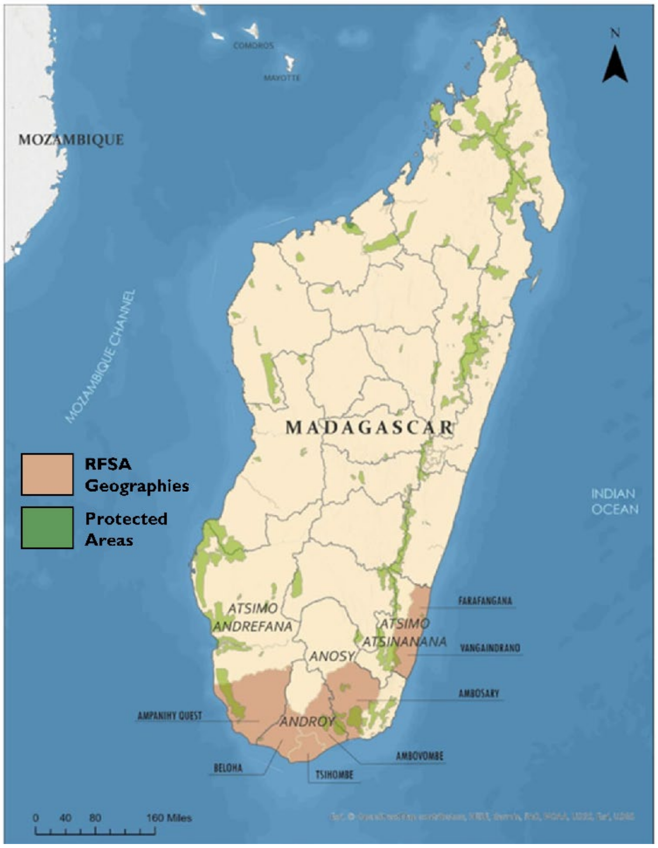
Climate Risks to Resilience & Food Security in Bureau for Humanitarian Assistance Geographies

Madagascar

Country Overview

Madagascar is one of the top 10 most disaster-prone countries and is the most cyclone-prone country in Africa. Slow development, high levels of income inequality, rapid population growth, political corruption, and the impacts of repeated extreme weather events all contribute to Madagascar's status as one of the most impoverished countries in the world, with 77.4 percent of the population living on USD $1.9 a day in 2020. The nation as a whole is already coping with the impacts of climate variability and change, and regularly experiences stressors including extreme heat, flooding, cyclones, and drought. Women, children, and rural communities are particularly at risk for the associated health and economic impacts of these climate extremes. In southern Madagascar, the situation is especially dire—the region experienced severe periods of drought between 2018 and 2022, leading to extreme food insecurity across the region. Meanwhile, regular cyclone events such as Cyclone Freddy in 2023 have caused widespread destruction. As the climate continues to change, storms and droughts are projected to become even more intense, further threatening food security and livelihoods, especially in the south. (1, 2, 3, 4, 5)



Highlighted area represents focus geographies where food security activities are planned in Madagascar.

The United States Agency for International Development (USAID) Bureau for Humanitarian Assistance (BHA) is proposing resilience and food security activity (RFSA) investments focused on household-level interventions in the following geographic areas of south and southeast Madagascar: Androy (in Ambovombe, Beloha, and Tsihombe), Anosy (in Amboasary), and Atsimo Andrefana (in Ampanihy Ouest)—collectively referred to as the Grand Sud)—and Atsimo Atsinanana (in Farafangana and Vangaindrano). These regions are some of the most arid (Grand Sud) and cyclone-prone (Atsimo Atsinanana) parts of the country. The Androy and Anosy regions are particularly vulnerable to climate-related food insecurity, and both have elevated rates of chronic malnutrition among children under age five. In 2022, an estimated 2 million-plus people in southern and southeastern Madagascar experienced high levels of food insecurity

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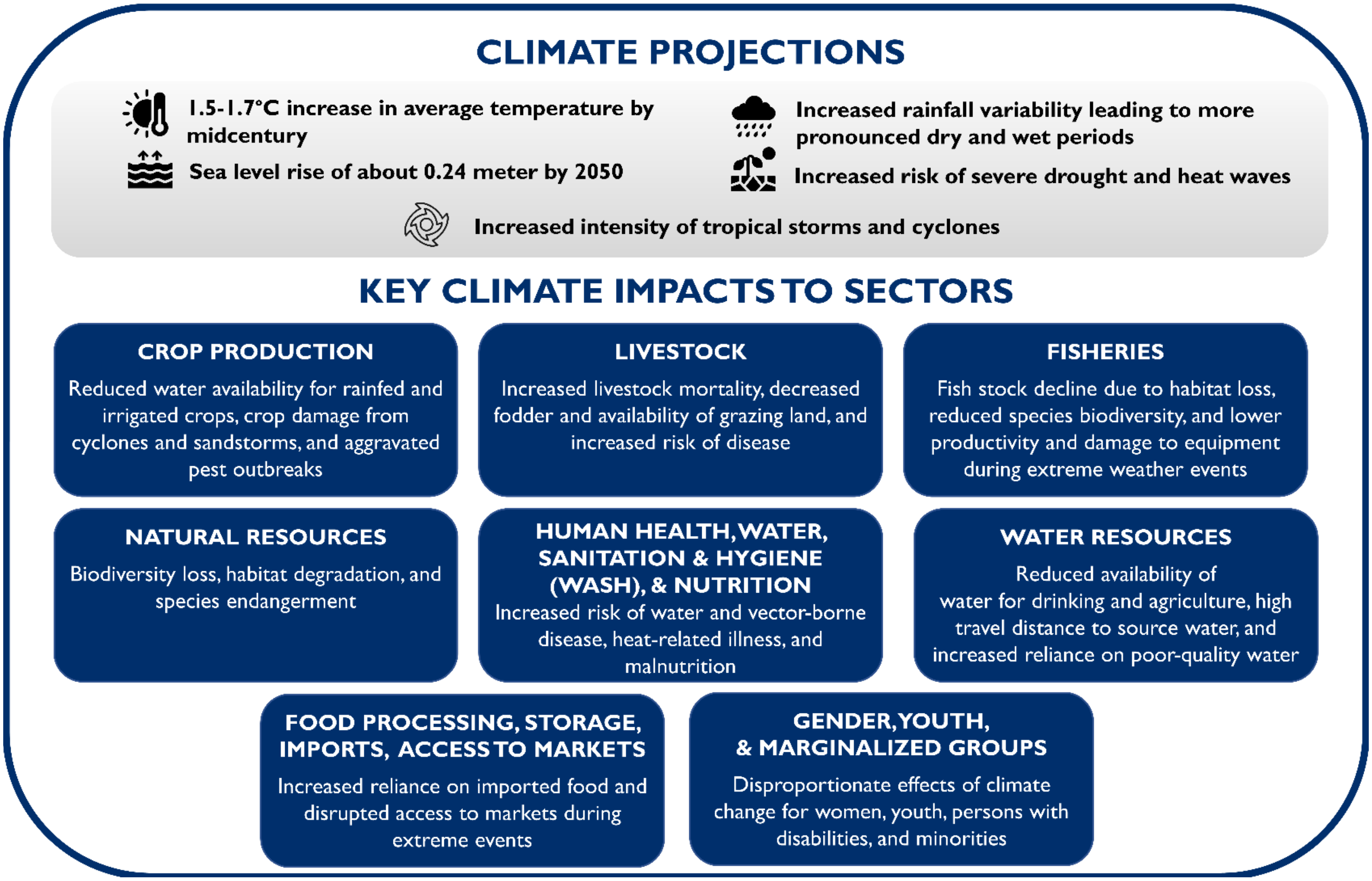
related to the 2018–2022 drought. While the situation has improved, over 1 million people in the region still faced high levels of food insecurity in mid-2023. (1, 6, 7)

In line with USAID's Climate Risk Management guidance, USAID resilience and food security investments in these areas must consider and adapt to changing conditions to manage the risks to programming posed by ongoing climate variability and change. This report discusses projected climate stressors and associated risks in RFSA geographic areas and proposes illustrative household-level climate risk management measures. Key climate projections and associated impacts to RFSA sectors are summarized in the image below.



