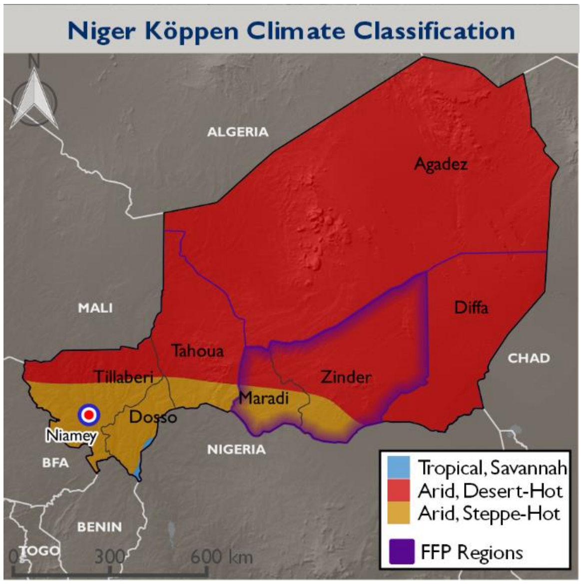
Climate Risk Profile

CLIMATE RISKS IN FOOD FOR PEACE GEOGRAPHIES

NIGER

COUNTRY OVERVIEW



Niger is one of the hottest and driest countries in the world, with a vast part of the country falling within the Sahara Desert and the Sahel. High intra- and interannual climate variability constrain health outcomes and water resources and contribute to chronic food insecurity such that food production does not meet consumption even in good years. People are highly vulnerable to climate shocks that drive down agricultural production and increase food prices. Recent climate trends and projected climate change, including increasing temperatures, elevated evaporation rates, heavy rainfall events and potentially increased rainfall variability, may exacerbate existing challenges related to drought, floods and heat waves. Climate shocks also affect household incomes, government finances and national economic growth. In addition to climate factors, low economic development, gender inequality, and political and regional instability stress livelihoods and the Nigerien economy. With a current population of 19.8 million, rapid population growth (3.9 percent per year) will continue to put pressure on limited land and water resources. Four coups (1974, 1996, 1999, 2010) have led to political instability and inconsistent government support for agriculture. Poverty is pervasive – about 55 percent of the population lives below the national poverty line. The country ranks 187 out of 188 countries on the UNDP Human Development Index. (24, 39, 40, 41, 42)

CLIMATE PROJECTIONS

1.6–2.9°C increase in temperatures by 2050

Increased interannual variability in rainfall, with sudden fluctuations between very wet and very dry years

Increased occurrence/severity of heavy rainfall events, dry periods, and extreme droughts or floods

KEY CLIMATE IMPACTS

Agriculture and Livelihoods

Crop loss/failure and reduced livestock productivity
Increased heat stress, land degradation and pest/disease outbreaks
Increased natural resource conflict

Health, Nutrition and WASH

Reduced water availability/quality; increased vector- and waterborne disease
Increased food security and heat stress (particularly among vulnerable populations)

October 2017

This document was prepared under the Climate Change Adaptation, Thought Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00013 and is meant to provide a brief overview of climate risk issues. The key resources at the end of the document provide more in-depth country and sectoral analysis. The contents of this report do not necessarily reflect the views of USAID.

CURRENT FFP INVESTMENTS IN NIGER

USAID Mission and Food for Peace (FFP) priority objectives in Niger for Title II development food assistance programs (USAID's primary mechanism for food assistance) focus on: 1) reducing chronic malnutrition among pregnant and lactating women and children under five, with an emphasis on children under two; and 2) increasing local availability and household access to nutritious foods by diversifying agricultural productivity and rural households' income, and increasing resilience to shocks. Target areas for investments include the southern half of the country, primarily in parts of Maradi and Zinder Regions.

Current FFP investments include:

- Critical emergency food assistance for displaced Nigeriens, and Nigerian and Malian refugees and their host communities, in partnership with UN and nongovernmental organizations;
- Assistance to chronically vulnerable communities across Niger to strengthen their capacity to cope with shocks, in partnership with the UN World Food Programme (WFP);
- Support to a joint project between the UN Food and Agriculture Organization (FAO) and WFP for seasonal livelihood programming, agricultural training, small-scale irrigation projects and community-based planning;
- Support to the UN Children's Fund (UNICEF) for distribution of locally procured therapeutic foods to children suffering from severe acute malnutrition; and
- Support to three integrated development food assistance programs with Catholic Relief Services, Mercy Corps and Save the Children to reduce food insecurity and malnutrition and improve community resilience among rural households in Maradi and Zinder Regions. (36)

NIGER FFP PROGRAM AREA LIVELIHOOD ZONES

Livelihoods in Niger's major livelihood zones are strongly connected to rainfall patterns while activities in niche livelihood zones are more closely associated with groundwater access and the local natural resource base (Figure 1). From south to north, the major livelihood zones in the FFP program areas include: 1) Rainfed Millet and Sorghum Belt; 2) Agropastoral Belt; and 3) Transhumant and Nomadic Pastoralism. Niche livelihood zones include: 1) Niger River Rice Cultivation; 2) Southwestern Cereals With Fan Palm Products; 3) Southern Irrigated Cash Crops; 4) Southeastern Natron Salt Extraction and Small Basin Irrigated Dates; 5) Cropping/Herding With High Work Outmigration; and 6) Lake Chad Flood-Retreat Cultivation With Fishing. In addition to providing milk, meat and labor for plowing, livestock are important across the country as high-value assets (source of investment, credit and savings).

