UNDRR
UN Office for Disaster Risk Reduction

DISASTER RISK PROFILE

Niger

FLOOD

DROUGHT

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In memory of Katarina Mouakkid Soltesova, Programme Management Officer, UNDRR, Regional Office for Africa.

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Acronyms and abbreviations

AAL	annual average loss
CMIP	Coupled Model Intercomparison Project
GCM	General Circulation Model
IPCC	Intergovernmental Panel on Climate Change
LSU	Livestock Unit
PML	probable maximum loss
RCP	Representative Concentration Pathway
SDGs	Sustainable Development Goals
SEI-3	Standardized Evapotranspiration Index three-month average
SEP	socioeconomic projections
SPEI-3	Standardized Precipitation Evapotranspiration Index three-month average
SPI-3	Standardized Precipitation Index three-month average
SSFI-3	Standardized Streamflow Index three-month average
SSP	Shared Socioeconomic Pathway
UNDRR	United Nations Office for Disaster Risk Reduction
WCI	Water Crowding Index

Introduction

Over the years, climate change has escalated and caused a noticeable surge in interconnected disasters and extreme events. Understanding the risk posed by these disasters requires better understanding of the vulnerability and exposure of different countries. More than ever, disasters are a concern at the national and international scale due to their potential and proven negative impacts on people's lives, livelihoods and ecosystems. Disasters can cause the partial or total destruction of physical assets, and the disruption of basic services. They can also offset development investments.

The complex and rapidly evolving nature of disaster risk in sub-Saharan African countries has drawn attention. From 2000 to 2022, over 407 million individuals on the continent were impacted by natural hazards alone (United Nations Economic Commission for Africa, 2023).

Situated in the Sahel region, Niger is a developing nation that is extremely vulnerable to the adverse impacts of climate change. The country has diverse landscapes, including the Sahara Desert in the north, and savannas and agricultural areas in the south. Despite its abundant natural resources and cultural heritage, Niger faces several challenges, including its vulnerability to natural and human-induced disasters, particularly floods and droughts. Recognizing the significance of addressing these concerns, Niger's National Adaptation Plan for climate change places substantial emphasis on implementing adaptation measures, including strengthening international collaboration to combat natural hazards (National Council of the Environment for Sustainable Development [CNEDD], 2022).

The disaster risk profile for Niger is developed under the mandate of the United Nations Office for Disaster Risk Reduction (UNDRR) to implement the Sendai Framework for Disaster Risk Reduction 2015–2030 internationally and in alignment with the National Adaptation Plan for climate change. The framework prioritizes risk management over focusing solely on disasters. This profile aims to provide a comprehensive understanding of the dimensions of disaster risk, including hazard characteristics, exposure, vulnerability and impact in Niger.

Niger's disaster risk profile provides a picture of the critical risks that the country faces to inform decision-making for both risk reduction and adequate risk management. By understanding the dynamics of these risks and vulnerabilities, policymakers and stakeholders can also develop the targeted policies, strategies, plans and institutional arrangements needed to foster stable economic growth and resilience to shocks and to cushion the impact of flood and drought on the nation's people, economy and environment.

Risk indicators

Several indicators can be used to quantify the impacts of floods and droughts under current and projected climate and socioeconomic conditions. The choice of indicators is influenced by several factors: relevance to the country and context, availability of data and coherence with international policies such as the Sendai Framework.

A main objective of this project was to explore how information produced for the National Risk Profile could inform early warning, food security and development policies.

In its first phase, the development of the National Risk Profile focused on a set of risk indicators. These reflect the following needs and constraints (see also figure 1 and figure 2):

- Relevance of the exposure layers and related risk indicators for early warning and early action in the disaster risk management domain and specifically in the Early Warning domain
- Feasibility of deriving reliable metrics given the technical and time constraints in developing the National Risk Profile
- Availability of homogeneous and reliable impact data to calibrate the risk estimation method

Figure 1: Risk indicators selected for floods

THE FOLLOWING SET OF RISK INDICATORS WERE THEREFORE SELETED FOR FLOODS

PEOPLE LIKELY TO BE AFFECTED

Number of people likely to be affected based on flood extent and magnitude.

ECONOMIC LOSS

Direct economic loss based on flood extent and magnitude, divided into sector classes, according to the exposure categories reported in the Sendai Framework indicators:

TO BUILT-UP AREA

- Housing sector

TO CRITICAL INFRASTRUCTURES

- Transportation systems (roads)
- Education facilities
- Health facilities
- Cropland
- Grazing land

Figure 2: Risk indicators selected for drought

THE FOLLOWING SET OF RISK INDICATORS WERE THEREFORE SELETED FOR DROUGHT

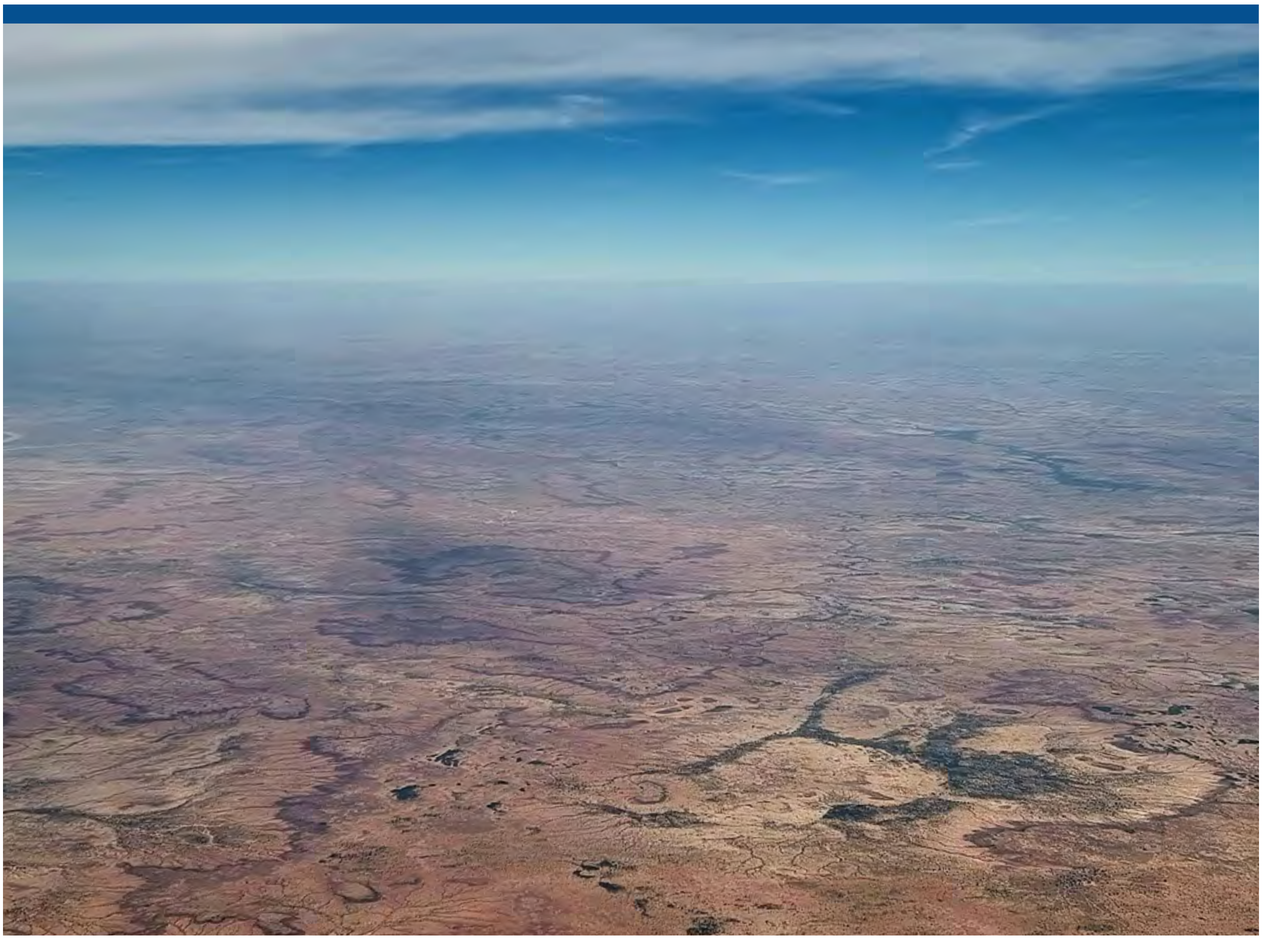
PEOPLE LIKELY TO BE AFFECTED

Number of people likely to be affected, hit by a severely impactful drought.