CLIMATE SUMMARY

HISTORICAL CLIMATE

Madagascar's climate exhibits distinct regional variability due to the island's size, topographical orientation, and diverse geography. The Eastern and Western halves of the country are geographically distinct, separated by a central mountainous ridge that includes a high-elevation plateau and three primary massifs. The country has a range of tropical, desert, and savannah-like zones, and the three major climatological regions in Madagascar include the eastern rainforests, central highlands, and southern and western arid regions. In general, the country's hot, wet season falls between November and March, followed by a cooler, drier season from April through October.

The RFSA geographic areas fall largely within the Grand Sud (Androy, Anosy, and Atsimo Andrefana), or southernmost tip of the country, and Atsimo Atsinanana region in southeast Madagascar. The Grand Sud is predominately arid and semi-arid, with warm temperatures and relatively low annual precipitation totals, whereas southeast Madagascar is more humid with more frequent rainfall throughout the year. In the Grand Sud, annual maximum temperatures generally range from 28°C to 32°C, and total yearly rainfall in the region is between 700–1,300mm, depending on location. In Atsimo Atsinanana, average annual maximum temperatures range from 27–30°C, and precipitation is higher at around 1,600mm on average. Similar to the rest of Madagascar, the southern regions experience slightly wetter conditions from November to March. The remaining portion of the year represents a prolonged dry season in these areas, which yields frequent drought conditions and a desert-like climate. (8)

The southern and southeastern regions of Madagascar have experienced slight warming and drying trends in recent decades, with annual average temperatures increasing and total annual precipitation diminishing. Specifically, annual average temperatures have warmed by approximately 0.25–0.28°C per decade in the Grand Sud between 1970 and 2020, and 0.17°C per decade in Atsimo Andrefana. Precipitation totals have decreased slowly but steadily: the Grand Sud experienced an approximately 20–30mm annual precipitation decrease per decade since 1970, while Atsimo Atsinanana had slightly smaller decreases (13mm on average per decade). (8)

With its hot and arid climate, the Grand Sud is susceptible to severe and prolonged drought, and observed evapotranspiration rates have increased in the region since 1980. Notable recent drought events include between 2018 and 2022, when extreme dry conditions resulted in widespread food insecurity and impoverishment. Further exacerbating arid conditions in the Grand Sud are the naturally occurring sandstorms known as tiomena. During a tiomena event, rising hot air causes strong winds to carry sand and dust that can coat crops, bury equipment and roads in dunes, and create respiratory issues, while also increasing evapotranspiration and erosion of soil. Tiomena events occur multiple times per year, usually concentrated in the period from May to October. However, since the recent rise in drought conditions, tiomena have been occurring more regularly and have been observed throughout the year since 2019. (9, 10, 11)

Its location in the southwestern Indian Ocean means Madagascar regularly experiences tropical cyclones. While tropical cyclone risk is greater in eastern and northern Madagascar, the Grand Sud is also susceptible to impacts from these storms. The storms can bring needed rainfall but also cause significant damage, especially along the coast. Since 2000, 47 tropical storms and cyclones made landfall in Madagascar, with 18 of these recorded in the RFSA geographic areas. Large storms typically bring extreme rainfall, high winds, and storm surge, which in turn can drive inland and coastal flooding, damaging agricultural land, housing, and infrastructure. In early 2022, Madagascar was struck by five tropical storms during a six-week period, impacting nearly a million residents. Most recently, Cyclone Freddy made landfall on the east coast in February 2023, resulting in extensive damage with torrential rains, severe winds, and strong storm surge and damaging and destroying crops, including in Atsimo Atsinanana and surrounding regions. , (12, 13, 14, 15, 16)

Madagascar has the longest coastline of any African country, and rising sea levels are already exacerbating coastal erosion at coastal ports and beaches. Between 1993 and 2017, measured sea level rise in Madagascar was approximately 1.6 mm per year—slightly lower than the global average. (9, 17)

FUTURE CLIMATE

Climate projections indicate with various levels of certainty that climate stressors in southern and southeastern Madagascar will intensify in both magnitude and severity in the future. Models suggest increases in average temperatures across all parts of the region, with slightly higher increases occurring during the months of October, November, and December and greater increases expected in inland areas compared to the coast. In addition to warming average temperatures, by mid-century, the RFSA geographic areas are expected to see an increase in the number of days per year with temperatures over 30°C (see Table 1 below). Despite its location along the coast, Atsimo Atsinanana in southeastern Madagascar will likely experience a greater increase in the average number of days with temperatures over 30°C per year compared other regions. As temperatures change, the likelihood of extreme heatwaves is expected to increase, along with the risk of severe dry spells and drought. Increasing temperatures lead to higher rates of evapotranspiration and, when coupled with diminishing rainfall totals, can significantly heighten drought risk. As temperatures and evapotranspiration rates rise and topsoil dries out, the risk of high winds causing tiomena events (sandstorms) can also increase, creating a vicious cycle that drives even more drying conditions and erosion. (8, 18, 19)

Precipitation projections for southern Madagascar are less certain. Climate models show a range of futures that include more variable precipitation, with potential for small overall precipitation increases or decreases and increased precipitation variability overall. However, average projections in the models under high-emissions scenarios indicate minor decreases in annual and monthly precipitation totals through mid-century, with April to November exhibiting a drying trend and December to March becoming slightly wetter. Annual total precipitation across the RFSA geographies is expected to reduce by around 7–8 percent by mid-century under a high-emissions scenario (see Table 1 below). (8)

Sea level rise across the coast of southern Madagascar is expected to continue. Projections under a high-emissions scenario show that by 2030 sea level rise could reach 0.1 meter, relative to a 1995–2014 baseline, and that by mid-century, this total could increase to approximately 0.24 meters. (20)

While research on the influence of climate change on tropical cyclones is limited, climate change is linked to warming ocean temperatures, and warmer waters are driving higher-intensity cyclones and tropical storms worldwide. A greater proportion of future tropical storms and cyclones are expected to be more extreme, bringing higher rainfall, more damaging wind speeds, and greater storm surge. The Indian Ocean is warming rapidly, and storms that occur often intensify quickly. This trend is expected to continue as ocean warming rises in the region. RFSA geographic areas could see an increase in extreme storm risk moving forward. (18, 21, 22, 23)

Table 1: Key climate projections in southern Madagascar for the near and mid-term. Data for projections comes from SSP5-8.5 CMIP6 ensemble projections, with 10th–90th percentile range in parentheses. Source: World Bank Climate Change Knowledge Portal, 2024 (8)

Climate Variable & Region	Baseline (1995–2014)	Near-century (2020–2039)	Mid-century (2040–2059)
Temperature			
Annual mean surface temperature			
Atsimo Andrefana	24.4°C	+0.75°C (+0.5–1.1°C)	+1.7°C (+1.2–2.3°C)
Androy	23.7°C	+0.7°C (+0.4–1°C)	+1.6°C (+1.1–2.1°C)
Anosy	21.7°C	+0.7°C (+0.4–1°C)	+1.6°C (+1.1–2.2°C)
Atsimo Atsinanana	21.5°C	+0.7°C (+0.4–1°C)	+1.5°C (+1.1–2.2°C)
Number of days per year with maximum temperatures >30°C			
Atsimo Andrefana	184	218 (196–240)	254 (226–281)
Androy	138	167 (144–190)	201 (172–228)
Anosy	71	94 (76–114)	126 (99–157)
Atsimo Atsinanana	10.5	26 (15–39)	52 (29–81)
Precipitation			
Total annual precipitation and projected percent change			
Atsimo Andrefana	752 mm	-4 percent (-20 to +11)	-8 percent (-26 to +6)
Androy	625 mm	-5 percent (-19 to +7)	-8 percent (-26 to +2)
Anosy	1015 mm	-4 percent (-17 to +7)	-8 percent (-22 to +2)
Atsimo Atsinanana	1973 mm	-4 percent (-10 to +4)	-7 percent (-17 to +1)

Policy Context

Madagascar is a signatory of the United Nations Framework Convention on Climate Change (UNFCCC) and to the 2015 Paris Agreement. The government has developed legislation that links objectives such as protecting pre-existing biodiversity, disaster management, and advancing sustainability programs with climate change goals. The National Policy to Combat Climate Change, passed in 2011, is the foundation of domestic climate policy in Madagascar and the National Climate Change Adaptation Plan guides adaptation action. The National Bureau of Climate Change, Carbon and Reduction of Emissions from Deforestation and Forest Degradation, sitting within the Ministry of Environment and Sustainable Development, is responsible for Madagascar's climate action policies and arose from the merger of the National REDD+ Coordination Office and the National Office of Climate Change Coordination. (24, 25)

Key national policies governing climate action include the following:

- Initial National Communication (2004), Second National Communication (2010), and Third National Communication (2017)
- Nationally Appropriate Mitigation Actions (NAMA) (2011)
- National Strategy for Climate Change in Agriculture-Livestock-Fishery (2013)
- National Disaster Risk Management Strategy 2016-2030 (2016)
- Nationally Determined Contribution (NDC) (2016)
- National Climate Change Adaptation Plan (2019)
- National Policy to Combat Climate Change (2011); Revised National Policy to Combat Climate Change (2021)
- National Adaptation Plan of Madagascar (2022)

Despite the prevalence of overarching climate policies, progress on climate action has been slow. As one of the most vulnerable countries to climate change in southern Africa, the Government of Madagascar faces barriers responding to multiple, often concurrent climate-related disasters with sufficient resources and governance systems. Moreover, coordination among government agencies and humanitarian organizations on climate efforts remains a challenge due to misalignment in priorities, planning, and budgeting. (9, 26)

Impacts and Vulnerabilities

In southern and southeastern Madagascar, multiple sectors related to food security and resilience face climate impacts. These include agriculture (which includes crop production, livestock, and food processing), fisheries, and water resources. Food security activities must consider the impacts of climate change on human health and nutrition and the intersectional vulnerabilities experienced by communities and groups that have been marginalized such as women; youth; lesbian, gay, bisexual, transgender, queer, and intersex people (LGBTQI); people with disabilities; and ethnic minorities. The sector-specific sections below contain greater detail about potential climate change impacts in the RFSA geographic areas.

Priority impacts identified across these sectors include:

- **Crop production:** Increasing temperatures, precipitation variability, and changes in frequency and severity of climate extremes like droughts, sandstorms, and floods may lead to increasing damage to crops and farmland, reduced availability of rainfall and water for irrigation, adverse impacts on soil productivity, and pest outbreaks.
- **Livestock:** Increasing temperatures and extreme weather events may negatively impact livestock health and productivity while also devaluing livestock as a form of family savings, thereby exacerbating vulnerabilities during times of crisis. Projected rainfall decreases will also impact livestock productivity and access to water.
- **Fisheries:** Increased frequency and intensity of severe weather events, rising ocean temperatures, and ocean acidification negatively impact fish habitats and traditional fishing practices in Madagascar, leading to reduced fish production, threatened livelihoods, and compromised food security.
- **Water resources availability:** Rising temperatures, decreased precipitation, and increased frequency of cyclones exacerbate water scarcity and quality issues in Madagascar; these climate stressors amplify risks of drought and flooding, particularly in the arid southern regions of the Grand Sud.
- **Human health, water, sanitation, and hygiene (WASH), nutrition, and health services:** Extreme weather events and temperature changes intensify existing health challenges in Madagascar, including infectious diseases, waterborne illnesses, and malnutrition, exacerbating vulnerabilities especially among socio-economically disadvantaged groups.

- **Natural resources management and endangered species:** Increasing cyclones, droughts, and extreme precipitation events amplify Madagascar's challenges in biodiversity loss and resource management, contributing to habitat degradation and species endangerment.
- **Gender, youth, and marginalized groups:** Groups like women, children, the elderly, LGBTQI populations, and ethnic minorities are more vulnerable to experiencing climate-driven impacts on natural resources, as well as cascading impacts on the economy and society.

Crop production

Agriculture contributes around 25 percent of Madagascar's gross domestic product (GDP) and employs approximately 80 percent of the population. Crop cultivation is primarily made up of smallholder subsistence farms and critical to the food security of the 60 percent of the country living in rural areas. Farmers often have small landholdings and are constrained in their access to technological advancements, credit, and extension services. While rice is the staple cereal crop in central and northern Madagascar, maize is also grown in the southern regions along with cassava, groundnuts, and sorghum. Sweet potato, beans, fruits, and coffee are grown on many farms in the southeast including in Atsimo Atsinanana. (27, 28, 29, 30, 31)

In the RFSA geographic areas, crops are predominantly rainfed and particularly vulnerable to rainfall variability and drought. Consecutive years of drought since 2019 have reduced yields of crops including rice, maize, and beans throughout the region, particularly in the arid Grand Sud. In Androy, the region experienced 40 percent less rainfall for two consecutive rainy seasons in 2019/2020 and 2020/2021. The lack of rainfall led to rainfed crop failures, signifying the worst drought since 1992. Following the drought, an April 2021 assessment found that 43 percent of the population in Southern Madagascar (1.14 million people) faced acute food insecurity challenges. In neighboring Anosy, the same prolonged drought led to a reduction in agricultural productivity, a loss of seeds, and the overall deterioration of crops. Drier conditions also enhance the spread of invasive species and crop pests in Madagascar (see Table 2). (32, 33)

Other climate shocks, including temperature extremes, floods, and intense tropical cyclones, further exacerbate the challenges brought by drought conditions. These events can have a compounding effect on agriculture value chains across Madagascar, including in the RFSA geographic areas. For example, in 2022, maize production declined below a five-year average, and food prices increased due to drought and an intense cyclone season that brought heavy rains, flooding, and strong winds that destroyed fields and orchards. During this season, there was an estimated USD $140 million in cyclone damage to food crops in the southeastern regions of the country. (6, 34)

Future climate variability and change will likely exacerbate challenges related to crop production, further threatening farmers' livelihoods and food security. As temperatures rise, farmers may experience negative impacts and health risks associated with extreme heat days, which can lead to a decline in agricultural labor productivity. In addition, reduced precipitation, longer dry spells, and drought-like conditions are likely to reduce growing days for major crops in southern Madagascar. Especially in the Grand Sud, increased incidence of sandstorms can further damage crops and erode topsoil. While projected warming could be potentially beneficial to irrigated rice cropping in the region, sustained high temperatures, rainfall variability, and damage from cyclone-driven high winds may work to negate these benefits. Specific climate sensitivities and considerations for major crops in the RFSA geographic areas are listed in Table 2 below. (27, 28 35)

Table 2: Climate sensitivities of major crop types in southern and southeastern Madagascar (36, 37, 38, 39, 40, 41)

Crop	Climate Sensitivity
Rice	• Rice is highly sensitive to dry conditions and drought, which can lead to stunting, leaf senescence, delayed flowering, and loss of yield. • Higher temperatures can cause sterility in flowers, reducing yield. • Higher respiration losses linked to rising temperatures can reduce productivity. • Strong winds and heavy rainfall can cause lodging in standing crops. • Flash floods in fields can cause stem breakage, reduce photosynthetic capacity, and increase susceptibility to pests and disease. Flooding during the flowering stage can disrupt fertilization, causing yield loss or complete crop failure.

Crop	Climate Sensitivity
Cassava	• Optimal average temperature for growth and yield is between 25–27°C. • Cassava can grow with as little as 500mm of rainfall but grows optimally and can tolerate significantly higher rainfall levels. • Cassava also has high drought tolerance, but prolonged dry periods can cause plants to become dormant, reducing yield. • Standing crops have high sensitivity to wind. • Crops are susceptible to cassava brown streak disease and mosaic disease often transmitted by whiteflies, which may proliferate with increasing temperatures.
Maize	• Maize is tolerant to hot conditions, but temperatures above 45°C can increase the risk of crop damage. • Maize requires 500–800mm of water per annum. • Maize is not tolerant to water deficiency in excess of five days prior to its vegetative phase.
Sorghum	• Optimal temperature for growth is above 25°C, but high temperatures (>35°C) can lead to poor seed set, problems with ripening, and reduced yields. • Average water requirement is between 450–600mm. • Sorghum is relatively drought tolerant, but severe water deficits during the flowering stages can cause pollination failure or head-blast which can result in reduced yield. • Sorghum is not tolerant to long periods of water logging. • Hot, dry conditions may increase susceptibility to khapra beetle and striga purple witchweed.
Sweet Potato	• The optimal temperature for sweet potato growth is 24°C. • Sweet potatoes can tolerate high-temperature soils with low fertility. • Dryness may reduce crop yields by up to 25 percent. • During the vining and root initiation stages, sweet potatoes are highly susceptible to a lack of water. However, after being rooted, sweet potatoes are considered a drought-resistant crop.