Food insecurity affects all livelihood zones, in particular (34,35):

Rainfed Millet and Sorghum Belt —in the country's most densely populated livelihood zone, millet, sorghum and cowpea are the main crops. While the zone has more rainfall than other zones (400 mm to more than 600 mm), poorly timed rainfall reduces crops and forage. Soils are increasingly depleted and population growth is leading to decreasing size of household plots. The poor have few productive assets (e.g., livestock to support agricultural production), are highly dependent on farm labor for employment, and are highly vulnerable to rainfall irregularities leading to drought and flooding and crop pest outbreaks.

Agropastoral Belt — the predominant crop in this zone is millet, but rainfed cultivation is often constrained by high interannual rainfall variability of more than 20 percent and annual rainfall of only 300–400 mm. Livestock ownership tends to be highly skewed toward better-off households, while poorer households are heavily dependent on cultivation, making them some of the most food insecure in the country. Recent agricultural settlement in this zone has led to a scarcity of available land, resulting in increasing depletion of soils. Drought, crop pest and livestock disease outbreaks, flash floods, and increases in food prices are the main hazards.

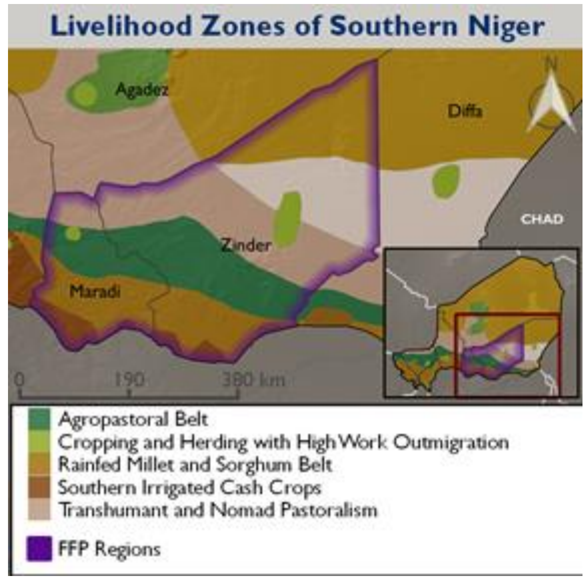


Figure 1: Livelihood zones of southern Niger

Source: USAID. 2011. FEWS NET Niger Livelihood Zones

Transhumant and Nomadic Pastoralism — animal husbandry is the predominant livelihood in this zone as the annual rainfall of 100–200 mm does not support crop production. Pastoralists here are the most dependent of all rural people on the market for the staple cereals (millet and rice) and thus vulnerable to food price volatility. Severe drought years lead to large-scale impoverishment and losses in livestock herds, which may take years to regenerate. Additional hazards are livestock disease outbreaks and bush fires.

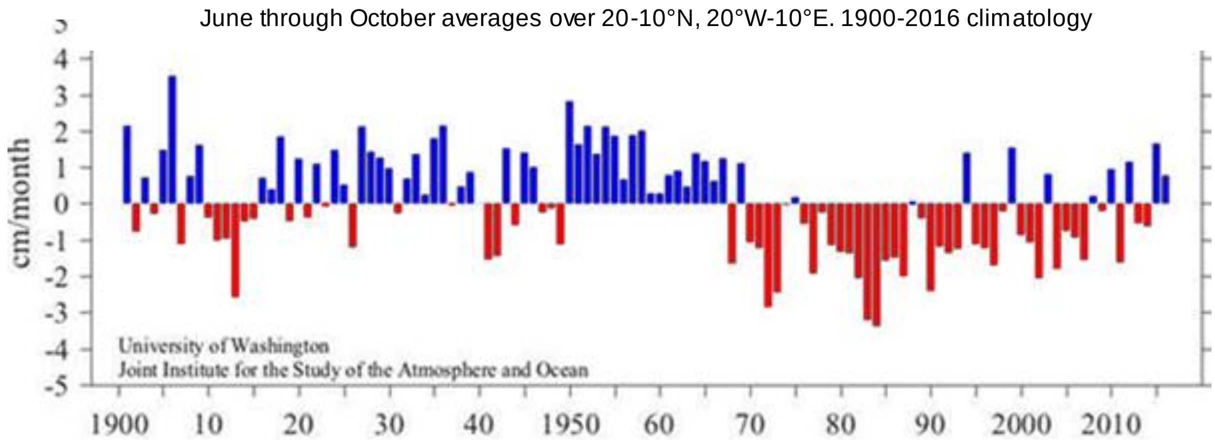
Cropping/Herding with High Work Outmigration — this zone consists of a series of pockets embedded in the larger livelihood zones. Depending on location and proximity to larger livelihood zones, the subzones are predominantly agricultural (producing millet, sorghum and cowpea), agropastoral or pastoral. Soils are relatively infertile across each of the subzones. Livelihoods are highly vulnerable to below-average rainfall and characterized by a low resource and asset base that leads to a high level of outmigration (both seasonal and long-term) for work. Rain failure, market disruption due to local conflict, and increases in food prices are the main hazards.