AGRICULTURAL LAND AFFECTED

Direct economic loss based on drought severity, expressed through different agricultural indicators:

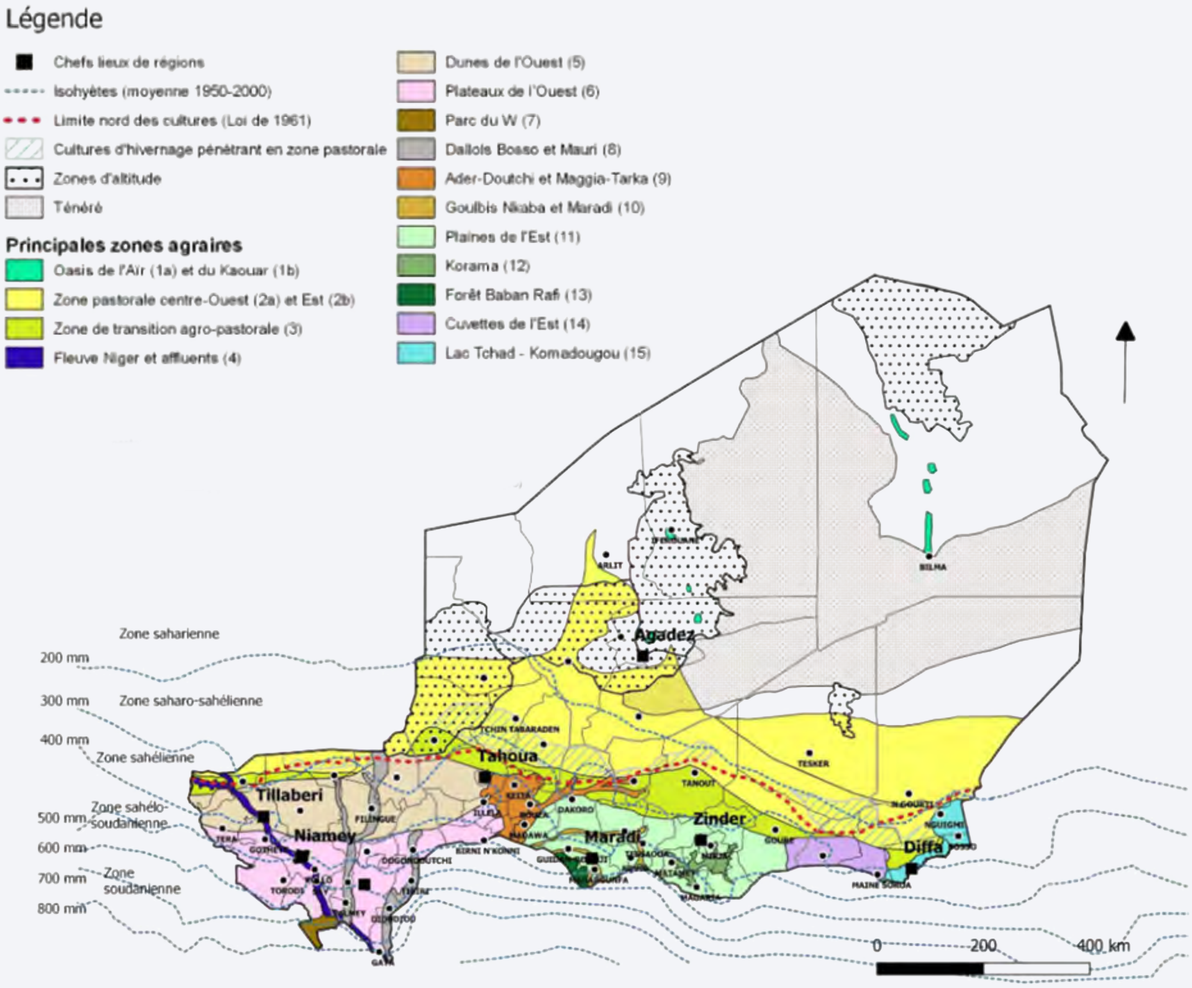
- Agricultural land
- Pastoral land
- Livestock



Socioeconomic outlook

Niger is a landlocked country in West Africa with limited water resources. The Niger River crosses the south-west part of the country. The area north-east of the river is characterized by an extensive plateau area, while the north of the country has a more accentuated topography. Niger is a transitional region between flat and rolling savannahs , and desert plains and sand dunes, that comprises the Sahara in the north and the Sahel in most of the country's remainder. In the extreme south, a tropical climate exists on the edges of the Niger River Basin. Niger is rich in minerals and has one of the world's largest uranium deposits. Substantial deposits of gold, phosphates, coal, iron, limestone and gypsum have also been found (International Atomic Energy Agency, 2020).

Figure 3: Agroecological areas, climate and zones of Niger



Source: Niger, Ministry of the Environment, Urban Planning and Sustainable Development, National Council of the Environment for Sustainable Development, High Commission for the 3N Initiative and Ministry of Agriculture and Livestock (2020).

Home to a population of 25 million in 2023, Niger has a high annual population growth rate of 3.7 per cent (Institut National de la Statistique du Niger [INS], 2023b). Most of the population lives in the southern part of the country, where the climate is more favourable for agricultural and pastoral activities (World Bank, n.d.-b; see also figure 3). The urbanization rate is low, with 84 per cent of the population living in rural areas. The highest populations are in the capital, Niamey, and the regions of Maradi, Zinder and Tahoua (INS, 2023b).

Nearly 11 million people (42.1 per cent of the population) live below the poverty line of $2 per day, based on the latest figures from 2021/2022 (INS, 2023b). There are over 700,000 forcibly displaced people in Niger, including 376,000 internally displaced people in the regions of Diffa, Maradi, Tahoua and Tillabéri, and over 320,000 refugees from Mali, Nigeria and Burkina Faso (European Civil Protection and Humanitarian Aid Operations, n.d.; Human Rights Watch, 2023).

With a real gross domestic product per capita of $505[1] in 2021 (INS, 2023a; INS, 2023b), Niger is one of the world's poorest countries, with a poorly diversified economy (World Bank, n.d.-c). The agricultural and services sectors each contributed 39 per cent to the country's gross domestic product in 2021, with the industrial sector contributing 22 per cent. The agricultural sector's main contributions came from crop production (26 per cent) and livestock (9 per cent) (INS, 2023a). Uranium, petrol and gold are the principal commodities exported. Staple crop production is dominated by cereals such as millet and sorghum. Onions and cow peas are the major cash crops. Other cash crops include groundnuts, sesame, tiger nuts and moringa (INS, 2023e). Oilseeds accounted for 9 per cent of Niger's total exports in 2021, while rice was the main agricultural import at almost 12 per cent of total imports (Observatory of Economic Complexity, n.d.).

Over 80 per cent of Niger's population works in the agricultural sector, heavily relying on agriculture for food security and livelihood. Concerns are rising over the effects of climate change, including rising temperatures, reduced water availability and the occurrence of floods and other extreme weather events. Agricultural production in Niger is primarily subsistence-based and rain-fed. Less than 1 per cent of the country's arable land is irrigated (Niger, Ministry of Agriculture and Livestock, 2016). Smallholder farmers are particularly affected by the impacts of climate variability, which can reduce their food supply and increase the risk of hunger and poverty. The agricultural sector has limited adaptive capacity, increasing Niger's vulnerability to climate change (Tomalka and others, n.d.).

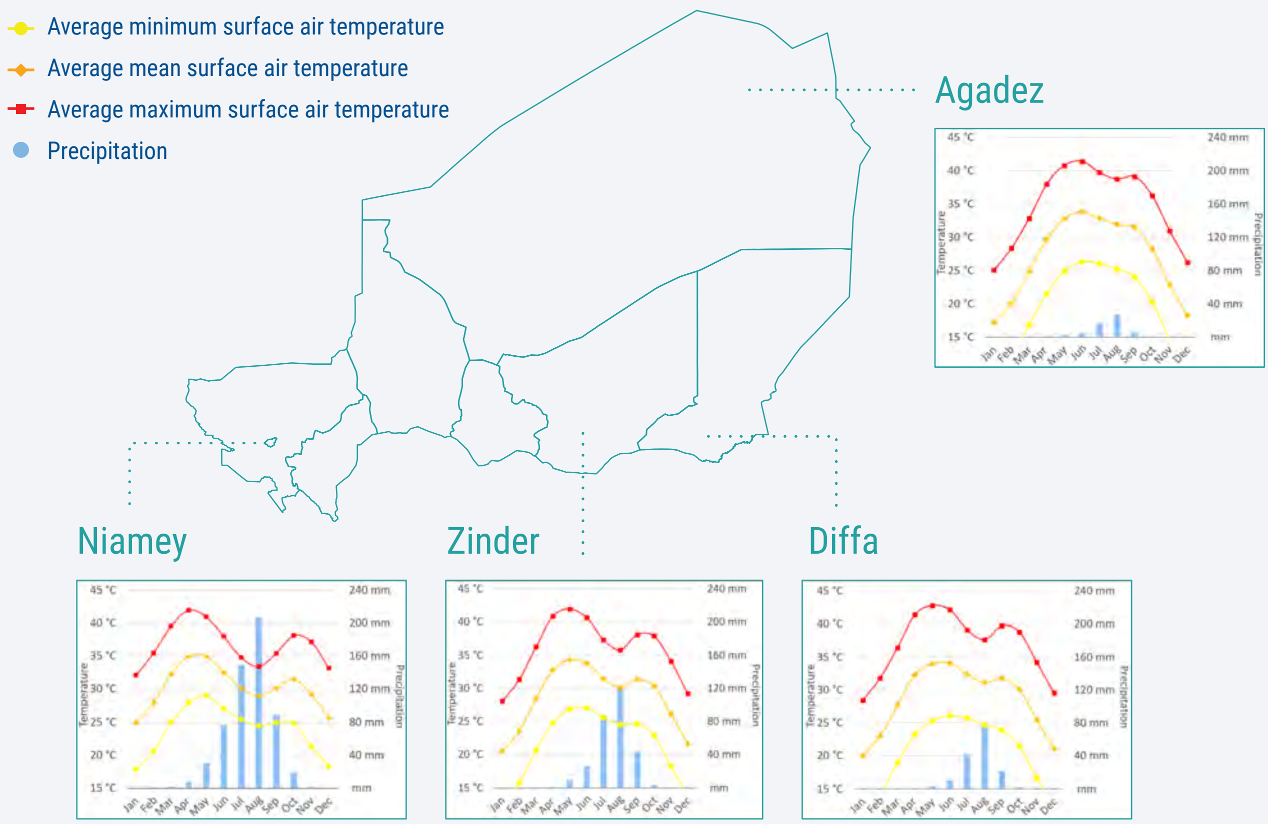
1 Using a conversion rate of 1 USD = 600 XOF.

