resistant crop varieties. (36)

Increased crop damage. Hurricanes and tropical storms bringing heavy rains and high winds that damage and waterlog crops (especially in HT01, HT02, HT06, and HT08). (7, 14)	• Improve available information:
	  ○ Develop early warning systems to prepare farmers for extreme events. (29, 35)
	  ○ Identify the communities most vulnerable to flooding through a national flood map. (10)
	• Improve drainage:
	  ○ Improve drainage of soils prone to waterlogging. (37)
	  ○ Construct and improve existing drainage systems. Concrete-lined channels allow for more efficient movement of water and improved drainage. (39)
	• Increase access to insurance, including parametric insurance.
	• Provide agricultural vouchers to backstop and prevent negative coping strategies.

Change in the prevalence of pests and pathogens due to changes in climate conditions. (14)	• Supply or subsidize biological pest control, organic pesticides, and non-organic pesticides. (39)
Reduced water resources in coastal areas due to salinization of coastal aquifers and estuaries. (7, 10)	• Implement crops that tolerate saline soils. • Manage groundwater extraction to minimize seawater infiltration. • Relocate crops.
Shift in the timing of planting and	• Shift planting times. • Use early warning systems for earlier/delayed onset of growing season.

Climate Risks	Potential Adaptation Responses
growing seasons due to shifts in temperature and rainfall conditions and patterns.	• Change crop.
Longer mosquito season, increasing the risk of mosquito-borne diseases and further reducing labor availability, particularly in HT07. (6)	• Drain pools of standing water. • Apply insecticide, larvicide, oil drip, and/or biological controls in mosquito breeding areas to kill mosquito larvae. • Apply insecticides to kill adult mosquitos. • Apply mosquito repellent.

Cross-cutting risks leading to crop failure and/or reduced yields.	• Identify opportunities to collaborate with other USAID programs (e.g., Sustainable Landscapes, FAA 118/119 Biodiverseity and Tropical Forestry), NGOs (e.g., World Wildlife Fund, Nature Conservancy), and other programs and projects (e.g., the Natural Capital Project).
	• Reduce the financial risk associated with crop failure and provide financial services:
	  ○ Diversify livelihoods by developing additional off-farm, income-generating opportunities. (12, 29, 37, 39)
	  ○ Improve access to credit and crop insurance, which can also improve access to improved agricultural outputs. (37, 39)
	• Improve agricultural inputs:
	  ○ Improve the availability of improved and high-yield seeds, and encourage seed stockpiling and multiplication of improved seeds. (38)
	  ○ Support research on and dissemination of crop varieties and breeds that are more productive and better adapted to changes in climate (e.g., low-fertility soil, drought, high winds, waterlogging, saline soil). For example, in 1998, Haiti adopted the TCS10 variety of rice, which produces higher yields and is more disease-tolerant relative to the previous Crete apibio variety. (29, 37, 39)
	  ○ Improve access to and use of inputs (e.g., seeds, compost, fertilizer). (37)
	  ○ Improve the availability of labor by incentivizing farmers to cultivate their own land rather than seeking labor in the Dominican Republic, and facilitate mechanization, where appropriate, to reduce labor needs, particularly for very poor households that tend to sell their labor in the Dominican Republic. (10)
	• Improve access to information and agricultural inputs:
	  ○ Develop a service that collects weather and agricultural price data and disseminates it to local farmers. (39)
	  ○ Establish support centers for regional agricultural development. Centers could provide farmer training to teach cost-effective farming methods, such as (1) conservation farming principles, such as preventing the soil from being bare and using cover crops; (2) better manure and composting strategies to build up soil organic matter; (3) erosion control using living barriers from non-invasive grasses; (4) tied ridges that reduce erosion and encourage water and nutrient conservation; (5) cost-effective fertilizer application, such as microdosing; and (6) improved practices for legume-cereal intercrops (e.g., intercrop spacing to prevent leaf shading, improved crop rotation). (10, 15)
	• Improve post-harvest systems:

Climate Risks	Potential Adaptation Responses
	○ Improve food storage, processing, and strengthen value chains (e.g., there is a lot of waste following tomato and onion harvests, use pigs or another system to process waste). (16, 39) ○ Develop and improve market links for agricultural crops to enable farmers to generate sufficient profits to cover typical expenses and invest in better germplasm and soil and water conservation (i.e., use the market to drive better natural resource management). (10) • Improve programs that support farmers: ○ Use the Famine Early Warning Systems Network (FEWS NET) to track food insecurity. ○ Compile a map-based database of disaster preparedness and risk management, natural resource management, infrastructure investments, and other efforts related to agricultural climate resilience within the country to better coordinate across resilience efforts. This should include the efforts of grassroots NGOs in Haiti addressing soil infertility, such as Mouvman Peyizan Papay (MPP), Sustainable Organic Integrated Livelihoods (SOIL), Veterimed, and Organization for the Rehabilitation of the Environment (ORE). (10, 15) ○ Monitor and evaluate key economic and resilience metrics to inform planning (e.g., chart productivity differences across project zones, regional productivity trends, demographic trends, infrastructure constraints, product flow barriers). (10) ○ Fund local civil society organizations to manage, farm, and or conserve absentee owners' land. (39) ○ Encourage new mutual interest coalitions in targeted watersheds, or projects based on economic engines, social development, and natural resource management that benefit parties from multiple classes. (10) ○ Support participatory local community development, where community members participate in projects focused on improving their well-being and their environment. (10) ○ Support the national government in passing laws that enact policies which promote agriculture, and support the implementation of these policies. (39)

Pesticide Use

Crop pests and diseases substantially limit Haiti's agricultural productivity. (6, 7, 40) In some areas, households lose all of their crops due to inadequate pest management. (5) Haiti's crops are affected by various pests, including predatory birds and locusts (HT01, HT03, and HT07), insects and caterpillars that attack cacao (HT02), parasites and pests attacking rice crops (HT04), diseases such as black sigatoka fungus affecting banana plantations (HT05), caterpillars affecting maize and beans, and marocas affecting maize and tubers (HT06). (6, 7) Despite the widespread damage, pesticide use is limited as pesticides are typically financially out of reach for many farmers. (7, 41, 42)

Extreme events can reduce pesticide effectiveness and exacerbate the negative externalities of pesticides, such as environmental contamination and adverse human health effects, as outlined in Table 5. Climate change has the potential to increase the need for pesticides as it is expected to further aggravate pest-driven crop damage, alter pest and disease geographic ranges, and increase their metabolic rates and population growth, as described in Table 5. (43, 44)

Table 5. Pesticide use: Climate risks and potential adaptation responses.

Climate Risks	Potential Adaptation Responses
Increased threat from pests due to changes in climate. (45)	• Implement pest-monitoring systems to track the presence of pests. (45) • Study and disemminate information about emerging threats. (45) • Increase the availability of pesticides.
Need for more pesticide due to increased drought stress (e.g., when treating crickets, grasshoppers). (40)	• Apply additional pesticides. • Improve water management in order to reduce crop drought stress.
Increased extreme rainfall rinsing away topical pesticides and reducing pesticide effectiveness, and increasing environmental contamination through runoff and groundwater infiltration. (45)	• Encourage the adoption of integrated pest management, and non-chemical cultural and biological controls. (40) • Apply systemic pesticides rather than topical pesticides. (45) • Provide training on pesticide application (appropriate timing and quantity). (45) • Use seasonal weather forecasts to plan the timing of pesticide application (avoid applying before rain is expected). (45) • Reduce runoff by leveling fields and implementing runoff capture systems. (45) • Avoid pesticide application near surface waters, areas with high water tables, or intertidal areas. (40)
Increased environmental contamination due to increases in intense winds. (45)	• Encourage adoption of non-pesticide integrated pest management, and non-chemical cultural and biological controls. (40) • Use seasonal weather forecasts to plan the timing of pesticide application, and avoid applying immediately before or during windy conditions. (45) • Encourage application in morning and evening to minimize drift of pesticide sprays. (40)
Reduced effectiveness and/or shelf life due to climate stressors. (45)	• Encourage adoption of non-pesticide integrated pest management, and non-chemical cultural and biological controls. (40) • For pesticides distributed or activated by water, promote pesticide storage in watertight containers, high ground that will not flood, and covered areas. (45) • For pesticides distributed or activated by water, promote the monitoring of pesticides to check for leakage and contamination, particularly during rainy seasons. (45) • For pesticides that are sensitive to heat, store in cool locations. (40)
Increased risk of crop damage when applying certain pesticides (e.g., sulfur) in hot conditions. (40)	• Encourage adoption of non-pesticide integrated pest management, and non-chemical cultural and biological controls. (40) • Avoid applying pesticides during hot conditions to prevent leaf burn. (40)
Increased health hazards due to rising temperatures (e.g., farmers may be less willing to use personal protective equipment, tissue irritation may worsen). (40, 45)	• Encourage adoption of non-pesticide integrated pest management, and non-chemical cultural and biological controls. (40) • Encourage adoption of less toxic pesticides and improved application methods. (45) • Increase the availability of comfortable, affordable personal protective equipment. • Increase the availability of safer use training. • Discourage pesticide application when temperatures exceed 36°C (97°F). (40)