CLIMATE SUMMARY

Niger has a hot, semi-arid (south) and arid (central and north) climate characterized by very high temperatures year-round; the Sahara Desert covers most of the country. A long, intense dry season occurs from November–May and a brief, irregular rainy season is linked to the West African monsoon; rainfall peaks in August. Annual rainfall has high interannual and interdecadal variability; rainfall levels are highest in the south (800 mm), shifting to lower levels in the Sahel–Sudan (400–600 mm) and Sahel (300–400 mm) zones, to almost no rain in parts of the Sahara–Sahel (200–300 mm). The Sahara climate zone, 74 percent of the country's territory, receives annual rainfall of 0–200 mm. In the winter (November–March), the dry, dust-laden Harmattan trade winds blow from the northeast, inducing low humidity, very little cloud cover, no rainfall and severe dust/sandstorms.

Across the Sahel, annual rainfall was above average from 1915 through the 1930s and again during the 1950s and 1960s. Rainfall declined from 1960 to 1990, with the largest deficits in the early 1980s. The trend has increased somewhat since the 1990s (Figure 2). With the declining rainfall from 1950–1990, agroclimatic zones shifted south by 100–200 km. With increasing rainfall in recent decades, however, crop production zones appear to be shifting northward again (Figure 3). (26, 39)

Figure 2: Annual rainfall variability compared to average in the Sahel (1900–2016)



Source: University of Washington Joint Institute for the Study of the Atmosphere and Ocean 2017

Annual average temperatures are highest in the south at 30˚C. Moving north, they decrease to 24˚C. In the south, seasonal temperatures vary little and stay above 25°C, while in the north seasonal temperatures can range from 15°C to 35°C. The warmest periods precede the rainy season, and on average, heat waves last six days. (3)

Table 1: Climate trends and projections in Niger		
Parameter	**Observed trends**	**Projected changes (2040–2069)**
Temperature	• Increased average temperature of 0.35°C per decade from 1983–2013; for the longer period of 1901 to 2013, warming averaged 0.05°C per decade • Increased minimum temperatures with no clear increase in maximum temperatures	• Increased average annual temperature of 1.6–2.9°C by 2050 with greatest warming in June–September, the main agricultural season • Longer duration heatwaves[1] (by 8–28 days) by 2050
Rainfall	• Increased average annual rainfall of 36 percent over the last 30 years, with a shift in peak rainfall from August to July; however, this increase followed a low rainfall period such that there is no overall change in rainfall from 1901–2013	• Potential for increased precipitation during the second half of the wet season (July–October) by 2050 • Uncertain precipitation projections due to high interannual variation, but interannual and spatial variability could potentially increase • Potentially decreased rainfall during the dry season (November–March), with important

[1] Consecutive days above the 95th percentile for average temperature.

		implications for livestock and water resources • Increased frequency and intensity of heavy rainfall events

Figure 3: Increasing precipitation trends (1960–1989 and 1990–2009) and projections (2010–2039) shown with major millet and cowpea cultivation areas for Niger