Climate outlook

As part of the Sudano-Sahelian region, Niger has a hot climate with very high temperatures year-round; a long, intense dry season from October to May; and a brief, irregular rainy season linked to the West African monsoon (World Bank, n.d.-b; see also figure 4). In the extreme south, a tropical climate exists on the edges of the Niger River Basin (International Atomic Energy Agency, 2020).

Niger is regularly exposed to episodes of drought. Given the great vulnerability of its population, this can result in major food crises. Despite an overall trend towards a more humid climate in the region, the country has experienced several major droughts over the past 20 years.

Figure 4: Monthly climatology of average minimum, mean and maximum surface air temperature, and precipitation for Niger, 1991–2022

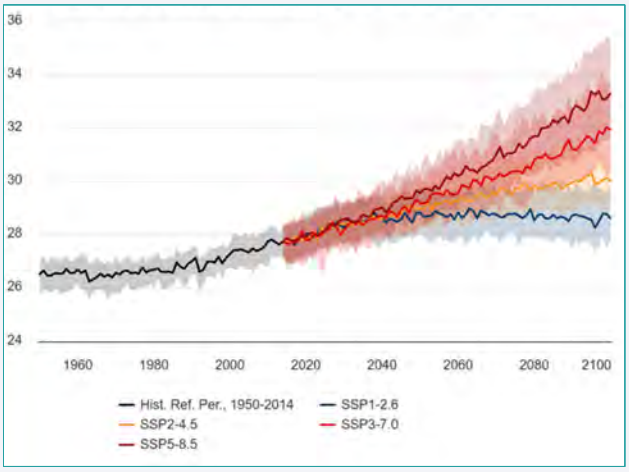


Source: World Bank (n.d.-b).

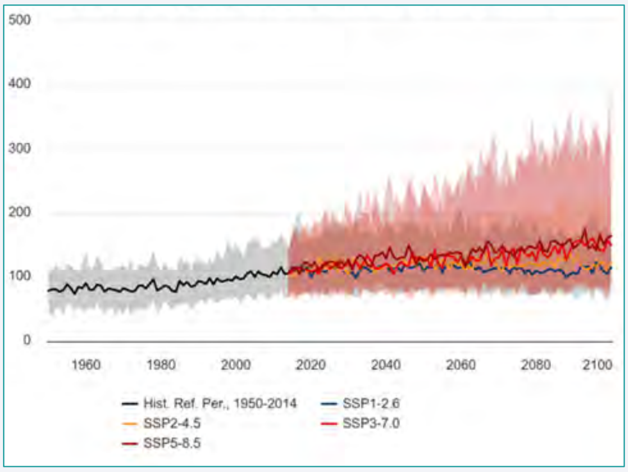
Precipitation trends are highly uncertain, with projections ranging from a slight decrease to a stronger increase in annual precipitation totals. Future dry and wet periods are likely to be more extreme. Depending on the scenario, temperatures in Niger are projected to rise by between 0.8°C and 4.0°C by 2080, and between 0.9°C and 5.5°C by 2100 compared to the current climate, with higher temperatures and more temperature extremes projected for the south-west of Niger. Heatwaves will become more frequent; they affected an average of 1.7 per cent of the population per year in 2000, which is projected to increase to 12 per cent in 2080. This translates into 50 more very hot days per year. Consequently, heat-related mortality will increase with an estimated factor of three by 2080 (Tomalka and others, n.d.; World Bank, n.d.-a; see figure 5).

Figure 5: Trends and projections of global air temperature and precipitation according to the available General Circulation Models/Shared Socioeconomic Pathway scenarios

Projected average mean surface air temperature
(ref. period: 1995–2014), multimodal ensemble



Projected precipitation
(ref. period: 1995– 2014), multimodel ensemble



Note: Climate projection data is modelled data from the global climate model compilations of the Coupled Model Intercomparison Project (CMIP), overseen by the World Climate Research Program. The CMIPs form the data foundation of the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports. Data presented are CMIP6, derived from the sixth phase of the CMIPs. CMIP6 supports the IPCC's Sixth Assessment Report (World Bank, n.d.-c).

Agroecological zones might shift, affecting ecosystems, biodiversity and crop production. Models project regionally varying changes in species richness and tree cover in response to climate change (Tomalka and others, n.d.).

Climate data for flood and drought risk profiling

Historical climate data

The meteorological data set used for the simulation of basins' responses in the present climate (historical period) is composed of the W5E5 climate data of precipitation, air temperature, air humidity, wind velocity and solar radiation. W5E5 is a merged data set (Potsdam Institute for Climate Impact Research, 2019). It combines WFDE5 data over land with ERA5 data over the ocean. The WFDE5 data set has been generated using the WATCH Forcing Data methodology applied to surface meteorological variables from the ERA5 reanalysis. Bias-adjusted monthly precipitation totals of WFDE5 result in more plausible global hydrological water balance components, as analysed in an uncalibrated hydrological model (WaterGAP), than use of raw ERA5 data for model forcing.

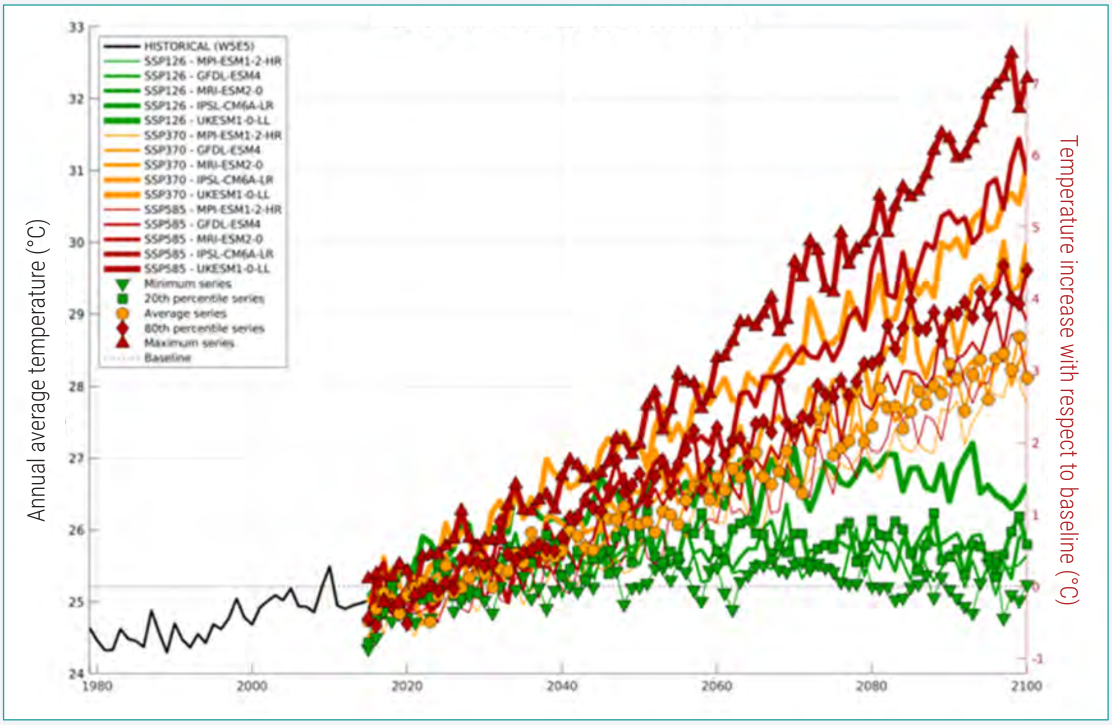
Future climate data scenarios

For the future climate, the ISIMIP3b data set[2] has been selected as state-of-the-art climate projection. Different General Circulation Models (GCM) are available for different Shared Socioeconomic Pathway (SSP) scenarios, namely constituting an ensemble of 15 combinations of models and scenarios (five GCMs available for each of three SSP scenarios). Figure 6 shows all these SSP/model combinations in terms of continental average air temperature trends, including the historical period represented by the W5E5 data set.

2 See https://www.isimip.org/about/#simulation-rounds.

Figure 6: Statistical analysis of the continental air temperature trends according to the available General Circulation Models/Shared Socioeconomic Pathway scenario combinations

Africa – ISIMIP3b land temperature scenarios



Source: The Inter-Sectoral Impact Model Intercomparison Project.

The variability of the temperature change among the different models/scenarios is very large, thus, to reach a compromise between a proper representation of this variability and the available computational resources, a selection was made. The intent of the probabilistic risk model is to provide realistic bounds to the risk figures in Niger. The uncertainty in future climate projections can be attributed both to the biases introduced by the projections of the numerical model used, and our inability to predict future scenarios of greenhouse gas emissions connected to specific socioeconomic development pathways. From the risk assessment perspective, both sources of uncertainty should be considered, and selection of bounding climate scenarios should be independent from the modelling suite and SSP considered.