Spread of Invasive Species

Invasive species can harm habitats and agricultural systems by adversely affecting existing plants and animals, including crops and livestock. (46) Climate change both enables invasive species to spread and establish themselves, and reduces the resilience of habitats and agricultural systems, compounding the impact of invasive species. (46)

Haiti is home to various invasive species with the potential to damage crops. (47) For example, the invasive house mouse (*Mus musculus*) has destroyed crops and consumed and contaminated food supplies. (48) *Bidens pilosa* is an herb that can threaten crops and native fauna. (48) The fire ant (*Solenopsis geminata*) can also damage crops as it promotes honeydew-producing insects. (48)

LIVESTOCK

The livestock sector is dominated by small-scale animal production. (6) Generally, better-off households own more livestock; on average, very poor households own around 4 animals, poor households own around 8 animals, middle-income households own around 18 animals, and better-off households own around 30 animals. (6) Livestock can act as a savings mechanism and augment income through the sale of transport services, animal products, and the animals themselves, increasing household financial resilience to crop losses. (6) Animal sales and animal product sales typically contribute up to 15 percent of income. (6)

Hurricanes and drought have led to loss of livestock in Haiti; recently, Hurricane Matthew is estimated to have resulted in thousands of cattle deaths, including up to 90 percent of livestock lost in some areas. (49) Climate change has the potential to adversely affect livestock health, as described in Table 6.

Table 6. Livestock: Climate risks and potential adaptation responses.

Climate Risks	Potential Adaptation Responses
Reduced livestock growth rates, milk production, and overall health due to heat stress.	• Shift to more heat-tolerant livestock species. • Construct shade structures to cool animals. • Diversify livelihoods through combined cropping, livestock, and non-farm income.
Loss of livestock grazing pastures and fodder due to hurricanes, floods, and drought.	• Substitute vegetation that is more resistant to climate stressors. • Where possible, feed livestock crop waste products, and shift to species that are more tolerant of these products (e.g., pigs).
Reduced water available for livestock due to drought and sea level rise-driven salinization of coastal water resources.	• Improve water infrastructure, implement water efficiency measures, implement rainwater catchment systems, and extract groundwater, if appropriate, to increase the availability of water for livestock.
More frequent and/or widespread livestock pest and disease outbreaks. In the past, livestock diseases have been the greatest issue in HT01, HT02, HT03, HT07, and HT08. (6)	• More closely monitor livestock for pests and diseases, and develop action plans for implementation when pests and diseases are identified (e.g., seek treatment, implement quarantines). • Increase access to veterinary services, and establish community-based disease control programs. • Incentivize and increase access to vaccinations and pharmaceuticals.
Loss of livestock due to increased frequency and intensity of hurricanes.	• Develop early warning systems to prepare livestock owners for extreme events.