Source: USAID 2012. FEWS NET Climate Trend Analysis of Niger

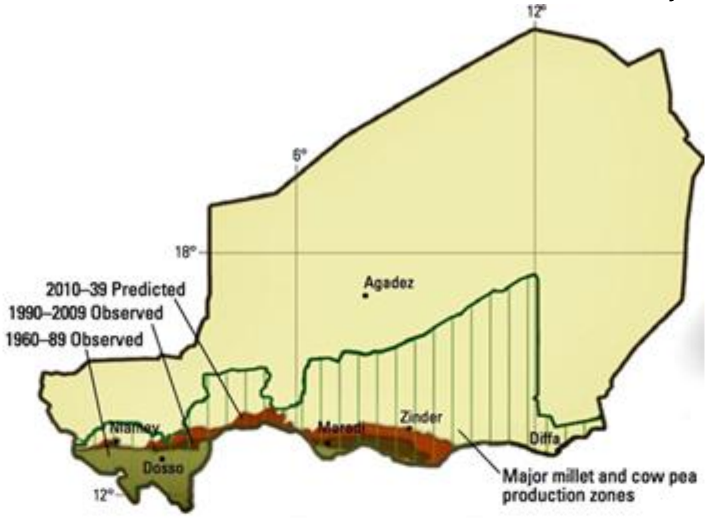


Figure 3 illustrates precipitation trends and projections of increasing rainfall relative to cropping areas in the country (wetter conditions moving into the drier north). The map's green polygons show the major crop production regions. The colored bands show the areas with average rainfall of 500 mm during June to September (500 mm isohyets) for 1960–1989 (light brown), 1990–2009 (dark brown), and 2010–2039 (orange, predicted). While the country is expected to see increased rainfall in coming decades, increased temperatures, erratic rainfall and intense storms may bring other climate-related challenges.

SECTOR IMPACTS AND VULNERABILITIES

CROP PRODUCTION

Crop production (mainly millet, sorghum and cowpea) is predominantly rainfed and reliant on the region's low and highly variable rainfall, making it extremely vulnerable to climate variability and change. Climate change trends could negatively impact productivity in the FFP zones. These include increasing temperatures, heat wave duration and evaporation along with heavy rainfall and potentially increased rainfall variability. In addition to harsh climate conditions, declining soil fertility and high and increasing population pressure on arable land challenge crop production. Agriculture accounts for roughly 40 percent of gross domestic product (GDP) and is the principle source of livelihoods for more than 80 percent of the population. Given agriculture's prominence, climate variability and shocks have significant impacts on livelihoods and the economy. The country faces serious food security challenges and is heavily dependent on cereal imports, even in good years. As most rural households do not produce enough to meet their consumption needs, food purchases account for more than 60 percent of expenditures. (34, 39)

The country's poor soils, low level of irrigation and small average farm size (4.1 hectares) increase vulnerability and limit adaptive responses in the face of increasing impacts from climate change.

With few exceptions, soils are low in nutrients, organic matter and water retention capacity, and are vulnerable to erosion that will be exacerbated by increased heavy rainfall events. Irrigation in Niger is very low, with just around 0.1 percent of arable land irrigated. Additionally, small farm sizes are being further reduced due to population growth, which outpaces the current expansion of cultivated areas. The consequence is increasing pressure on arable land, increasing soil degradation and an increasingly limited scope for restoration techniques such as fallowing land to preserve and restore soil fertility. (10, 34, 39)

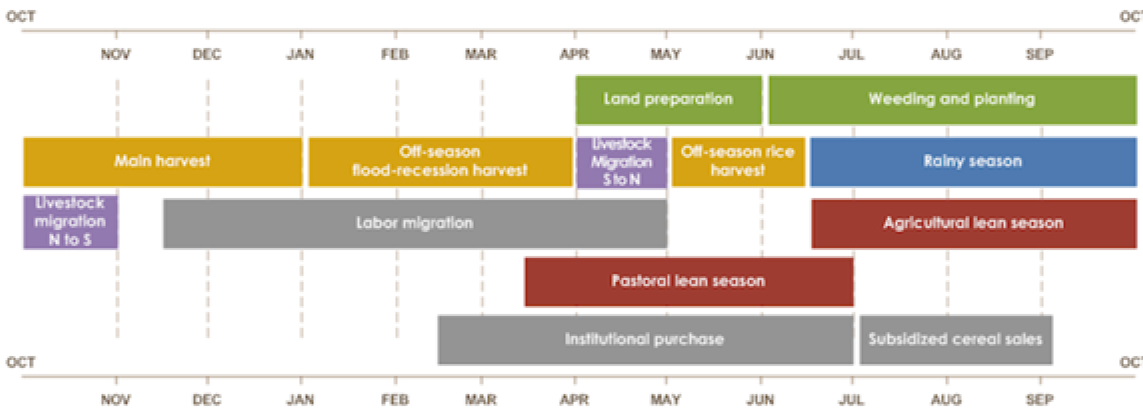
Traditional livelihood strategies, such as crop/livestock integration, seasonal and longer-term migration, and reliance on communal networks, align well with the realities of a dry and uncertain climate. Nevertheless, the rising temperatures, more heavy rainfall events and more erratic rains threaten to alter the effectiveness of traditional livelihood methods. Research estimates that an increase of more than 2°C (likely by late this century), for example, could decrease yields by 15–25 percent for millet and sorghum in Niger. One study indicates that in small areas of southern Niger, increased temperatures could make sorghum nonviable by 2030 and finger millet nonviable by 2050. Temperature extremes in Niger have already reached 48°C, exceeding the estimated thresholds for millet (development stops at temperatures higher than 46°C or 42°C during flowering) and sorghum (44°C). [2] Additionally, droughts, floods, crop pests and diseases, bushfires and windstorms (all risks to crops) are directly or indirectly linked to temperature and rainfall. Most crop production, while low in yield, is resilient due to intercropping of millet, cowpea and sorghum. These three crops are cultivated in 85–90 percent of the country's agricultural areas. Cropping strategies are restricted by very limited access to irrigation and inputs (i.e., improved seeds and fertilizer). The seasonal calendar is structured around the June–October rainy season, though increasing variability in rainfall will have a future impact on crop production (Figure 4). (20, 25, 34, 39)