To preselect the runs used in risk computations, a combined analysis at the continental scale of the temperature and the precipitation trends has been performed to identify which runs can produce the maximum variation of the risk figures for the different hazards. Two scenarios were chosen, adopting as criterion a statistical selection based on the percentiles of the ensemble of temperature trajectories (precipitation trends are perfectly correlated with temperature trends for all the models and SSPs). For each year of the future projection period (2017–2100), the twentieth and eightieth percentiles of the ensemble of average continental temperature on land were computed, yielding two additional temperature trajectories produced as the 20-percentile and 80-percentile ensemble mean. Then, the most similar simulation, among the model runs available, was selected for each of the two percentiles. These two combinations of GCM/SSP were used to characterize the climate change variability without having to deal with the whole ensemble. The selected simulations were SSP1-RCP2.6/IPSL-CM6A-LR for the twentieth percentile (lower boundary, optimistic scenario) and SSP5-RCP8.5/IPSL-CM6A-LR for the eightieth percentile (higher boundary, pessimistic scenario).

Floods risk analysis

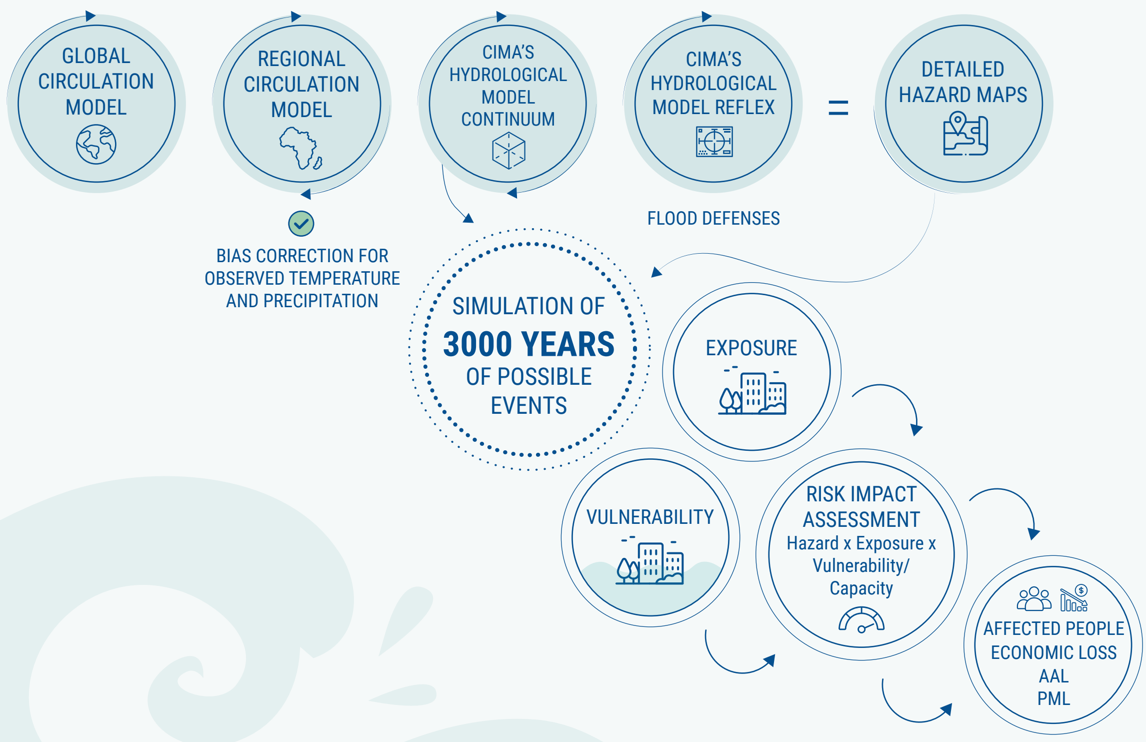
Probabilistic disaster risk profiles consider all possible loss/impact scenarios in a certain geographical area. This means that both low-frequency, high-impact events and high-frequency, low-impact events are included in the calculation.

The flood risk assessment aims to understand the probability that damaging floods of different magnitudes will occur over an extended period. These estimates can be calculated both for current and projected climate conditions, resulting in detailed hazard maps, to be then combined with the reproduction of past event patterns and the modelling of projected future events. Information on the performance capacity of flood protection measures is also added to the analysis. This workflow allows for estimation of the "expected" water depth for a certain location and/or individual infrastructures, for a set of reference scenarios. After this step, the frequency distribution of events and the consequent damage to exposed assets can be explored, considering their different levels of vulnerability (UNDRR, 2019).

Flood risk results are calculated in terms of annual average loss (AAL) and probable maximum loss (PML) curves for several indicators at different spatial levels of aggregation, national and subnational (administrative level 1), and under current and projected climate conditions (SSP1-RCP2.6 and SSP5-RCP8.5).

In particular, the AAL is the expected loss per year, averaged over many years. While there may be little or no loss over a short period of time, the AAL also accounts for much larger losses that occur less frequently. The AAL can represent the funds required annually to cumulatively cover the average disaster loss over time. The PML curve shows the likelihood of a certain scenario producing an estimated number of losses. It is expressed in terms of annual probability of exceedance or its reciprocal, the return period. The PML is relevant to define the size of reserves that should be available to insurance companies or governments to manage losses.

Figure 7: Flood risk assessment process



Flood hazard assessment

The hazard assessment activity consisted in recalibration of the distributed hydrological model Continuum (Silvestro and others, 2013) on a portion of the Niger River Basin, based on the observed discharge time series extracted from the African Database of Hydrometric Indices (ADHI, see Tramblay and others [2021]) and the Global Runoff Data Centre database (Global Runoff Data Centre, 2020). The two databases provide about 20 time series of flow values in different periods in the interval 1979–2016 in different tributaries of the Niger River that fall inside Niger's national territory. The calibration procedure was carried out by applying a cost function that minimizes the difference between observed discharge flows and simulated ones. Once the calibration procedure was completed, long-period hydrological simulations were performed in three time series: the historical period 1979–2016, and the future climate change scenarios SSP1-RCP2.6 and SSP5-RCP8.5 from 2051 to 2100.

The simulations performed with the Continuum model provided flow time series for all the streams in the region of interest's river network, covering part of Niger's national territory. To characterize the hydrological extremes in both the present and future climates, a statistical analysis was performed on the modelled time series to extract flow quantiles for a given set of return periods: 2, 5, 10, 25, 50, 100, 200, 500 and 1,000 years.

These quantiles, computed for the whole river network of the area of interest, was then employed in the REFLEX flooding model to produce hazard maps providing water depths and flooded areas. These maps were then merged with the current available hazard maps of the Niger River's main branch, to produce a final product of flood hazard mapping for the whole Niger national territory.

Data collection

In this process, access to data is essential to achieve an accurate risk evaluation. Not only is it necessary to feed information to the modelling chain for identification of possible hazards in specific locations, such as historical series of observed temperature, rainfall and discharge volumes; it is also crucial to feed damage models with detailed data on population and assets' levels of exposure and vulnerability. Only with these data can we fully understand the economic, social and environmental impacts of possible past and future events.

The present risk profile considers five categories of potentially exposed values. Information about these values were collected by local institutions whenever available. Unfortunately, this process was not concluded in time for these data to be included in this profile. At this stage, only regional and global data sets were used.

Local data collected could be used in the future as substitutes, when local data are not available, or as data validators, to cross-check the consistency of different data sources. Local data collection has been carried out by the Abdou Moumouni University of Niamey.

POPULATION

Population estimates were obtained from global data sets (United Nations, Department of Economic and Social Affairs, Population Division, 2022), which provide spatial binary information (population/no-population at any point in space) or information on the relative distribution of population in a given area. This study considered population according to its density, i.e. the spatial distribution of the population across the country.

Projections for future population were produced starting from United Nations 2050 projections (United Nations, Department of Economic and Social Affairs, Population Division, 2022).

CRITICAL INFRASTRUCTURE

Critical infrastructure data refer to the description of the physical exposure in terms of spatial location of educational and health facilities, as well as the transport network. The main added value of this information lies in knowing the exact location of the infrastructure.

Critical infrastructure layers are derived from global data sets (OpenStreetMap) for a uniform representation of the spatial locations of critical infrastructure in the whole country.

BUILT-UP AREA

Information on the built-up area refers to two main aspects: the description of the physical exposure of buildings, in terms of their economic value and their spatial location inside or outside flood-prone areas; and the elements that might influence a building's vulnerability, such as its occupancy characteristics, existence of basements, and typology of constructive materials.

The built-up data prepared for the present risk profile were obtained from the exposure data set used in the Global Assessment Report, updated by UNEP-GRID (Piller, Benvenuti and De Bono, 2023). They have been divided into three sector classes, according to the exposure categories reported in the Sendai Framework indicators:

- Housing sector distribution
- Service sector distribution
- Industrial sector distribution

The spatial resolution of this information has been improved through a downscaling procedure, guaranteeing coherence among the distributions of population and residential areas.

CROPLAND RANGELAND

Cropland and rangeland maps are derived from ASAP cropland and rangeland masks (Anomaly Hotspots of Agricultural Production Version 03, Joint Research Centre). Each pixel represents the crop and rangeland area in square metres.