Crop Pests

Changes in temperature, more variable rainfall, and more intense cyclones can drive changes in the severity and spread of crop pests and diseases in southern Madagascar. Heavy rainfall events (such as those seen during cyclone events) can provide suitable conditions for locusts, which thrive during the vegetation surge that follows periods of heavy rains after drought conditions. Migratory locust outbreaks can cause widespread destruction of food crops and livestock pastures; the 2012–2013 locust outbreak in Madagascar infested areas over two-thirds of the country and caused as much as 40 percent crop loss in some regions. While locust invasions have been a consistent challenge, the fall armyworm is a more emergent risk. In 2018, 35 districts, including several in the southern and southeastern region, were affected by the fall armyworm and experienced a 47 percent loss in maize yield. Data on the closely related African armyworm indicates an increase in its populations following droughts. As temperatures increase, this will create more-favorable reproductive conditions and have the potential to expand populations of the cassava whitefly. (28, 37, 42, 43)

Increasing incidences of pests may also drive an increase in the use of pesticides and insecticides, if available. Increase in heavy precipitation and flooding events may reduce pesticide effectiveness and increase the risk of pesticide contamination through surface runoff or increased percolation into groundwater resources. (44)

CROP PRODUCTION	
Climate Stressors	**Risks**
Increased rainfall variability	• Rain-fed crops may be sensitive to increased variability in rainfall, leading to reduced yields or crop failure • Disruption to cropping calendars

CROP PRODUCTION	
Climate Stressors	**Risks**
Increased incidence and severity of dry spells and droughts	• Increased evapotranspiration and desiccation of agricultural land • Reduced water availability for agriculture • Increased risk of high winds causing sandstorm events given dry topsoil conditions • Increased incidence of pests (such as locusts, fall armyworm) and diseases (such as sheath rot, bacterial blight) • Adverse impact on farmers' livelihoods and income leading to reduced coping capacity to withstand future climate and economic shocks • Increased food insecurity • Increased migration out of the RFSA geographic regions • Increased strain on farmers with limited resources, such as elderly women, widows, and smallholder farmers, to respond to increasingly unpredictable and frequent extreme weather events
Increased temperatures and extreme heat	• Reduced soil moisture and increased evapotranspiration • Increased vulnerability of new crops to high heat events • Increased need for irrigation of water intensive crops like rice • Shift in agro-ecological zones • Increased health and safety risks for agricultural workers related to extreme heat
Increased severity of storms and cyclones	• Increased run-off, soil erosion, and loss of soil fertility • Waterlogging, leading to crop damage or failure • Damage to standing crops from strong winds during cyclones and sandstorm events • Reduced agricultural labor opportunities during disaster events with disproportionate impacts on poorer households • Storm force wind leading to sandstorms (tiomena), erosion, and sand-deposition that can reduce arability of land • Increased strain on farmers with limited resources to respond to increasingly unpredictable and frequent extreme weather events, such as women and smallholder farmers

LIVESTOCK

Madagascar's smallholder farms often cultivate a mix of crops and livestock. In Atsimo Atsinanana, 50 percent of smallholder farmers raise cattle, pigs, and poultry. In the Grand Sud, livestock raising is widespread among smallholders, especially in the most arid areas where rainfed agriculture is challenging. Small herds of goats and (to a lesser extent) sheep are dominant, and most houses keep chickens. Herds of cattle are also common but concentrated in many areas of the Grand Sud to those households that can afford to keep them. Livestock serve as household savings where secondary products such as milk can be sold for small short-term needs, and the livestock themselves can be sold for cash that can allow for larger investments or economic needs during times of crisis. Cattle raising also holds social and ceremonial value in Madagascar: the zebu, a breed of cattle indigenous to the island, is often slaughtered at funerals and is linked closely with the local belief in the divinity of the dead. (30, 45, 46)

Households that keep livestock in southern Madagascar are already facing challenges due to ongoing drought conditions. In the Grand Sud, pasture biomass availability was well below average at the end of 2022, and livestock herd sizes were lower due to the impacts of above-average sales as households have tried to raise funds to meet their needs. Because livestock function as family savings, projected increases in drought, dry spells, and other climate risks to livestock pose threats to livelihoods and economic stability. Generally, zebu hold high monetary value in Madagascar; however, the value of zebu and other livestock may diminish as climate change increases the frequency of natural hazards, which can lead to an increase in the number of livestock sold in times of crisis. In addition, zebu are sometimes the target of livestock theft and raiding in southern Madagascar. The incidence of cattle raiding rose during past periods of poverty, and there was an increase in such attacks in the Grand Sud during the recent 2018-2022 drought. As droughts and other climate stressors continue to exacerbate livelihood opportunities and drive food insecurity in the region, this may increase incidence of zebu or cattle raiding and associated violence due to organized crime called "*dahalo*." (46, 47, 48)

Studies show that zebu can regulate body temperature more effectively when confronted with heat stress compared to other cattle breeds, indicating resilience to heat shocks. However, while zebu may demonstrate resistance toward heat stress, other livestock breeds do not. Increased temperatures in Madagascar are expected to trigger heat stress in pigs and chickens most frequently, with smaller expected impacts to goats, sheep, and cattle. Zebu and other livestock are also not immune to the consequences of climate stressors that restrict access to water, grazing land, or livestock fodder. Livestock fodder production and the viability of rangelands diminishes during drought periods or when heavy rains or storms damage unprotected fodder stores. Households may need to travel to secure access to grazing land or water for livestock, and animals that are malnourished or dehydrated are more susceptible to parasitic and insect-borne infection. (46, 47, 49, 50, 51, 52, 53)

Though livestock in Madagascar have experienced Rift Valley Fever (RVF) epidemics (in 1990–1991 and again in 2008–2009), environmental factors are not considered the dominant trigger for these epidemics. Rather, RVF is introduced through trade with other RVF infected countries. As changes in precipitation patterns and temperature make RVF potentially more common in mainland African countries, the risk of introducing RVF into Madagascar may similarly increase. RVF is linked to climate change in other African countries, and outbreaks are strongly related to El Niño. (54)

LIVESTOCK	
Climate Stressors	**Risks**
Increased incidence and severity of dry spells and drought	• Decreased livestock fodder availability and reduced options for productive grazing land • Decreased water for livestock • Decreased livestock productivity • Increased livestock susceptibility to disease and infection • Increased livestock sales driven by drought conditions, reducing household savings
Increased temperatures and extreme heat	• Decreased livestock birth rate, ability to gain and maintain weight, and production of secondary products such as milk due to heat stress
Increased severity of storms and cyclones	• Damaged fodder stores and reduced availability due to sand, wind, and/or flooding • Increased risk of livestock mortality due to storm related floods • Increased spread of pests and diseases that may contribute to livestock loss due to wet conditions

FISHERIES

Madagascar's fisheries sector makes up more than 7 percent of the national GDP and contributes 6.6 percent to the country's total exports. Small-scale marine fisheries play a significant role in Madagascar, contributing up to 65 percent of the nation's total fish production. In Atsimo Atsinanana, marine fisheries are a primary source of protein for coastal communities, and in coastal regions of the Grand Sud, marine fisheries are prevailing livelihood options given they are not as affected by drought as livestock. Marine fisheries in Madagascar face challenges including overfishing and illegal catch, introduction of invasive species, and offshore reef damage due to bleaching. In 2005, warm ocean temperatures led to bleaching of up to 80 percent of the coral in northeast Madagascar. Some communities practice freshwater and riverine fishing in southern Madagascar, but it is not a common livelihood option. For example, people fish for food in lakes and rivers around Atsimo Andrefana, however, during certain times of the year, many of the rivers and tributaries dry up. (27, 46, 55, 56, 57)

Climate risks to fisheries in Madagascar include the effects of warming ocean temperatures, more severe cyclones, sea level rise, and ocean acidification—all of which have potential to impact the fisheries sector in southern and southeast Madagascar. Warmer waters can lead to the loss of fish habitats and breeding grounds, while acidification (partially driven by warming waters and elevated oceanic absorption of carbon dioxide) degrades coral reefs and other crucial marine habitats. Both these phenomena are likely to reduce fish production and biodiversity, threatening the livelihoods of local fishing communities and impacting the broader population's food security. In addition, the southern region's small-scale fisheries heavily depend on traditional practices that rely on predictable wind and sea conditions. Increased frequency and intensity of severe weather events like cyclones can result in greater disruption of these traditional practices or damage of fishing equipment. In Madagascar, freshwater biodiversity is also at risk from drought, increase in temperatures, and sedimentation and turbidity from runoff due to high precipitation events. Reduced water levels during drought conditions and increased water temperature in freshwater ecosystems can negatively affect fish reproduction and growth, leading to diminished fish stocks and affecting the availability of species important for local subsistence and small-scale trade. (58, 59, 60)