Drought, a result of low or irregularly timed rainfall, is the single largest threat to crops, responsible for yield losses and crop failures. From 2000 to 2012, the country experienced four drought years (2000, 2004, 2009, 2011), affecting millions of people and reducing the fodder and cereal balance (down by as much as 70 percent and 28 percent, respectively), and requiring international humanitarian assistance. Climate models project increasing temperatures and rainfall variability, which may amplify the impacts of drought on crops, soil and water resources. Projected increased frequency and intensity of heavy rainfall will also increase flood risk. Niger experienced damaging floods in 2009, 2012, 2013 and 2014, leading to loss of crops and damaging cultivated land. Meanwhile, locust outbreaks often follow floods. Rising temperatures could shorten the incubation and maturation periods of pests, leading to a rise in locust numbers. (6, 39)

[2] Temperature extreme recorded at Bilma station in 2010.

Figure 4: Typical seasonal calendar in Niger

Source: USA3ID. 2014. FEWS NET Niger food security brief



Despite constraints, agricultural production steadily increased over recent decades as the amount of land farmed increased. Droughts, floods, pests and locusts, however, regularly impact crops and, to a lesser extent, livestock production (Figure 5). And while overall agricultural production increased, it did not keep pace with population growth, leading to a decrease in production per capita and increased food insecurity. Despite the expansion of agricultural lands, yields remain stable or lower. Average yields for major crops remain 43 percent lower than those in other Sahelian countries. (34, 39)

Figure 5: Major shocks to crop and livestock production in Niger, 1980–2010

Source: World Bank. 2013. Agricultural Sector Risk Assessment in Niger

Niger's major crops (millet, sorghum and cowpea) exhibit both sensitivity and adaptive characteristics related to projected climate change (Table 2). (22, 24)

Table 2: Adaptive characteristics and climate sensitivities of key crops		
Crop	**Climate sensitivities**	**Adaptive characteristics**
Millet	• Crop cannot tolerate waterlogging or immersion • Crop requires evenly distributed rainfall during growth period; does not go into dormancy during drought like sorghum • Excess rain during flowering can cause crop failure • Hot, dry conditions increase risk of witchweed infection and damage; hot, wet conditions increase risk of downy mildew	• Most reliable grain in hot, drought-prone areas with sandy soils • Tolerant of temperatures up to 46°C (42°C at flowering) • Only rainfed grain productive in areas with less than 400 mm of rainfall • Traditional varieties of plants photo-period sensitive, such that development post-germination and pre-flowering primarily depends on day-length, rather than temperature; therefore, under increased temperatures, these cultivars are more adaptable and can readily maintain growth and production
Sorghum	• Crop is sensitive to moisture stress during grain development stage when dry periods of two weeks or more significantly diminish yields • Crop's performance is poor if rainfall is less than 450 mm • Temperatures more than 35°C can reduce yields • Hot, dry conditions increase risk of damage from khapra beetle and striga purple witchweed; hot, wet conditions increase risk of sorghum midge, anthracnose, sorghum downy mildew and zonate leaf spot	• Drought-tolerant (although less so than millet); goes dormant during water stress and resumes growth when conditions improve • Tolerates waterlogging of up to two weeks • Does well on most soils; moderately tolerant to soil salinity • Photo-period sensitive
Cowpea	• Average temperatures over 33–35°C can negatively impact flower development, leading to reduced yields • During flowering, crop is sensitive to dry periods greater than 3–5 days • Warm, moist conditions can delay maturity • Hot, dry conditions increase risk of damage from cowpea aphids, cowpea aphid-borne mosaic virus (CABMV) and root-rot nematodes • Hot wet conditions increase risk of legume pod borer, cowpea caterpillar, cercospora leaf spot and scab	• Tolerant of low rainfall, performing well with 400–700 mm per year but producing with 300 mm or less per year • Fast-maturing • Performs best in sandy soils but does well in a wide variety of soil types and conditions • Some varieties photo-period sensitive • Tolerates waterlogging of up to 5 days during vegetative growth • Tolerates dry periods of up to 15 days during emergence and grain-filling stages

Climate stressors such as rising temperatures, heatwaves, heavy rainfall and increased rainfall variability directly impact crop yields and increase certain pest and disease risks; sorghum in particular shows reduced yields at temperatures over 35°C (Table 3).