Flood results

There are two major river basins in Niger: the watershed of eastern Niger, dominated by the Lake Chad and Komadougou Yobe Basins; and the watershed of western Niger, dominated by the Niger River and its tributaries. Most surface run-off (90 per cent) is in the Niger River and its tributaries from the right bank. The Niger River floods every year, starting in September, peaking in November and ending in May. The eastern part of Niger is part of the Chad Basin. This basin consists of deserts and savannahs with very limited rainfall.

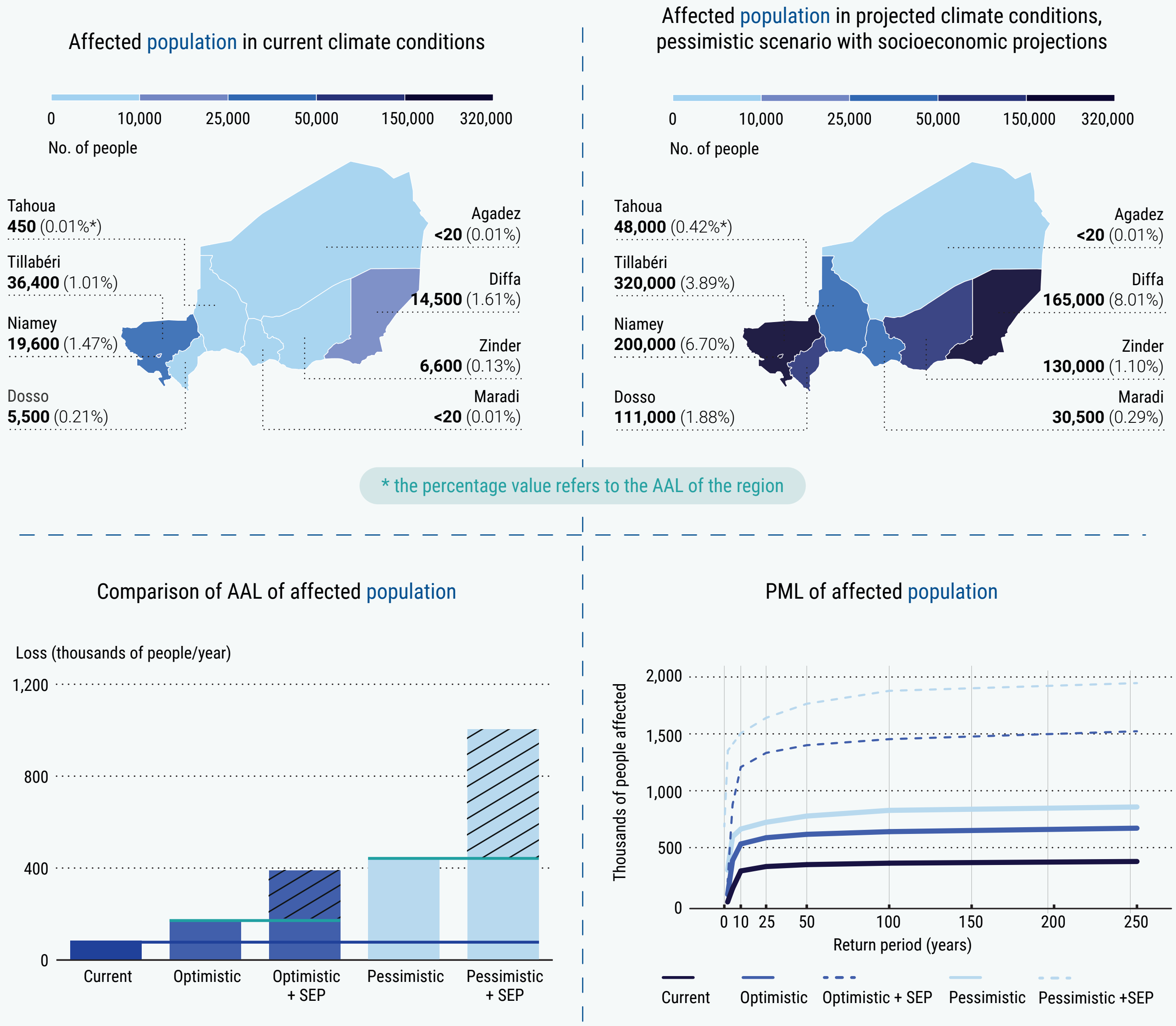
The southern part of Niger is most affected by floods. The highest-risk areas have been identified along the border with Nigeria and Chad. The land along the Niger River and its tributaries is particularly prone to flooding.

The western part of Niger belongs to the Niger River Basin. This area covers about one third of the country's surface. About 40 per cent of the population lives within this basin.

Population

Considering population growth, the average yearly number of people affected by floods at the national level grows from almost 83,000 under current climate conditions to more than 171,000 under projected climate conditions SSP1-RCP2.6 (optimistic scenario) without considering socioeconomic projections (SEP), and up to 390,000 considering SEP. Under projected climate conditions SSP5-RCP8.5 (pessimistic scenario) the average number of people affected on a yearly basis grows from almost 442,000, without considering SEP, to 1 million, considering SEP.

Figure 8: Affected population in current and projected climate conditions



Analysis of the PML curves shows that a 10-year return period loss corresponds, under current climate conditions, with 294,000 people affected (which is about four times the annual average affected population); this figure could increase by more than four under projected climate conditions SSP1-RCP2.6 and SEP, and reach up to 1.5 million under projected climate conditions SSP5-RCP8.5 and SEP.

Impacts of floods on the population under current climate conditions are concentrated mainly where the Niger River crosses Niamey. The highest average numbers of people annually affected are mainly in the Tillabéri Region, where figures exceed 35,000 people affected under current climate conditions and 318,000 under projected climate conditions SSP5-RCP8.5 & SEP.

The two maps in figure 8 show that the south-eastern and south-western parts of Niger have the highest values of AAL: particularly in the pessimistic scenario with SEP, Niamey and Diffa have an AAL that exceeds 5 per cent of the regional population.

Built-up area

The AAL suffered by the built-up area due to floods at the national level is estimated at almost $90 million under current climate conditions, growing to around $200 million under projected climate conditions SSP1-RCP2.6, and up to $500 million under projected climate conditions SSP5-RCP8.5.

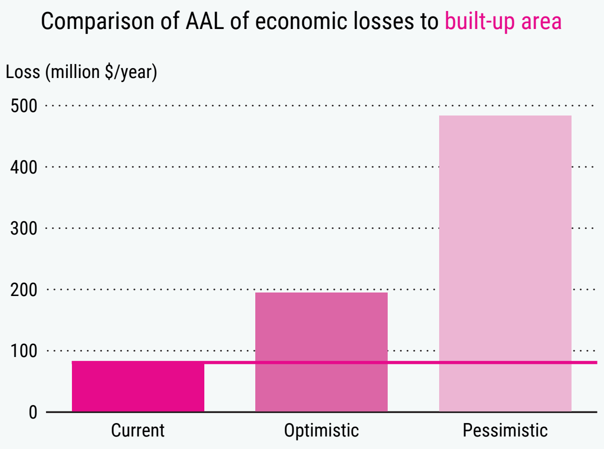
Analysis of the PML curves shows that a 10-year return period loss could result in $300 million of losses under current climate conditions. For the same return period, under projected climate conditions SSP5-RCP8.5, the losses are more than double (around $800 million).

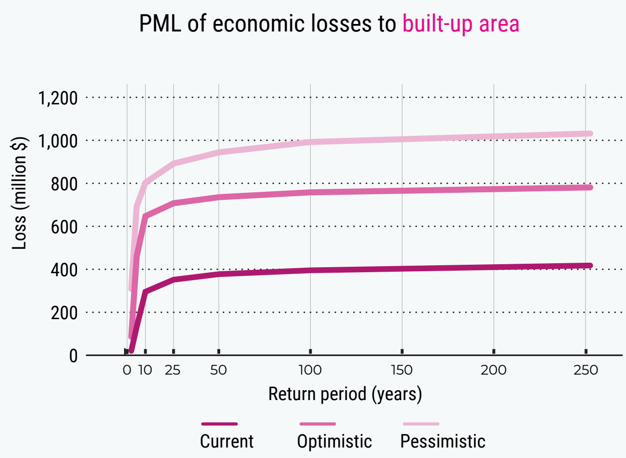
The residential sector appears the most affected (78 per cent), followed by the service sector (17 per cent) and the industrial sector (only 5 per cent). This is also due to the relative contribution of each sector to the total exposure.

As shown on the two maps in figure 10 , the most affected regions are Niamey and Tillabéri, which are the most built-up. Under current climate conditions, Tillabéri has more than $30 million of losses in the built-up sector. This value is $155 million for the pessimistic future climate scenario. In percentage value, the most affected region is Diffa, where, for the actual condition, it reaches more than 1 per cent (for $15 million of losses), increasing to almost 7 per cent for the pessimistic future climate scenario (for $85 million of losses). However, the Agadez Region has less than $5 million of losses in built-up areas for both scenarios.

Photo credit: 'Niamey, Niger' by abdallahh is licensed under CC BY 2.0 on Flickr.