Fisheries in Madagascar also face indirect climate risks. For example, changes in rainfall or drought conditions lead to crop failures, subsequently leading to an increase in fishing activities and overfishing. Soil erosion from heavy rainfall events or increased pesticide use to manage crop pests upstream can pollute marine ecosystems and lead to fish stock decline. Additionally, intense storms and cyclones can destroy coastal mangroves and reduce near-shore fish populations, forcing fisherfolk to sail farther to fish. (27)

FISHERIES	
Climate Stressors	**Risks**
Increased ocean and water temperatures	• Changes in ocean species abundance and distribution, affecting seafood catches and livelihoods of coastal fishing communities • Increased river and lake temperatures threaten fish biodiversity and reproduction in freshwater ecosystems
Increased air temperatures and extreme heat	• Increased rate of fish spoilage
Increased rainfall variability	• Inconsistent river flow threatens fish stocks
Increased severity of storms and cyclones	• Disruption of traditional fishing practices reliant on predictable wind and sea conditions • Damage to or destruction of fishing boats and fishing supplies • Destruction of coastal community home and critical infrastructure, making it harder to maintain fishing communities • Increased runoff and sedimentation leading to pollution of riverine and marine ecosystems • Destruction of mangrove ecosystems in coastal zones reduces habitat for marine life
Increased incidence and severity of dry spells and droughts	• Reduced productivity in freshwater fisheries and potential for biodiversity decline • Potential for higher demand for fisheries as people turn to fishing as an alternative livelihood source after crop failure or loss
Ocean acidification	• Fish habitat loss through reef reduction or bleaching, potentially leading to loss of fish production and diversity • Diminished food chain for larger fish such as tuna • Loss of protection for coastal areas from storm events through reduced reef formation

FOOD PROCESSING, STORAGE, IMPORTS, AND ACCESS TO MARKETS

Food processing enterprises comprise approximately one-fifth of Madagascar's industrial sector. The industry is made up of many small individual enterprises, and production primarily targets local markets, with just 2 percent of food being exported. Many rural communities in southern Madagascar have limited access to modern food processing facilities and equipment; as such, the majority of processing is done manually or in smaller-scale, traditional facilities. For example, sun-drying, smoking, and fermenting are common practices to process staple crops such as rice, cassava, and maize. Rural communities often face challenges in food processing, including the absence of suitable packaging infrastructure, a lack of expertise in preservation methods, substandard quality of agricultural produce, and insufficient knowledge regarding market access and consumer outreach. (61, 62, 63, 64)

After processing, rural areas of southern Madagascar generally lack modern food storage facilities such as cold storage rooms and warehouses. As a result, the region often experiences post-harvest losses and reduced food availability even during years with favorable growing conditions. Communities employ traditional methods such as underground storage pits to store crops like sweet potatoes and yams for extended periods of time. Access to markets in southern Madagascar is challenging due to inadequate road infrastructure and market facilities. People in this region typically access small local markets and may have limited ability to transport and sell their products beyond these markets unless they are close to larger cities. (62, 65, 66)

Climate change threatens to exacerbate existing challenges at various points of the agricultural value chain in southern and southeastern Madagascar. Given the high proportion of the population engaged in agriculture, fisheries, and food production livelihoods, climate risks could drive significant and far-reaching challenges to local economies and food security. At the processing phase, a reduction in crop yields during drought years reduces supply of inputs, threatening processing livelihoods. Cyclone events, temperature increases, or excessive moisture can cause food spoilage and losses, particularly among crops stored in traditional pits or open structures. Climate change-driven flooding or erosion may render roads impassable, inhibiting transportation of local and imported goods—and consumers—to markets.

Cassava, rice, and maize are important staple crops to households in southern Madagascar. While locally produced rice is preferred, imported rice is often cheaper and less susceptible to poor growing conditions due to drought or extreme weather. However, the retail prices of imported rice have been higher on average in recent years compared to prices between 2018 and 2022. The reliance on imported rice, especially for households with fewer resources, makes the country vulnerable to international commodity price fluctuations and supply chain disruptions. Rural communities in the southern regions of the island, which have in the past experienced drought-driven agricultural yield decreases, may be more at-risk given their already high levels of spending on food and reliance on imports. For example, very poor households in the Anosy region of the Grand Sud spent approximately 75 percent of income on staple food purchases in years before the 2018–2022 drought. Projections indicate that climate change will increase the severity of cyclones and associated flooding; these events have the potential to disrupt supply chains, driving delays or shortages of imported goods. (46, 67, 68, 69)

FOOD PROCESSING, STORAGE, IMPORTS, AND ACCESS TO MARKETS	
Climate Stressors	**Risks**
Increased rainfall variability	• Variability in crop yields affecting supply for food processing • Unexpected moisture levels, increasing risk of food spoilage and losses in storage • Unpredictable or shifting crop seasons, which may impact production schedules
Increased incidence and severity of dry spells and droughts	• Reduced agricultural productivity leading to overall food scarcity and increased reliance on food imports • Increased food prices due to limited local food supply
Increased temperatures and extreme heat	• Reduced crop quality and negatively impacted storage conditions • Increased prevalence of pests and diseases, affecting stored crops
Increased severity of storms and cyclones	• Disrupted local and international supply chains for imported goods during or after storms • Damaged infrastructure, including roads and storage facilities, which in turn may affect transportation and storage capabilities and cause food shortages in local markets • Damage to food stores

WATER RESOURCES

Access to freshwater resources in Madagascar varies throughout the country. The southern regions have significantly less annual rainfall than areas to the north, with the southwestern Grand Sud having the lowest rainfall in the country. Rivers are also sparse through the southwest, and there is minimal access to surface and groundwater in the Grand Sud. The Mahafaly Plateau and Androy Regions have particularly limited access to surface water as their adjacent rivers dry quickly and are rarely replenished by rainfall. Groundwater recharge rates are high, making groundwater availability sensitive to climatic extremes. Accordingly, groundwater stores in southern Madagascar have decreased over time. During dry periods in the region, household members (often women and girls) are required to travel longer distances to gather water or must resort to use of overcrowded or polluted water holes. Despite the chronic low water supply, there are little to no government sponsored monitoring systems in Madagascar that track groundwater depletion. (46, 70, 71, 72)

With limited groundwater sources and a dry, arid climate, water stress and access are predominant issues in the Grand Sud. During the drought from 2018–2022, the region experienced four consecutive failed rainy seasons, fueling widespread crop failure and food insecurity. Rising temperatures and increased precipitation variability due to climate change are projected to increase the risks of drought in this region. (70, 73)

In the southeast, where rainfall is more prevalent, the intensity and frequency of cyclones and extreme storms have caused repeated destruction of available water infrastructure. Extreme weather has also limited the availability of clean water sources. Agricultural runoff from heavy precipitation has enriched surface water with chemical compounds like nitrogen and phosphorus from fertilizer and other inputs. Runoff has led to harmful algal blooms in Lake Ranomafana and hypoxia in Lake Alaotra, and invasive species have proliferated as a result, making water unsafe for drinking or productive use. (70)

Most surface water drains through Madagascar's Western and Eastern slopes from the Central Highlands. Industrial wastewater has contaminated these waterways, and surface water is contaminated with lead, chromium, mercury, uranium, and other toxic pollutants. This contamination is particularly notable in Madagascar's southeast region and along the Eastern, Amber Mountain, and Tsaratanana slopes. (70)

Southern Madagascar's groundwater basins are already prone to salinity, even in inland areas of the RFSA geographic zones. There is evidence of saline intrusion in aquifers along Madagascar's southern coast. Rising sea levels are expected to increase the risk of coastal flooding and saltwater intrusion into aquifers in Madagascar's coastal areas, which could intensify the acute water scarcity challenges in the region. (72, 75)

Cyclones and extreme precipitation events exacerbate soil erosion, further increasing an impacted region's vulnerability to drought and flooding. Topsoil usually serves as a highly permeable layer that captures water during heavy precipitation events, but intense precipitation erodes this layer and leaves the affected region even more vulnerable to flooding. Soil erosion also increases surface water turbidity and siltation and can reduce recharge ability of groundwater stores. Climate change is expected to increase precipitation extremes—particularly during cyclone events—continuing to drive this cycle of flood and contamination risk. (70, 76)