Table 3: CROP PRODUCTION – Climate stressors and risks

Climate stressors	Climate risks
Increased temperatures **Increased duration of heat waves** **Increased evaporation rates** **Increased risk of drought** **Increased heavy rainfall frequency and intensity** **Increased length and/or intensity of dry periods; more variable rainfall**	Reduced soil moisture and heat stress from increased rainfall variability
	Increased erosion and plant damage from heavy rainfall events
	Crop failure and/or reduced yields (leading to higher food prices)
	Increased incidence of pests and diseases

LIVESTOCK

With the largest herd population in the Sahel (estimated in 2013 at 10.5 million Tropical Livestock Units), cattle, goat, sheep and camel production is integral to livelihoods in Niger. The livestock sector accounts for 14 percent of the country's GDP and 40 percent of the agriculture sector's contribution to GDP. While typically more resilient to climate variability and shocks than crops, livestock are susceptible to heat stress and production is affected by rangeland productivity, feed production, water availability and pest and disease dynamics. Livestock are also impacted by drought and heavy rainfall. Expanding cultivation, driven by a range of factors including increasing rainfall, population growth, access to plows, and farm land degradation may also exacerbate conflicts related to access to traditional migration routes to water and rangeland. Production techniques vary among livelihood zones, but in general households are trending toward agropastoralism, as evidenced by the average annual increase of 2.5 percent in livestock production. Livestock are important for meat and milk production, employment and cultural identity and as a source of income, investment, credit and savings. (30, 31, 34, 39)

Drought is the most significant risk in livestock production, and in combination with other shocks, led to major sector losses in recent decades. In 2009–2010, drought followed by heavy rains and flooding led to estimated losses across agropastoral and pastoral zones of 26 percent of cattle, 39 percent of sheep, 31 percent of goats and 3 percent of camels. Drought also aggravates mortality and morbidity by altering livestock disease dynamics, triggering food price spikes and increasing conflicts over rangeland and water resources. In addition to drought shocks, projections for more variable rainfall and more severe dry seasons could lead to rangeland degradation and loss of grazing potential. (39)

The incidence of floods is already on the rise in Niger as a result of increases in heavy rainfall. Climate projections for higher heavy rainfall frequency and intensity will further drive this trend and have direct implications for livestock losses. Most flooding occurs during the rainy season when crops are being cultivated and livestock are kept close to settlements, making them vulnerable to flash floods. While floods tend to be localized, high numbers of livestock can be washed away. In the 2010 floods, 115,114 animals (mostly small ruminants) were washed away along the Niger River and across the southern part of the country. (39)

Rising temperatures also negatively impact livestock production through heat stress, mortality and changes in disease dynamics. Heat stress in livestock can reduce feed consumption, reproduction and growth rates, longevity, milk production, egg laying and disease resistance. Chickens are particularly sensitive to heatwaves, which can cause extensive mortality.

Rising temperatures and shifting rainfall patterns are likely to impact the range, transmission rate and outbreaks of certain livestock diseases. The most damaging livestock diseases include: anthrax, hemorrhagic septicemia (*pasteurellose)*, *peste des petits ruminants* (PPR) and Newcastle disease. Hotter, drier conditions are expected to increase the already significant losses from anthrax (cattle, camels, goats and sheep) and Newcastle disease in the case of poultry (Box 1). (15, 28, 39)

Box 1: Risks to livestock under two climate scenarios
Source: USAID. 2014. Agricultural Adaptation to Climate Change in the Sahel: Expected Impacts on Pests and Diseases Afflicting Livestock

While overall rainfall projections remain uncertain, it is projected that increased rain in the wet season and increased drying due to increased temperatures in the dry season will occur, even if rainfall patterns remain the same. Both scenarios (warmer and wetter or warmer and drier) have significant implications for the livestock sector.

Under *warmer and wetter conditions projected during the wet season*, risks include:

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

Under *warmer and drier conditions projected during the dry season*, risk of certain diseases would diminish while others are projected to increase. Increased risks include:

- Increased anthrax due to longer periods spent grazing on infected pastures (cattle, camel, sheep, goats)
- More frequent Newcastle disease outbreaks among chickens
- Expansion of tropical theileriosis among cattle
- More frequent outbreaks of foot and mouth disease among cattle
- Increased occurrence of highly pathogenic avian influenza

Finally, while increasing rainfall could benefit farmers, it threatens to exacerbate livestock-related conflicts and to indirectly limit the mobility that gives the livestock sector its resilience to climate variability. The combination of higher rainfall, population pressures and other social, economic and environmental drivers is pushing cultivation north, where it increasingly encroaches on rangelands and traditional livestock migration corridors. This competition over land and water resources intensifies the farmer–herder conflicts that have claimed hundreds of lives since the 1990s. Additionally, in this region, where forage varies greatly both temporally and spatially, the ability to migrate in pursuit of forage and water is key to the sector's resilience. Cultivation expansion hinders pastoral migration, even as climate change may make this practice more necessary for successful livestock production. (30, 31, 39)