Figure 9: Comparison of AAL of economic losses to built-up area





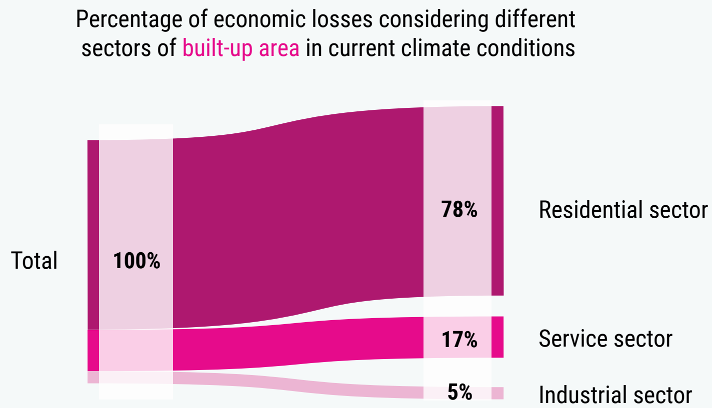
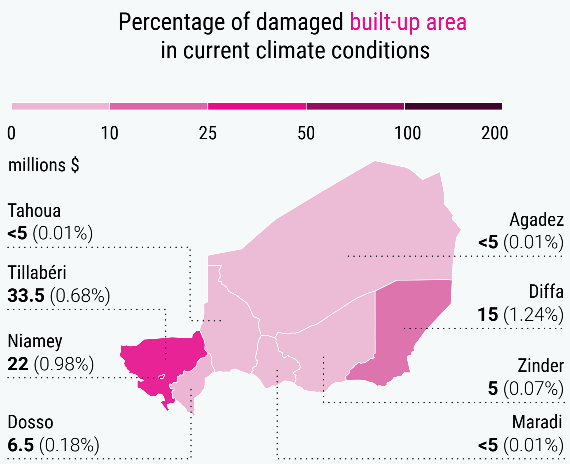
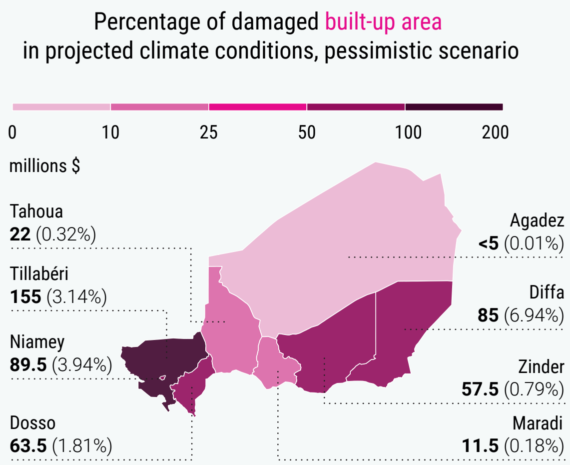


Figure 10: Percentage of damaged built-up areas in current and pessimistic scenarios





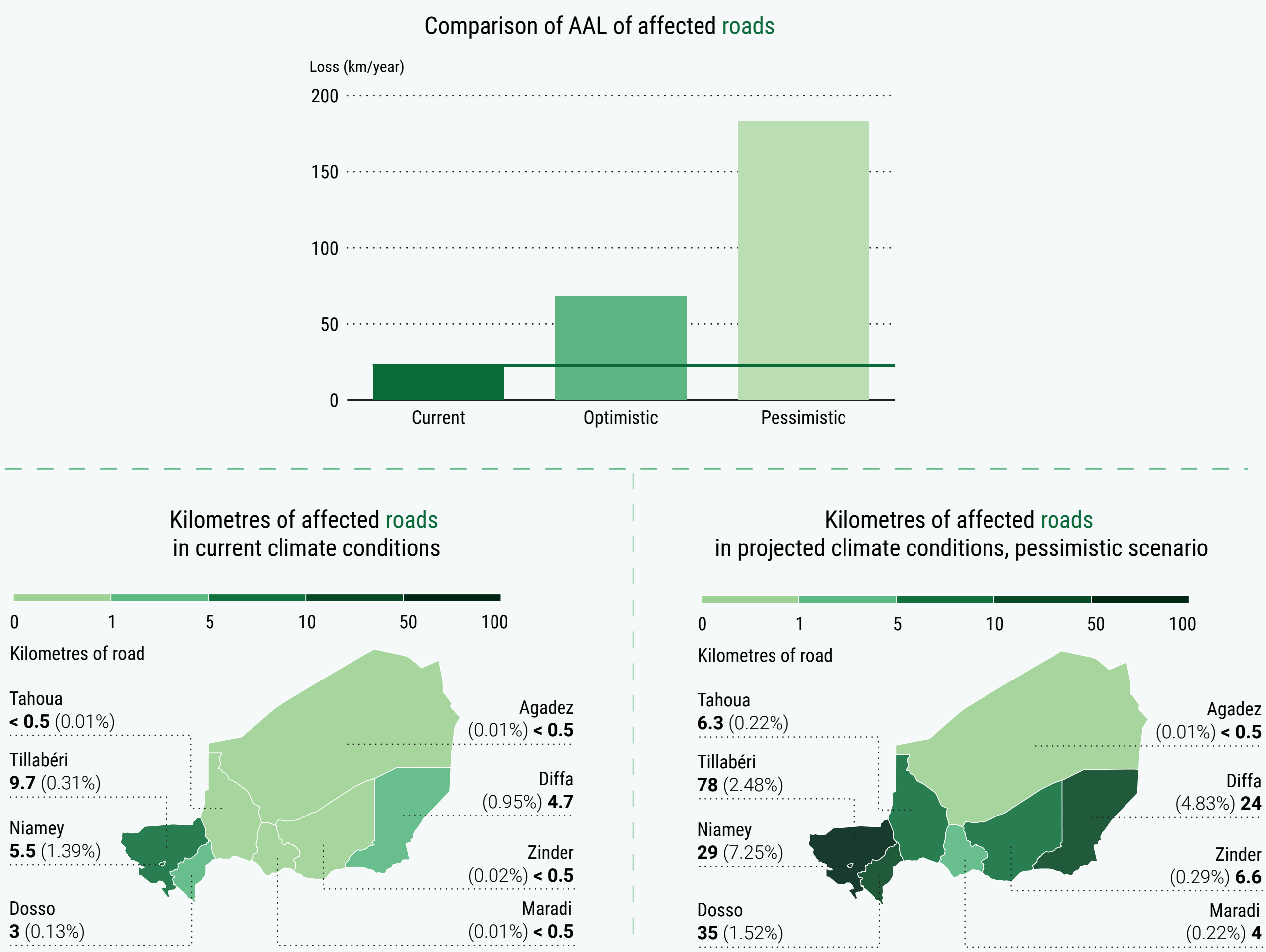
Critical infrastructure

As the national road network is 21,240 km long in total (INS, 2020), the AAL for the current climate conditions is close to 25 km/year. Under projected climate conditions SSP1-RCP2.6, this value increases by three to around 75 km/year, and up to 180 km/year under scenario SSP5-RCP8.5.

As shown by the two maps in figure 11 , the most affected region is Tillabéri. Considering its proximity to the capital city, the exposed elements are relevant, and the affected kilometres of roads increase from 9.7 km to 78 km.

A similar variation trend is seen in the Diffa Region, where the kilometres of affected roads are five times higher under projected climate conditions: from 4.7 km under current climate conditions to 24 km under scenario SSP5-RCP8.5.

Figure 11: Comparison of AAL of affected roads



Cropland

Agriculture is the principal activity of rural populations and employs more than 80 per cent of the active population (Tomalka and others, n.d.). Under current climate conditions, 40,000 ha of cropland are affected each year on average. The increase in impact is rather limited for the projected climate conditions SSP1-RCP2.6 (55,000 ha/year of losses), but the AAL for the projected climate conditions SSP5-RCP8.5 is more than 200,000 ha/year.

Pearl millet appears to be the most affected crop type (56 per cent), followed by cow peas (25 per cent), sorghum (16 per cent) and groundnuts (3 per cent).

The potentially cultivable area is estimated at 15 million ha, representing less than 12 per cent of the country's total area (CNEDD, 2016). More than 60 per cent of the national cultivable area is exposed to flood risk and around 2 per cent of the cropland is affected annually under projected climate conditions SSP5-RCP8.5.

The most affected regions are Diffa and Zinder. In Diffa, the hectares of affected cropland increase by more than six: 17,500 in the SSP1-RCP2.6 scenario and 83,000 in the SSP5-RCP8.5 scenario (which is close to 17 per cent). For the Zinder Region, the increase is less significant, around 4.5 times.