WATER RESOURCES	
Climate Stressors	**Risks**
Increased incidence and severity of dry spells and droughts	• Loss of surface and groundwater for agriculture and consumption • Increased dependence on contaminated water • Increased exposure to gender-based violence due to increased travel times to gather water, traditionally a woman's responsibility (see Gender, Youth, and Marginalized Groups section below). • Increased physical burden and psychosocial stress among women when required to travel long distances to procure water
Increased temperatures and extreme heat	• Increased rates of evapotranspiration, potentially increasing demand for surface and groundwater resources for agriculture
Increased severity of storms and cyclones	• Increased surface water contamination from agricultural runoff • Increased rate of coastal erosion with long term nutrient removal from agricultural land and decreasing groundwater recharge rates and filtration • Increased risk of damage to infrastructure
Increased rainfall variability	• Increased surface water contamination from agricultural runoff during high-rainfall events • Reduced rainfall increases demand on groundwater for irrigation
Sea level rise	• Saltwater intrusion into groundwater and aquifers in coastal regions, contaminating drinking and agricultural water

Human health: WASH, nutrition, and health services

Residents of southern and southeastern Madagascar are facing one of the most extreme food security crises worldwide. This crisis is interconnected to the broader landscape of health challenges in the country, including high rates of infectious diseases, low levels of household sanitation, poor water quality, and lack of access to reliable healthcare. These health challenges are already exacerbated by climate impacts, including prolonged drought and cyclone and sandstorm events in recent years. As the climate continues to change and these stressors become more severe, there are potentially acute associated human health risks in the region.

In the Grand Sud and southeast, food insecurity and malnutrition are acute concerns. Famine-like conditions compounded by prolific drought and severe cyclones have driven high rates of food insecurity in recent years. Acute malnutrition is a related challenge, with over 400,000 children under the age of 5 projected to suffer from acute malnutrition in the Grand Sud and southeast in 2023–2024. Beyond the health effects, these compounding climate crises can have long-term impacts on children and youth in the region. In the fall of 2020, three out of four children in the Amboasary region had stopped attending school to forage for food with their families. These kinds of absences can have long-term educational and economic effects, the risks of which may increase as climate-related disasters become more severe in the future. (7, 77)

In addition to food insecurity, the infectious disease burden is disproportionately prevalent across Madagascar, and several climate-sensitive infectious diseases rank in the top 10 causes of mortality, including diarrheal diseases, acute respiratory infection (ARIs), and malaria. The prevalence of mosquito-borne diseases like malaria is projected to increase as temperature increases and rainfall variability expand and shift the geographic range of vector habitats. Intervention efforts have temporarily slowed malaria transmission in Madagascar, but population-level immunity has decreased as a result, increasing risk for future outbreaks. In the Grand Sud and southeast, the prevalence of infectious disease is especially high for children, with an up to 22 percent infection rate for malaria in children in the region in early 2023. In addition to malaria and diarrheal disease, ARIs are a leading cause for clinical visits in Madagascar. ARIs can be exacerbated by weakened immune systems due to exposure to hazards driven by climate change (e.g., poor air quality, malnutrition resulting from waterborne diarrheal diseases or famine, etc.). Studies have noted a marked increase in ARIs in Farafangana, the capital of the Atsimo Atsinanana region, and measured ARI rates in children in the Grand Sud and southeast in 2023 at up to 16 percent. (77, 78, 79)

Madagascar also faces one of the starkest water and sanitation crises in the world, particularly in the RFSA geographic areas. Nationally, only 54 percent of the population has access to basic water services, and as of December 2023, there were 3.57 million people in the south and southeast lacking access to safe water, hygiene, and sanitation. The impacts of prolonged drought and heavy precipitation during cyclone events can dry up or contaminate water sources and destroy water infrastructure, further reducing access to safe drinking water. A lack of access to quality water and hygiene can fuel spread of disease and exacerbate malnutrition, particularly among children under 5 years of age. (78, 80, 81)

Access to healthcare services, already limited in south and southeast Madagascar, is also challenged by climate change impacts. For example, Tropical Cyclone Freddy in 2023 damaged many health centers in southeastern Madagascar, limiting access for over 100,000 people. In general, women have lower access to basic healthcare and reproductive services in Madagascar. The projected increase in climate-sensitive infectious disease incidence, such as diarrhea and malaria, will adversely impact the health and wellbeing of children and women, particularly pregnant women and nursing mothers. As climate change intensifies and drought becomes more frequent and severe, these associated threats to public health access may become increasingly acute and widespread. (69, 77, 82)

As temperatures and high-heat days rise in south and southeastern Madagascar, a greater number of people will be at risk of heat-related illnesses. Heat exhaustion or stroke, dehydration, and even death can occur from prolonged exposure to heat, particularly for outdoor workers including smallholder farmers. Older adults, children, persons with disabilities, and individuals with existing medical conditions are incredible vulnerable to extreme heat. Limited cooling options or the means to alleviate heat stress combined with strained healthcare systems will continue to threaten the lives and livelihoods of the Malagasy. (83)

HUMAN HEALTH: WASH, NUTRITION, AND HEALTH SERVICES	
Climate Stressors	**Risks**
Increased temperatures and extreme heat	• Altered vector habitats, prolonging exposure and expanding vector populations to new geographies • Increased incidence of heat-related illnesses (i.e. heat exhaustion, heat stroke, exacerbated cardiovascular and respiratory diseases)
Increased incidence and severity of dry spells and drought	• Reduced access to clean drinking water and associated exposure to waterborne disease • Depleted crop yield and associated food insecurity • Dehydration and associated health effects
Increased rainfall variability ***and*** Increased severity of storms and cyclones	• Increased exposure to waterborne disease from contaminated water • Expanded mosquito habitats, increasing risk of mosquito-borne disease • Fatality from infrastructural damage or other physical risks posed by extreme weather and flooding • Damage to healthcare facilities or limited access to healthcare during storm events

NATURAL RESOURCES MANAGEMENT AND ENDANGERED SPECIES

Madagascar is among the richest biodiversity hotspots in the world: Approximately 90 percent of all Madagascar's mammals, reptiles, and plant species are found nowhere else on Earth. However, this rich biodiversity is threatened by both development pressures and climate change. Madagascar's lush forest habitats have fragmented through nearly 5,000 years of human settlement, and the country is projected to lose 30 percent of its current species by the end of the 21st Century. (84, 85)

Madagascar has significantly expanded protected areas in recent years, including designating 54 marine protected areas and 7.1 million hectares of protected land. There are 21 Ramsar sites in the country, including several in the RFSA geographic areas such as the marine Nosy Ve-Androka Reef system. However, challenges including widespread deforestation, lack of effective management and sustainable financing for protected areas and law enforcement, expansion of agricultural zones, unsustainable fishing, and land fragmentation threaten protected areas and ecosystems across the country. For example, conservative estimates suggest that more than half of the nation's tree cover has been eliminated since the year 1950 due to rampant *tavy* (slash-and-burn land clearing for farming), illegal wood trade, and charcoal production. (27, 86, 87)

Climate change will likely compound these challenges. For example, by the year 2070, the combination of deforestation practices and climate stressors could eliminate 38–93 percent of the eastern rainforest. Drier and hotter conditions are already expanding the risk of wildland fire in Madagascar's forests, and as temperatures rise and droughts become more severe, the likelihood of damaging fires increases. Studies show that over 100 endemic species in Madagascar are vulnerable to climate change, and many are expected to shift their habitat range as climate conditions change. As these shifts happen, species may experience a lack of suitable—or contiguous—habitat. Plants are vulnerable to rainfall variability and drought, and forests and other ecosystems can be damaged during cyclones, floods, and high-wind events. As ecosystems shift and the range of plant species changes, so too will the vertebrate species that depend upon them for food and shelter. Likewise, both marine and riverine habitats and fish biodiversity are threatened by climate stressors including increased temperatures, ocean acidification, cyclones, and droughts (see Fisheries section above), and rising sea levels exacerbate the erosion of coastal and wetland habitats. (27, 89, 90)

Climate change can also have indirect effects on natural resource management and endangered species. Extreme poverty and food insecurity can drive Malagasy populations to illegal logging, fishing, and animal trade. Wild meat is an important source of protein for many in Madagascar. However, as droughts and rainfall variability threaten crop production and food security, more people may turn to hunting wildlife—such as lemurs. Deforestation is also associated with topsoil loss, which can be exacerbated by erosion during wind events and cyclones. Eroded sediment can deposit in dunes during sandstorms (see discussion of tiomena above) and builds up downstream during heavy rainfall events, blocking critical waterways and estuaries and damaging viability of fisheries and water supplies. In addition, Madagascar's natural resources are a source of tourism revenue, and degradation of ecosystems and endangered species in the face of climate stressors threatens the over US $600 million that the tourism sector contributes to the country's annual economy. (27, 91, 92, 93, 94)