Table 4: LIVESTOCK – Climate stressors and risks	
Climate stressors	**Climate risks**
Increased temperatures	Reduced livestock reproduction, growth rates and milk production due to heat stress
Increased duration of heatwaves	Rangeland degradation and loss of perennial grasses, diminishing dry season grazing potential
Increased evaporation rates	Reduced rangeland and crop productivity, leading to reduced livestock weight and livestock losses during drought
Increased heavy rainfall frequency and intensity (more variability)	Early drying or loss of seasonal water sources due to increased evaporation and a more severe dry season
Increased length and/or intensity of dry periods	Altered pastoral mobility patterns, increasing conflict with farmers
	Increased expansion, occurrence and outbreaks of certain livestock diseases

HUMAN HEALTH, NUTRITION AND WASH

In Niger, the most pressing climate change impacts to human health, nutrition and WASH are projected increases in infectious diseases, heat stress, food insecurity, diminished water quality and flooding. Health indicators in Niger improved in recent years but are still some of the lowest in the world. Life expectancy is 61 years. Infant and under-five mortality rates are high – 57 and 96 per 1,000 live births, respectively – with higher risk in rural areas. Health issues are exacerbated by a weak health care system with very limited access to care, low immunization coverage, a dispersed population and precarious living conditions. (32, 42)

Rising temperatures and heavy rainfall events are projected to: 1) accelerate reproduction in disease-causing bacteria and disease vectors (e.g., mosquitoes); 2) increase heat stress; and 3) degrade water quality. These impacts will likely lead to shifts in the distribution, timing and severity of each of the leading causes of death in children and adults, namely malaria, respiratory infection and diarrhea. Cases of malaria, for example, may increase in some areas, corresponding with the increase in mosquito population under warmer temperatures. However, in some areas, temperatures may exceed the threshold that enables mosquitoes to reproduce, thus reducing malaria transmission. Longer and hotter heat waves, in addition to overall warmer temperatures, increase heat stress (heat exhaustion, heat stroke) and the risk of respiratory and cardiovascular diseases. Additionally, cases of diarrhea, closely tied to water quality, have been found to increase in Niger under conditions of increased temperature and rainfall. Climate projections also suggest increased incidence of meningitis and measles by mid-century. Warming trends already appear to be expanding meningitis occurrence southward throughout the Sahel. (4, 9, 13, 34, 37, 44)

Malnutrition, a primary concern in Niger, could be aggravated by the impacts of climate change on agricultural production and water quality. Chronic malnutrition affects 42 percent of children under five; 10 percent are acutely malnourished. Micronutrient deficiencies for vitamin A, iron and zinc are common. More than 73 percent of children under five and almost 46 percent of women of reproductive age have anemia. Primary causes of malnutrition include food insecurity driven by persistent domestic food production deficits, food crises (which are often related to climate shocks), and diarrheal disease related to water quality. Poor harvests can be devastating to rural households, leading to reduced food consumption and loss of assets and income. In addition to shocks that cause acute food insecurity, much of the population suffers from chronic food insecurity, especially during certain seasons. Drought, a key driver of food insecurity, could occur more frequently with increased climate variability and/or more severe dry periods. After the 2009 drought, per capita caloric consumption decreased by 24 percent compared to 2007. (32, 39, 43)

In Niger, already insufficient drinking water supplies are increasingly affected by climate variability, particularly with respect to water availability and quality. An estimated 49 percent of the rural population has access to an improved water source and just 5 percent to improved sanitation. Almost half of all households (48 percent) are at least a 30-minute walk from a drinking water source. The low rainfall trends of the 1960s to 1990s contributed to drying lakes and ponds, most notably Lake Chad, which shrank 94 percent between the 1960s and the 2000s. Surface water in Niger is highly seasonal and concentrated in the transboundary Niger River and its tributaries; it is thus subject to upstream withdrawals. Further, a significant proportion of water originates from Mali and flows out of Niger into Nigeria. Niger and its neighbors are signatories to the Niger Basin Water Charter (2008) designed to ensure equitable and responsible sharing of the river's resources (including access for irrigation). Renewable surface water is estimated at 31 km^3 per year, with only a small portion (1 km^3 per year) originating within the country. Groundwater is plentiful but has very low recharge rates. Nonrenewable groundwater is extensive, estimated at 2,000 km^3, but generally deeply buried, making water point construction and maintenance expensive and problematic. In south Maradi Region, for example, the water table averages 50–60 m below the surface and flow rates are low, at about 1m^3/hour. In Zinder Region, well sites show groundwater depths of 1–117 m. Renewable groundwater is estimated at 2.5 km^3 per year. The country uses only 1 percent of surface and 20 percent of groundwater resources. (1, 5, 19, 23, 31, 44)