Figure 12: Comparison of AAL of affected cropland

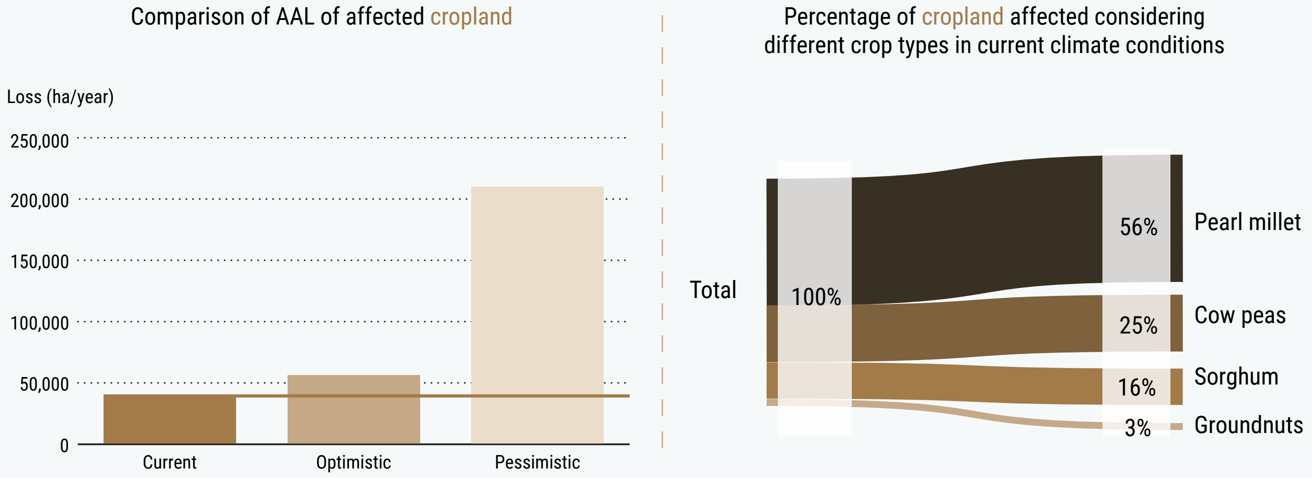
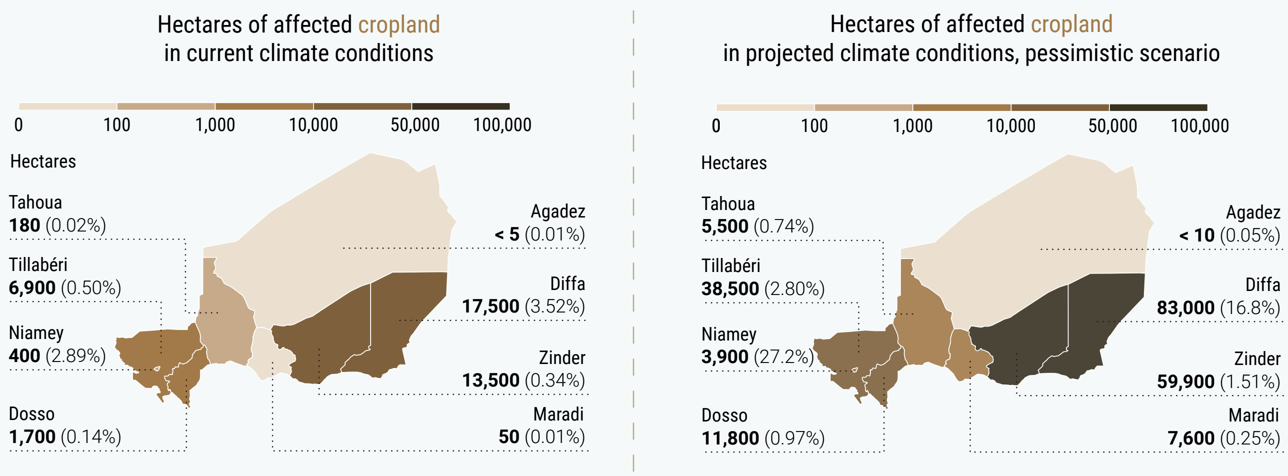


Figure 13: Hectares of affected cropland in current and pessimistic scenarios



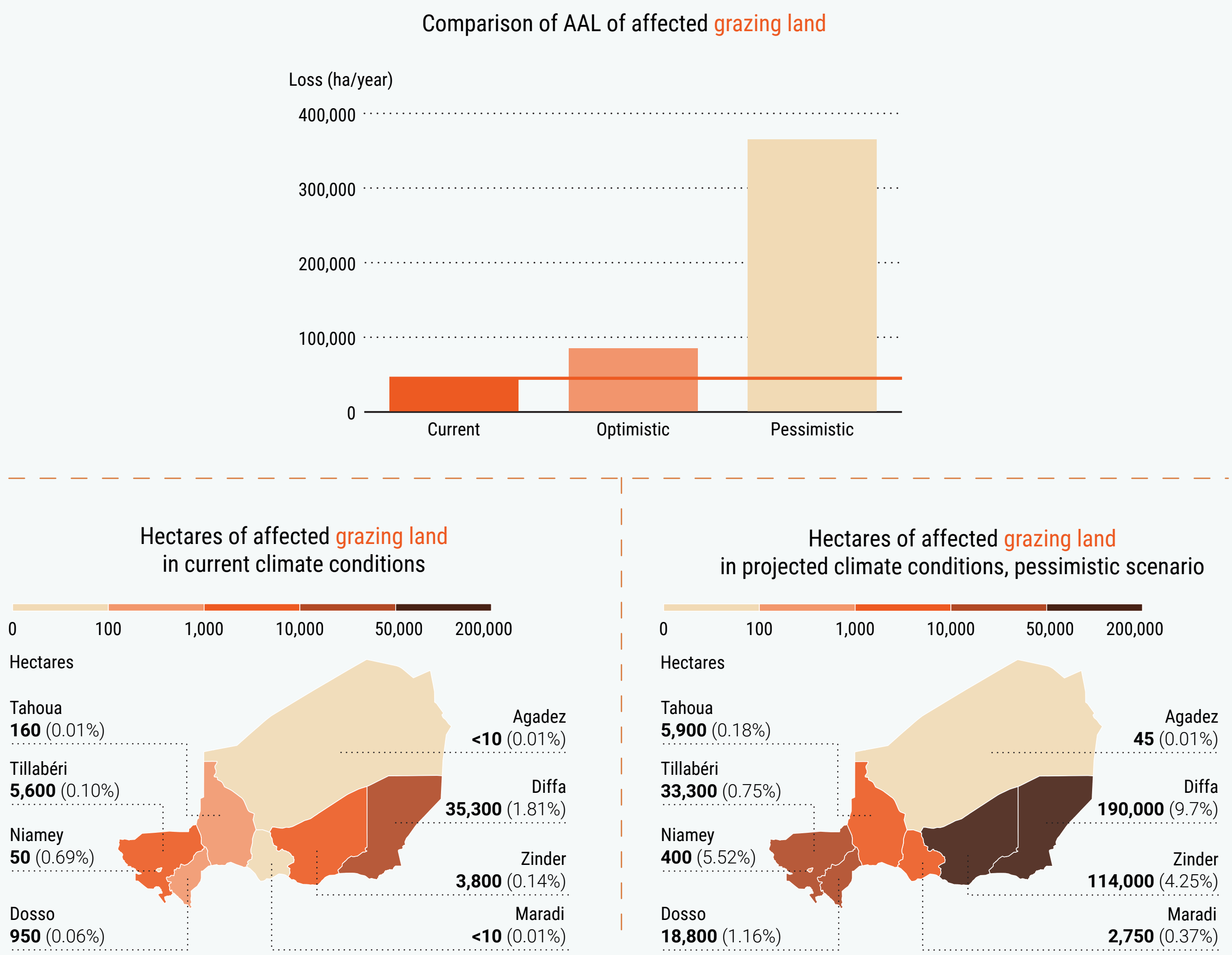
Grazing land

There are three types of farming systems in Niger. These are extensive, semi-intensive and intensive farming. The grazing area of the country covers approximately 62 million ha. Considering current climate conditions, on average 50,000 ha are affected every year.

The AAL doubles for the projected climate conditions SSP1-RCP2.6 (close to 100,000 ha/year of losses), but the growth of losses for the projected climate conditions SSP5-RCP8.5 reaches more than 350,000 ha/year.

The southern regions of the country have the highest values of affected grazing land, which is most evident for the pessimistic climate scenario. The most relevant increase is estimated for Zinder and Diffa. Diffa has around 190,000 affected hectares of grazing land, with a percentage value that increases from 0.14 per cent (current climate conditions) to 4.25 per cent (pessimistic scenario).

Figure 14: Comparison of AAL of affected grazing land

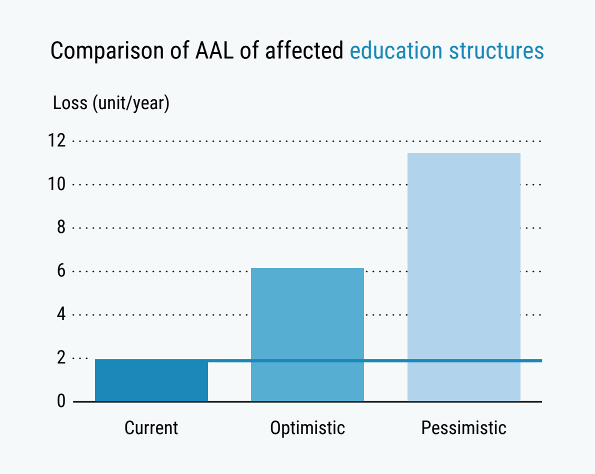


Education structures

The average number of education structures affected yearly by floods grows at the national level from two under the current climate conditions to more than six under projected climate conditions SSP1-RCP2.6, and up to almost 12 under projected climate conditions SSP5-RCP8.5.

In 2022, over 800 schools (particularly in Tillabéri) have been closed for safety reasons due to terrorist attacks (France24, 2022; Mustapha, 2022).