The challenges of natural resource management and endangered species protection at large are linked with the ongoing impacts of climate shocks in the RFSA geographic areas in southern and southeastern Madagascar. Studies show that there are increased rates of deforestation in northern and central regions of Madagascar, including the Menabe region, as people have immigrated to avoid the chronic drought in the south and southeast. In 2023, the Government of Madagascar started to work on expanding its "Titre Vert" initiative in Menabe to provide agricultural assistance and increase land tenure opportunities to attempt to reduce clearing of forests to grow crops by those that have moved to the area from the Grand Sud and other drought-stricken regions. (27, 65)

NATURAL RESOURCE MANAGEMENT AND ENDANGERED SPECIES	
Climate Stressors	**Risks**
Increased severity of storms and cyclones	• Increased soil erosion from intensified precipitation, causing degradation to terrestrial and coastal water ecosystems and wetlands, including mangroves • Damage to species and ecosystems due to high winds • Decreased natural water storage from loss of topsoil
Increased temperatures and extreme heat	• Wetland ecosystem degradation • Species migration and change of habitat range
Sea level rise	• Increased erosion to coastal and wetland habitats
Increased incidence and severity of dry spells and droughts	• Increased prevalence of extractive practices and hunting due to loss of agricultural livelihoods • Decreased water availability and drying of riverine and forest habitats • Increased risk of wildfire

Gender, Youth, and Marginalized Groups

Climate change disproportionately impacts groups in vulnerable situations, including women, children, persons with disabilities, the elderly, LGBTQI populations, and ethnic minorities. These populations also bring unique perspectives and innovative solutions to manage climate risks.

Women and Children

Chronic malnutrition is pervasive in Madagascar, and gender inequality leads to higher rates of malnutrition among women and girls. Women and children are more likely to experience hunger due to drought, and often have more limited access to healthcare (see above). The country already has one of the highest malnutrition rates among children in the world and was ranked tenth in the Children's Climate Risk Index, which quantifies children's vulnerability to climate impacts. In the Grand Sud, an estimated 479,000 children under 5 years of age face acute malnutrition risks as of January 2023. Households headed by women are poorer, on average, and at higher risk of food insecurity than those headed by men. Compared to the national average, a greater proportion of households in southern Madagascar are headed by women, owing primarily to the increased migration of men in search of better economic opportunities. Climate change impacts on crops and livestock can further reduce food availability, increase food insecurity, and limit vulnerable groups' access to adequate nutritional resources. (6, 95, 96, 97)

Besides exposure to climate shocks and poor agricultural productivity, food insecurity in southern Madagascar is also associated with limited access to clean water. The responsibility of fetching water falls primarily on women and girls, and climate-driven impacts on water resource availability are likely to mean traveling longer distances to fetch water and firewood, which increases their exposure to gender-based violence. Southern Madagascar already had the highest rates of violence against women and girls nationwide, and during the 2018–2022 drought, there was a noted increase in rates of communal violence and violence against women. However, at the same time, women and girls bring a wealth of knowledge of water resources due and are key stakeholders in identifying potential climate risk management and adaptation solutions in the water sector. (98, 99, 100)

Research demonstrates that women and children are disproportionately vulnerable during and after crises, and Malagasy women may be excluded from certain crisis resolution measures that may facilitate adaptation to extreme conditions. In addition, sociocultural norms often limit economic opportunities for women, including ownership of land and livestock. These financial restrictions diminish their adaptive capacity, or ability to respond to climate shocks. For example, gendered societal norms make it challenging or impossible for women to sell assets such as household supplies or small animals, or to take out loans in times of financial need. (98, 102)

Persons with Disabilities

Persons with disabilities are at greater risk of poverty due to pervasive societal inequalities including inaccessible environments, unequal access to healthcare, and discrimination and exclusion. As such, they typically have access to fewer resources and mechanisms to adapt to climate change. Persons with disabilities also experience higher rates of injury and mortality during climate-related shocks such as cyclone events. In Madagascar, drought and disaster response mechanisms do not effectively integrate persons with disabilities. In the Grand Sud in particular, there is a general lack of data and understanding of the intersectional risks faced by persons with disabilities in the face of ongoing challenges from climate stressors like drought and cyclone events. Studies from the region show that people with disabilities often do not have access to productive resources like land or water and are therefore less food secure. (103, 104)

Ethnic Minorities

While the term "Malagasy" refers to any individual from Madagascar, approximately 90 percent of Madagascar's population ethnically identifies as Malagasy. This predominant ethno-linguistic group comprises two geographic and twenty ethnic subdivisions. The Highland cohort includes Merina, the largest Malagasy subgroup which constitutes 26 percent of Madagascar's total population. The Coastal ("Côtier") cohort includes Betsimisaraka, the second largest Malagasy subgroup, which represents 15 percent of Madagascar's total population. (105)

This primary ethnic divide was exacerbated through Madagascar's colonial history and the persisting tensions between these two major groups underlie Malagasy politics and civil conflict. In recent years, famine and drought conditions in southern Madagascar have driven members of the local Antandroy and Antanosy tribes to the north. While the northern regions have been spared the effects of these extreme weather conditions, resources are still scarce, and the influx of migrants has exacerbated interethnic tensions. (106, 107)

Populations that have been marginalized are disproportionately affected by climate hazards. While exposure to climate events is contingent upon geography, their vulnerability is exacerbated by the systemic inequalities that limit access to resources and relief services. Caste systems rooted in slavery have historically pervaded Malagasy socioeconomics, and populations descended from enslaved peoples disproportionately lack equal access to education and jobs. (108, 109)

Ethnically non-Malagasy populations face economic challenges as well. The non-Malagasy minority has historically included immigrants from China, South Asia ("Karanas"), and Muslim populations from the Comoros Islands. These groups have not been well-received by existing populations. Karana populations primarily migrated to Madagascar in the 20th century but were largely denied citizenship and remain stateless. Until 2017, children born to Malagasy women married to immigrants were also deemed stateless. While this law is no longer in effect, the change has not been sufficiently publicized, and the financial burdens of statelessness persist. In addition to Karana, there are several other minority groups in Madagascar who are also without Malagasy nationality. Malagasy Muslim communities with generational roots in the country may face difficulties acquiring citizenship or receiving government services, reportedly due to their non-Malagasy names. All stateless individuals are burdened with expensive residency permits to remain in the country, and failing to pay these fees could result in arrest. (110, 111, 112, 113, 114)

Since ethnic minorities often experience increased financial burdens, possible statelessness, and lack of community integration, they may be less likely to financially recover from lower agricultural yields or climate-related shocks such as cyclones, especially without secure land tenure.

EXISTING AND POTENTIAL INTERVENTION MEASURES

Designing and implementing resilience and food security activities in the context of changing climate conditions requires informed decision-making that accounts for climate risks as well as contextualized experience from existing and past activities in Madagascar. This section includes the following:

- A table titled "**Potential Climate Risk Management Measures**" provides a snapshot of potential climate risk management measures for consideration by teams working in the RFSA geographic areas in Southern Madagascar. These illustrative measures are primarily applicable at the household level.
- The table titled "**Selected Ongoing Experiences**" outlines examples of concurrent or active projects in Madagascar. These projects have a climate adaptation or food security focus and could present potential lessons learned or opportunities for collaboration. USAID's Climate Risk Management (CRM) tools provide further examples and resources for systematically addressing climate risks throughout the programming cycle.

Failure to account for climate risks in program or activity design and implementation can result in underperforming outcomes or even inadvertently increase vulnerability or risk. This can range from failed agricultural projects that do not consider future water availability or weather patterns to underperforming health initiatives that do not target potential new areas where vector-borne diseases may spread. Understanding the disproportionate impact of climate change on populations that have been marginalized is also critical to designing successful resilient food security activities. Furthermore, accounting for climate risks does not always guarantee successful adaptation; implementation of climate adaptation strategies that result in unintended harm to communities would be considered a form of maladaptation. Maladaptation especially affects populations that have been marginalized and underrepresented, such as women, youth, ethnic minorities, persons with disabilities, displaced individuals, and other groups, as these populations may lack resources and political representation compared to those that hold more socioeconomic power. Furthermore, impacts of maladaptation may sometimes not be apparent for many years. For example, a crop production project developed to supplement agricultural products lost from climate hazards may result in the fragmentation of landscapes, isolation of animal populations, and loss of biodiversity, which could impact the food security and income of local groups dependent on hunting. Design and implementation of risk management measures to address the climate risks outlined throughout this document must carefully consider and avoid potential adverse impacts given the environmental, social, and political contexts in the Madagascar RFSA geographic areas.