Climate Risks	Potential Adaptation Responses
Cross-cutting impacts	• Provide inputs and technical assistance for fish farming to provide an alternate source of protein. (36)

FOOD PROCESSING AND STORAGE

Food processing and storage in Haiti is inadequate, leading to large post-harvest losses. (7) Large-scale food processing is limited to a few major importers, while small-scale food processing occurs across the country but relies on outdated equipment. (7) Storage facilities are limited, and many were damaged in the 2010 earthquake. (7) Warehouse space is concentrated around Port-au-Prince, and is in poor condition. (7) Poor storage practices further reduce product shelf life, particularly for maize, sorghum, pulse, and tubers. (7) Table 7 summarizes the major post-harvesting challenges facing staple crop production, as well as the climate risks facing the various post-harvesting components.

Table 7. Major post-harvesting challenges by staple crop.

Post-Harvesting Component	Major Challenges	Climate Risks	Adaptation Responses
Product at Harvest	Poor product quality at harvest, seasonality of production, consumer preferences favor varieties susceptible to disease (bananas)	See climate risk described in Crop Production section.	See adaptations described in Crop Production section.
Processing	Old and poorly maintained processing equipment such as mills, poor processing practices leading to damages and losses, undeveloped processing industry	Increased frequency and intensity of extreme events and coastal flooding may further damage processing equipment and/or products. There is an altered effectiveness of fumigants driven by changes in temperature and humidity.	Implement early warning systems and plans to address extreme event impacts.
Packaging	Limited access to quality packaging, high perishability	Increased temperatures may accelerate perishability.	Increase the availability of climate-controlled storage. Encourage the development or accessibility of improved packaging.
Storage	Lack of storage facilities, poor condition of storage facilities, poor storage practices resulting in a shorter shelf life	Increased frequency and intensity of extreme events and coastal flooding may further damage facilities.	Relocate and incentivize the development of storage away from high-risk locations (e.g., coastal areas, areas prone to flooding and hurricane damages, very humid and very hot areas). Retrofit existing storage and create new storage that is more resilient to floods and hurricanes, and can more effectively control temperature.

Post-Harvesting Component	Major Challenges	Climate Risks	Adaptation Responses
Transportation	High transportation costs, poor transportation and road infrastructure, limited transportation options due to product bulkiness	Increased frequency and intensity of extreme events and coastal flooding may further damage and inhibit access to roads.	Implement early warning systems and plans to address extreme event impacts Assess the vulnerability of the transportation network.
Distribution	Inefficient aggregation and distribution, challenges in improving distribution processes due to a large number of actors	Increased frequency and intensity of extreme events and coastal flooding may further disrupt distribution.	Implement early warning systems and plans to address extreme event impacts Assess the vulnerability of the transportation network.
Inability to Scale Up Operations	Inability to supply consistent quantity and/or quality to access better markets, lack of capital to expand operations, limited financing to support production cycle length	Climate impacts may increase variability in the quantity and quality of harvests. Costs from climate impacts may further reduce the capital available to expand operations.	See adaptation responses for Crop Production (Table 3 and Table 4)

Source: USAID and FEWS NET 2018, USAID 2017, USAID 2013

FOOD PURCHASES AND IMPORTS

Half of Haiti's food supply is composed of imports that households purchase. As noted above, agriculture is central to the Haitian economy, employing 66 percent of the population. (17) Therefore, when agricultural productivity is limited, the ability to purchase imported foods on the market becomes limited as well. (2, 10, 14) The ability to meet food needs through market purchases is limited by widespread poverty, as poorer households are generally more dependent on market purchases, with some households purchasing up to 85 percent of their food needs. (2, 7)