In recent years, recurrent flooding (2010, 2012, 2015, 2016) had direct (mortality and morbidity) and indirect (lost crops and livestock, degraded water quality) health impacts. Floods in 2010, for example, displaced more than 250,000 people, damaged or destroyed more than 10,000 houses, and led to crop and livestock losses. Flooding in 2012 killed approximately 300 people and injured 6,000. The 2016 floods led to loss of life, household displacement and the loss of 19,536 livestock (cows, goats, sheep and camels). Flooding combined with increased temperature can severely diminish water quality, increasing the risk of diarrhea and other waterborne diseases. Open defecation, which is common in Niger, increases the risk of water pollution during heavy rainfall events. (39, 45)

Table 5: WASH AND HEALTH– Climate stressors and risks

Climate stressors	Climate risks
Increased temperatures	Increased heat wave- and heat stress-related mortality and morbidity (i.e., cardiovascular, respiratory and kidney diseases, heat exhaustion, heatstroke)

Increased duration of heat waves	Expanded ranges of disease vectors (e.g., mosquitoes) and increased transmission of infectious disease such as meningitis and malaria
Increased heavy rainfall frequency and intensity (more variability)	Increased flood-related mortality and morbidity, including an increase in infectious diseases from degraded water quality; increased damage to water and sanitation infrastructure
Increased length and/or intensity of dry periods	Reduced water availability due to drying water sources during more severe dry periods
	Diminished nutrition and food security due to impacts on agriculture from increased heat, heavy precipitation and variable rainfall

PESTICIDE USE

Chemical pesticide use is generally low in Niger, however, herbicide use in particular is increasing across the Sahel. A national survey of 2,200 households in 2011–2012 showed that 7.8 percent used agrochemical pesticides, herbicides and/or fungicides and 17 percent used inorganic fertilizer. Pesticide use poses risks to human and livestock health and has caused respiratory tract problems in humans and poisoning in livestock in the country. Additional risks include minor to acute neurological, immunologic and reproductive effects. Most pesticide use occurs in irrigated areas with limited quantities used in subsistence, rainfed farming. Demand for pesticide use could increase, however, in response to the low level but persistent agricultural damage that occurs from pests and diseases. Farmers could be incentivized to increase pesticide use if climate variability and change bring increased adverse impacts on agricultural production. Supply-side changes such as increased availability and low-cost pesticides from China and India have also driven increased use in parts of the Sahel. Risk of pesticide contamination in soils and surface water is high, given incomplete or absent pesticide labelling, lack of awareness about safe and effective use, and poor soils, which lead to high rates of water runoff during heavy rainfall events. Increased frequency and intensity of heavy rainfall could increase contamination risks and reduce pesticide effectiveness. (11, 12, 16, 21, 22)

Table 6: PESTICIDE USE – Climate stressors and risks

Climate stressors	Climate risks
	Increased surface runoff due to increased heavy precipitation
Increased heavy rainfall frequency and intensity (more variability)	Increased percolation/groundwater infiltration due to increased annual rainfall
	Increased threat from current pests/introduction of new pests
Increased length and/or intensity of dry periods	Reduced effectiveness of pesticides applied topically or activated/distributed by water due to increased annual and heavy rainfall
Increasing temperatures	Farmers' reduced willingness to use Personal Protective Equipment (PPE) due to increased temperatures

INVASIVE SPECIES

Invasive species are often highly adaptable, frequently responding positively to increased temperatures and variable climate conditions. Many invasive plants are early-maturing and able to capture a larger share of nutrients, water and pollinators and outcompete crops and native species. Invasive species can establish in (and sometimes even prefer) degraded lands, which are likely to increase with climate change. Converting native vegetation to cultivated land disturbs the soil and disrupts plant communities, giving invasive species additional opportunities to proliferate. Problematic invasive species reduce crop and livestock production, displace native biodiversity and increase production costs (Table 7). Although specific information on invasive species in Niger is lacking, invasive plant species, including various *Prosopis juliflora*, *Eichorniae crassipes* (water hyacinth), *Cyperus rotundus* and non-native *Acacia* species, are a risk to grasslands, shrub lands, savannahs and wetlands. (2, 7, 8, 14, 17, 38)

Table 7: INVASIVE SPECIES – Characteristics and link to climate

Species	Characteristics	Link to climate
Prosopis juliflora	Perennial, deciduous, fast-growing, nitrogen-fixing and very salt- and drought-tolerant shrubs or trees with deep tap roots; grows in arid and semi-arid environments, forms dense stands and outcompetes native vegetation	Has shown increased distribution under increasing temperature and long dry periods in Kenya
***Eichorniae crassipes* (water hyacinth)**	Aquatic species of a few centimeters to over a meter in height; forms dense floating mats that impede water flow and create mosquito breeding areas	Adapted to temperature range of 12–35ºC; seeds can germinate in a few days or remain dormant for 15–20 years to survive variable conditions
Cyperus rotundus	Sedge species of about 30 cm with a smooth, grass-like appearance; perennial weed with extensive underground tuber and root system; one of the world's worst invasive weeds based on its distribution and effect on crops	Adapted to high temperatures and solar radiation; performs well with elevated levels of CO_2, suggesting it may become more invasive in the future

Key Resources

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