Ensuring inclusive and localized planning initiatives are informed by diverse cultural values, traditional ecological knowledge, local knowledge, and scientific knowledge can help prevent maladaptation. Climate change disproportionately impacts populations that have been marginalized. BHA provides these communities with regular resilience and food security support. Given that these communities are also likely to be most affected by climate risk management and adaptation measures, all activities to strengthen climate resilience and food security should integrate diverse voices and perspectives and empower local communities. Robust stakeholder engagement and co-design with participant communities and those who know the local context, such as civil society organizations, should be a part of designing and implementing climate risk management measures.

POTENTIAL HOUSEHOLD-LEVEL CLIMATE RISK MANAGEMENT MEASURES

Climate Risk Area	Potential Climate Risk Management Measures
Crop production	• Link households to other actors providing improved and resilient irrigation systems, such as drip irrigation, while being mindful of the potential climate impacts and risk of overuse of water sources those irrigation systems may pull from • Increase training for farmers on integrated pest management • Improve access to agricultural tools and equipment, high quality inputs and seeds, and safe, sustainable pesticides/insecticides through asset transfer • Improve household capacity for participatory plant breeding and other collaborative

Climate Risk Area	Potential Climate Risk Management Measures
	approaches to encourage the establishment of local seed production systems and evaluate new crop varieties compared to existing varieties • Improve farmers awareness of and capacity to use weather and climate information • Help participant households identify and implement context-appropriate, climate-resilient agricultural and land management practices • Integrate Indigenous/local knowledge, land management techniques, and resilient crop varieties into agricultural production plans • As possible, avoid planting in flood-prone areas, including coastal areas that may face inundation from sea level rise and storm surge during cyclone events • Support culturally and contextually appropriate alternative livelihoods that are not dependent on crop production (income generating activities) • *Water resource strategies below would implicitly benefit the crop sector*
Livestock	• Promote sustainable land management and grazing practices to limit over-grazing and land degradation • Improve pastoralist access and capacity to use weather and climate information through training and coaching and integrate appropriate local technology and knowledge systems • Support culturally and contextually appropriate alternative livelihoods not dependent on livestock • *Water resource strategies below would implicitly benefit the livestock sector*
Fisheries	• Provide input support and training to promote sustainable fishing and harvesting practices • Support culturally and context-appropriate alternative livelihoods not dependent on fishing • *Water resource strategies below would indirectly benefit the fisheries sector*
Food processing, storage, imports, and access to market	• Encourage use of effective food preservation methods to protect crops against damage from humidity and pests through training and coaching • Strengthen capacity in contextually appropriate food preservation methods • Support cost effective, culturally appropriate food storage and processing enterprises that reduce food waste and loss and offer income generating opportunities to historically marginalized and excluded groups
Water resources	• Improve household and farmland management practices to improve water capture and natural storage capacity • Promote water conservation and capture across agricultural, household, and business practices through training and coaching • Connect households and communities in the target areas with WASH and water resource providers (such as those active through partner-led projects identified below) to increase access to reliable clean and safe drinking water and reduce the distances women and girls must travel to find water • Promote kitchen gardens to increase access to nutritious foods using water conservation technologies
Human heath: WASH nutrition and health services	• Encourage and build capacity for healthy hygiene and sanitation practices and preventative measures, especially in areas associated with water- and vector-borne diseases • Assess health and nutrition risks in population groups experiencing differing levels of vulnerability and integrate appropriate safeguards

Climate Risk Area	Potential Climate Risk Management Measures
Natural resources management and endangered species	• Promote sustainable land management and fertilization practices to prevent over-farming, pollution, or illegal extractive practices to limit impacts on protected areas in the RFSA geographic areas (including marine protected areas) • Adapt local knowledge and land management systems to respond to changes in landscape (i.e., fire management, land use, ecological restoration) • Promote natural regeneration of community and household managed degraded areas, including reforestation where appropriate
Gender, youth, and marginalized groups	• Promote livelihoods that are likely to expand women's participation in economic activities and increase women's economic empowerment, voice, and agency • Build women's financial management and enterprise development skills • Sensitize households around gender-based barriers to land and resource access, and women's access to and management of resources • Recognize the inequities of marginalized groups including widows, the elderly, and people with disabilities and support them with alternative livelihoods opportunities to support food security and income generation • Co-create and fund women's groups, youth groups, and collectives for groups facing historical or systemic marginalization that include innovative climate solutions in key sectors • Consult with the appropriate expertise on social inclusion and gender-based violence mitigation techniques and engage diverse voices during stakeholder engagement • Promote village savings and loan groups to help households in vulnerable conditions mitigate climate change impacts

SELECTED ONGOING EXPERIENCES

Diverse bilateral, multilateral, philanthropic and religious organizations work across the sectors mentioned above. The table below represents ongoing projects in natural resource management, agriculture production and value chains, food security, and climate adaptation. The programs outlined in this table serve as examples and offer insight into ongoing efforts.

Program	Amount	Donor	Year	Implementer	Implementation Regions
Fiovana Resilience and Food Security Activity (RFSA)	USD $45 million	USAID	2019–2024	USAID BHA	Vatovavy Fitovinany and Atsimo Atsinanana Regions
Maharo Resilience and Food Security Activity (RFSA)	USD $36 million	USAID	2019–2024	USAID BHA	Atsimo Andrefana and Androy Regions
Support for Resilient Livelihoods in the South of Madagascar ("Moinjo")	USD $200 million	World Bank	2021–2025	Government of Madagascar	Southern Madagascar
Integrated Urban Development and Resilience Project for Greater Antananarivo	USD $75 million	World Bank	2018–2025	Ministry of Planning and Land Management, *Fonds d'Intervention pour le Développement*	Antananarivo Region

Program	Amount	Donor	Year	Implementer	Implementation Regions
Feed the Future Innovation Lab Research Grants, Madagascar	USD $2.5 million	USAID	2023–2025	University of Georgia, Kansas State University	Nationwide
Rapid Rural Transformation Initiative	USD > $1million	World Food Program	2022–present	World Food Programme and Government of Madagascar	Androy and Anosy Regions
Early Warning Early Action	USD > $1.2 million	Food and Agriculture Organization	2022–present	Food and Agriculture Organization, Government of Madagascar	Nationwide
Ecosystem-based Adaptation in the Indian Ocean	USD $49.2 million across Madagascar, Comoros, Mauritius, and Seychelles	Green Climate Fund	2021–2031	Agence Française de Developpement	Multi-country
Building Regional Resilience through Strengthened Meteorological, Hydrological and Climate Services in the Indian Ocean Commission (IOC) Member Countries	USD $71.4 million across Madagascar, Comoros, Mauritius, and Seychelles	Green Climate Fund	2021–2027	Agence Française de Developpement	Multi-country
Transforming Financial Systems for Climate: Building up financial markets and technical knowledge for renewable energy and climate resilience in Africa, Latin America, and the Caribbean	USD $707.5 million across 17 countries	Green Climate Fund	2017–2028	Agence Française de Developpement	Multi-country
Sustainable Landscapes in Eastern Madagascar: Promoting investments in sustainable agriculture and renewable energy for smallholder farms	USD $19.3 million	Green Climate Fund	2016–2025	Conservation International Foundation	Eastern Madagascar

Program	Amount	Donor	Year	Implementer	Implementation Regions
Elevating Ecosystem-based Adaptation approaches in the Tsimanampetsotsa-Nosy Ve Androka Biosphere Reserve seascape	USD $4.8 million	Blue Action Fund	2022–2027	World Wildlife Fund	Tsimanampetsotsa-Nosy Ve Androka Biosphere Reserve
Project to Mobilize, Protect, Enhance Water Resources and Strengthen Resilience to Climate Change	USD $3.2 million	African Development Bank	2022–present	JIRMA, Madagascar Drinking Water and Energy Service Company	Central, Southeast, South Madagascar
Upscaling Ecosystem-based Adaptation for Madagascar's Coastal Zones	USD $26.7 million	Global Environment Facility	2023–present	Global Environment Facility	Coastal Zones in Menabe, Boeny, Atsinanana, Vatovavy-Fitovinany

Key Resources

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3. World Bank Group (2024). Madagascar At-A-Glance.
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