Rice is the primary staple food in the Haitian diet, yet Haiti depends on imports to meet demand; around 80 percent of rice consumed in Haiti is imported. (7, 50) Haiti relies completely on imports to meet demand for two other staple foods—wheat and edible oil. (7) Haiti generally imports cereals and pulse from the United States and the Dominican Republic, and imports edible oil from Malaysia; therefore, exchange rates—particularly against the U.S. dollar, Dominican peso, and Malaysian ringgit—can limit households' ability to purchase food. (7) Import tariffs, bans on imports of certain foods, and Haiti's relationship with the Dominican Republic also affect import prices. (7) Spikes in market prices and dips in income can therefore substantially affect food security, particularly that of poor households. For example, a rise in commodity prices (+9 percent per year) and inflation (+14.1 percent per year) substantially limited households' ability to access food in 2018. (5)

In addition to impacts to crop production described above, extreme weather events and changes in climate have the potential to adversely affect the availability of imported foods and increase the need for emergency food aid responses, as described in Table 8. (51)

Table 8. Food imports: Climate risks and potential adaptation responses.

Climate Risks	Potential Adaptation Responses
Compromised availability of imported foods as increased extreme events adversely affect import entry points (e.g., ports and cross-border points) and transportation routes.	• Improve the climate resilience of infrastructure (e.g., ports roads). • Implement early warning systems and response plans for ensuring food availability following extreme events. • Increase domestic agricultural productivity and the ability to meet a greater share of food needs through domestic production. • Develop tools to transfer climate risk and enable affordable social safety nets. (51)
Compromised ability to purchase foods as climate impacts to livelihood sources may reduce household income.	• Diversify income sources in order to reduce reliance on any one source. • Increase household agricultural productivity in order to reduce the need to purchase food at markets. • Develop tools to transfer climate risk and enable affordable social safety nets. (51)
Reduced supply of imported foods as climate impacts may adversely affect the production of imported foods. (51)	• Increase domestic agricultural productivity and the ability to meet a greater share of food needs through domestic production. • Develop tools to transfer climate risk and enable affordable social safety nets. (51)

HUMAN HEALTH: NUTRITION, WASH, AND HEALTH SERVICES

Haiti suffers from high rates of malnutrition and water-borne disease incidence. The causes of poor health include food insecurity, a lack of access to improved water supply and sanitation, poor hygiene practices, and poor access to healthcare services. Climate is a driver of malnutrition and disease, affecting crop productivity, and water supply and sanitation services.

Malnutrition is largely driven by early childbearing and is linked to particular seasons. Early childbearing increases the likelihood of mothers being malnourished and having babies with lower birth weights, who are malnourished and/or have increased risk of illness and death. Nutritional concerns are linked to periods of the agricultural year when food is less available, namely April–June. (52) As climate change drives an increase in the frequency and severity of droughts, floods, and hurricanes that damage crops, these lean seasons may lengthen, and food availability may become even more constrained.

Water supply and sanitation services in Haiti are limited, especially in rural areas. (53, 54) Water resources have been further compromised by deforestation, which has accelerated water system and reservoir siltation, reduced groundwater recharge, and increased runoff. (55) Largely due to poor water supply and sanitation services, and poor hygiene practices, waterborne diseases—namely diarrheal diseases such as cholera—continue to afflict Haiti, particularly the rural poor. (55, 56, 57) Hurricanes and extreme rainfall have historically led to flooding that triggers a surge in water-borne diseases due to compromised WASH infrastructure and services, contamination of water supplies, and use of untreated water sources. (58, 59, 60) Cholera epidemics can occur and be exacerbated by cascading impacts resulting from disasters, where damage to power, water, transport, and other infrastructure limits Haitians' ability to access clean water sources. (61) Transmission of water-borne diseases can also increase during dry seasons and droughts, as low flows and stagnant water enable pathogens to accumulate. (62) Climate change is expected to increase the frequency and intensity of hurricanes, floods, and droughts, which may heighten the incidence of waterborne diseases. (62, 63, 64)

Limited access to quality healthcare services further compromises human health, particularly among rural populations. (9) Haiti's healthcare system relies on substantial support from donors, and extreme weather events and health crises are likely to continue to stress the system. (14) Direct damage to healthcare facilities and damage to roads can limit access to medical services and supplies, and prolong the adverse health consequences of disasters. (65) For example, Hurricane Matthew damaged or destroyed more than 60 percent of Haiti's healthcare facilities. (65)

Natural disasters and climate impacts on human health have the potential to increase the need for emergency response to address crisis situations. However, measures can be taken to improve nutrition levels and WASH services, infrastructure, and practices, as well as strengthen healthcare services in order to improve human health. (66)

Table 9. Human health, nutrition, and WASH: Climate risks and potential adaptation responses.

Climate Risks	Potential Adaptation Responses
Reduced nutrition driven by direct climate impacts on agriculture**,** indirect impacts on staple food prices**, and/or impacts to health services.**	• Implement the interventions described in the Crop Production section. • Increase nutrition-rich food availability and affordability in the markets and at the home-consumption level. (52) • Implement a price stabilization program. • Encourage behavior change to improve child care and feeding practices. (52) • Provide and strengthen preventive and curative health and nutrition services to reduce the frequency of child sickness and help children recover sooner, preventing malnutrition and death. (52) • Address nutritional needs in the critical first 1,000-day period of life to ensure maternal and child nutritional health and prevent stunting. (52) • Provide adolescent girls with appropriate family planning, WASH, and health and nutrition information to combat the nutritional effects in girls who become pregnant before age 18. (52)

Disrupted or diminished water supply and sanitation services due to infrastructure damage from hurricanes, intense storms, and associated erosion.	• Rehabilitate water supply and sanitation systems, taking into account potential flood and erosion risks:
	  ○ Modify the design to address potential flood risk (e.g., undergrounding infrastructure).
	  ○ Site infrastructure outside of hazard zones.
	• Reinforce local water and sanitation committees to perform operations and maintenance.
	• Build local government capacity to promote low-cost WASH technologies and support decentralization of WASH services. (55)
	• Promote sanitation (i.e., safe disposal of human excreta) and hygiene behavior change. (55)
	• Apply proven, low-cost WASH technologies and services in tandem with sustainable financing strategies. (55)
	• Coordinate with the Centers for Disease Control and Prevention on the nature of continued U.S. support to Communal Water and Sanitation Technicians. (55)
	• Gather information about lessons learned from the earthquake and cholera emergency programs to improve WASH services. (55)

Reduced availability and destruction of clean drinking water due to drought and reduced water quality and availability.	• Prevent deforestation and implement reforestation in order to improve water quality and prevent further degradation. • Enhance seasonal water resource forecasting and monitoring abilities to more effectively undertake water resource management and planning. (34) • Repair existing water infrastructure in a manner in which it can withstand the expected extreme rainfall, erosion, and hurricanes. (34) • Construct community cisterns to catch and store rainwater. (34)

Climate Risks	Potential Adaptation Responses
	• Build new dams to hold water. (34) • Implement erosion control measures (discussed in the Crop Production section) to reduce sedimentation in the water supply. (34) • Manage aquifers to increase the quantity and quality of groundwater. (34) • Support increasing a public willingness to pay for access to safe water. (55)

Increased risk of water-borne diseases. More intense rainfall and poor waste management may cause an increased risk of waterborne diseases, namely cholera; this is especially an issue in Port-au-Prince.	• Improve water services to prevent diarrheal diseases and improve nutrition:
	  ○ Increase the chlorination of municipal water supplies. (55)
	  ○ Rehabilitate water distribution networks and water treatment stations. (55)
	• Improve sanitation services:
	  ○ Train latrine providers to better manage flooding. (67)
	  ○ Train households on siting latrines to account for climate risks. (67)
	  ○ Provide regional sanitation units with technical assistance to standardize latrine and fecal sludge management quality in dealing with flood and erosion impacts. (67)
	• Support improved hygiene:
	  ○ Distribute household water treatment products and soap. (55)
	  ○ Create household and community handwashing facilities. (55)
	  ○ Following disaster events, undertake cholera prevention campaigns. (54)
	• Encourage communitywide approaches for water supply and sanitation services and hygiene interventions, and focus on facilities at the household level and in public spaces and institutions (55):
	  ○ WASH investments in rural areas in the Artibonite, North, and Grande'Anse departments have the potential for the greatest effects, especially among children under age 5. (54, 55)

Increased difficulty of accessing medical treatment during and following extreme rainfall events that trigger flooding and landslides, which may damage transportation infrastructure.	• Improve flood management, landslide control, and drainage systems. Where possible, focus on natural and nature-based flood management practices, such as those outlined in the World Wildlife Fund and USAID Flood Green Guide.
Reduced availability or increased disruption of health services due to stress from extreme weather disruptions.	• Implement early warning systems. (34) • Improve flood management, landslide control, and drainage systems. Where possible, focus on natural and nature-based flood management practices, such as those outlined in the World Wildlife Fund and USAID Flood Green Guide.

ECOLOGICAL SENSITIVITY AND ENDANGERED SPECIES

Haiti has 35 protected areas that cover around 6 percent of the country, and is rich in biological diversity, with 75 percent of its fauna considered endemic. (68) However, due to severe deforestation, it is likely that endemic species have already been lost and that others are at risk of extinction. (68, 11) Furthermore, deforestation, combined with erosion-intensive agriculture, has compromised ecosystem health, leading to altered water flows, heightened erosion and sedimentation, and reduced soil health, and causing flooding and damaged aquatic ecosystems, and threatening ecosystem health and biodiversity. (68) Healthy ecosystems typically benefit communities and livelihoods, namely agriculture, by providing ecosystem services such as water

filtration, flood protection, coastal protection, and sustenance of pollinator populations. (21) However, when ecosystem health becomes compromised, so do these services. (21)

Compromised ecosystems have also made Haiti more sensitive to climate stressors and extreme events, particularly hurricanes and extreme rains, causing further damage to Haiti's ecosystems, communities, and their livelihoods, namely agriculture. Climate change has the potential to intensify extreme events and the resulting degradation, as described in Table 10. Preventing further environmental degradation and fortifying the remaining natural areas would enhance the resilience of Haiti's ecosystems and increase redundancy should extreme events eliminate rare species in particular areas. (68)

Table 10. Ecological sensitivity and endangered species: Climate risks and potential adaptation responses.

Climate Risks	Potential Adaptation Responses
Soil degradation. Increased extreme precipitation is expected to exacerbate erosion, further degrading soil and threatening ecosystems.	• Encourage reforestation and agricultural practices that improve soil health, as described in the Crop Production section. (48)
Upward shift in forests due to temperature increases, and loss of forests already at the highest altitudes with no potential for upward shift.	• Encourage reforestation in the remaining forested areas and in areas where temperatures will allow forest growth. (48)
Increased forest damage due to more intense hurricanes and severe weather events. Pine forests in the Chaîne de la Selle mountain range are particularly sensitive to wind damage.	• Encourage reforestation in the remaining forested areas and in areas where hurricane winds tend to be less intense. (48)
Increased sediment in bodies of water. Increased precipitation is expected to increase runoff carrying sediment into lower parts of watersheds and coastal ecosystems.	• Encourage reforestation and agricultural practices that reduce erosion, as described in the Crop Production section. (48)
Increased salinization of freshwater aquifers and estuaries due to sea level rise, reducing productivity and leading to species loss.	• Manage groundwater extraction in coastal areas to prevent exacerbation of seawater infiltration. (48)
Increased beach erosion due to sea level rise, greater storm surges, and increased hurricane intensity.	• Improve the health of coastal ecosystems, such as mangrove forests and seagrasses, to mitigate erosion. (48)
Increased coral reef damage due to ocean acidification and sediment-heavy runoff.	• Reduce sediment in runoff by mitigating erosion through reforestation and improved agricultural practices. (48) • Prevent human-induced reef damage (e.g., harmful fishing practices) to prevent additional damage to reef ecosystems. (48)
Cross-cutting risks causing ecosystem degradation.	• Engage in and support conservation, natural resources management, and environmental protection efforts that improve ecosystem health and the quality of ecosystem services. • Partner with community-based conservation efforts, such as the International Union for Conservation of Nature's conservation efforts.

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