Figure 15: Comparison of AAL of affected education structures

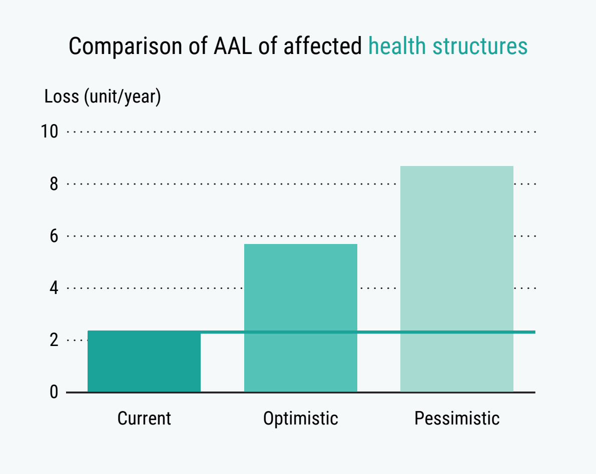


Health structures

In Niger, the health coverage rate increased from 47.48 per cent in 2011 to 48.47 per cent in 2015, with strong regional disparities (Niger, Ministry of Health, 2016). Floods tend to affect health structures, and risk computations estimate that, on average, two units per year are affected seriously by floods, further reducing the effectiveness of this critical service.

Projected climate conditions tend to exacerbate the impact of floods on health infrastructure, with loss reaching 6 units/year in SSP1-RCP2.6 and 8 units/year under climate conditions SSP5-RCP8.5

Figure 16: Comparison of AAL of affected health structures



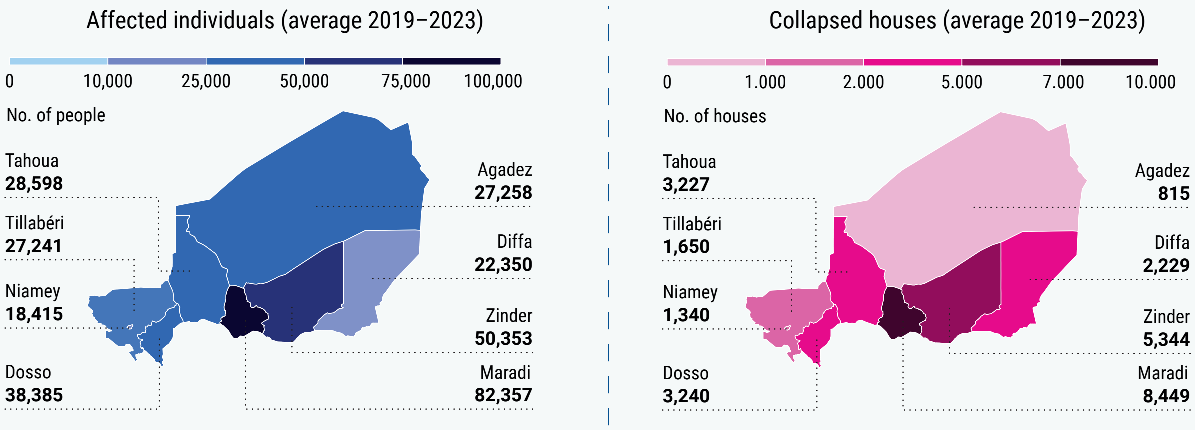
Damages data compared with profile results

In the project's final phase, flood damage data from World Food Programme Niger covering 2019–2023 was received and aggregated at the department level. These data were essential for comparison against the results of our project's profile analysis.

However, the data provided were not continuous over the five-year period for all categories considered. Consequently, parameters were prioritized demonstrating consistency across years and aligning with indicators presented in the profile.

After this selection process, analysis focused on "personnes sinistrées" (affected individuals) and "maisons effondrées" (collapsed houses), which are comparable to the profile's indicators of "people affected" and "built-up damaged".

Figure 17: Flood damage data 2019–2023



An alignment was shown in departments affected by large river basins; Niamey, Tillabéri and Diffa. These river systems were represented in the hydrologic model and provided sufficient hydrological data for specific calibration of modelling tools.

A discrepancy emerged in the Sokoto Basin, affecting the departments of Zinder and Maradi, where there was a clear underestimation of modelled flow rates and, consequently, hazard and risk figures. Several factors may contribute to this disparity.

First, the data collected in the field did not differentiate between flood types, encompassing impacts from riverine flooding, flash flooding, urban flooding and potentially localized ponding. In contrast, the profile predominantly focuses on riverine flooding from major river systems. This discrepancy is evident in Agadez, where the absence of rivers suggests that damage primarily arises from pluvial flooding, which is inadequately represented in the hazard modelling used.

Second, the collected damage data span a five-year period (2019–2023), not accounted for in modelling for the present climate. However, a discernible climatic trend is evident in the data, suggesting that this five-year period may already reflect part of this trend. When future climate model projections are compared to observations, the underestimations in the south-central part of Niger decrease, with a clear signal emerging in Zinder and Maradi, even in the modelled maps. These findings underscore the importance of considering both prospective model estimates and observed data when using profile information for strategic decision-making in disaster risk reduction domains.

In conclusion, it is recommended that decision makers in Niger's disaster risk reduction sector carefully consider both modelled projections and observed data to inform future policies. This holistic approach ensures a comprehensive understanding of flood risk dynamics and facilitates development of robust mitigation and adaptation strategies.

Drought risk analysis

Drought hazard assessment

Droughts are induced by periods of persistent low precipitation and increased evaporative demands (meteorological droughts). They propagate through the hydrological cycle, causing deficits in soil moisture (resulting in agricultural droughts), streamflow, water storage and groundwater (hydrological droughts) (Caretta and others, 2022). Socioeconomic droughts refer to negative impacts on society, such as the rise of food prices, food crises and public water supply shortages (Abdourahamane and others, 2022).

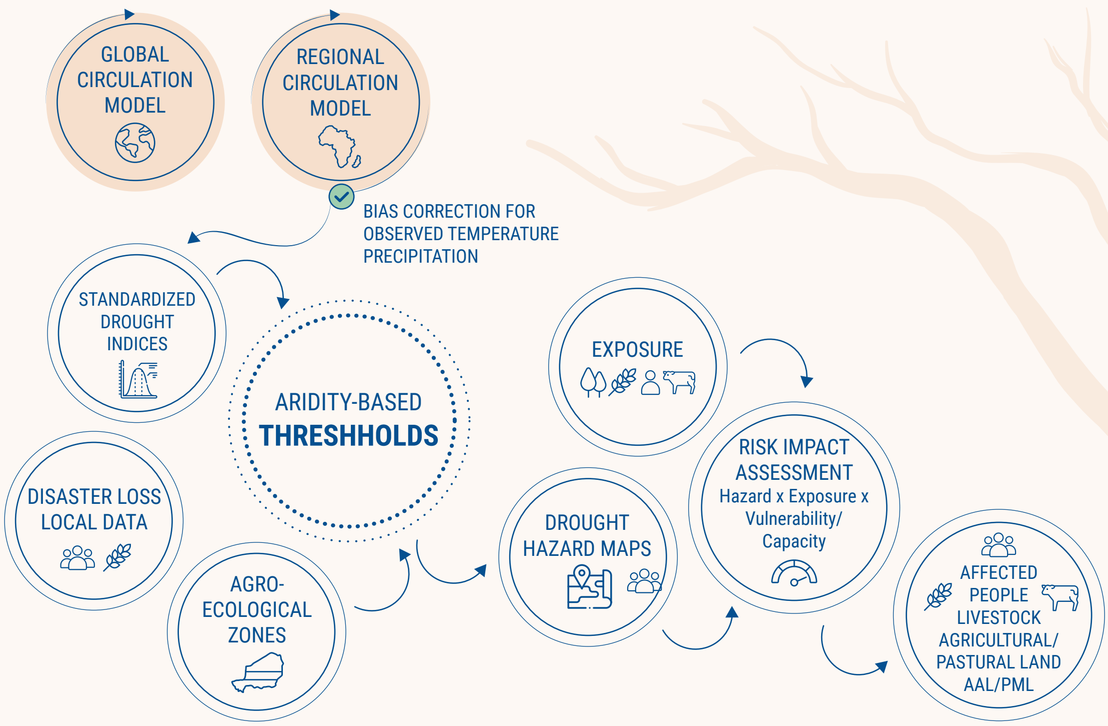
Soil moisture droughts induce plant stress and limit plant growth before leading to biomass reductions, crop damage and yield losses. The African Sahel is particularly vulnerable to this type of drought due to its high dependence on rain-fed agriculture and livestock raising (Abdourahamane and others, 2022). In the region, soil moisture droughts are a major threat to food production and food security. Ecological droughts further refer to the impact of limited precipitation and low flows on ecosystems (Sadiqi and others, 2022). Freshwater ecosystems are particularly vulnerable (Caretta and others, 2022). In Niger, this concerns numerous wetlands, including floodplains, ponds, lakes, oasis systems, the Dallols or basins. They are used for various activities, including agriculture, livestock raising and fishing, and are thus vital for poverty reduction and food security (United Nations Development Programme, Bureau for Crisis Prevention and Recovery, 2013). The societal impacts of hydrological droughts and low-flow periods spread throughout several sectors, including irrigated agriculture, energy production and overall water security (Carreta and others, 2022).

The drought risk assessment was based on five indices that cover major parts of the hydrological cycle in a standardized way: the Standardized Precipitation Index three-month average (SPI-3), the Standardized Evapotranspiration Index three-month average (SEI-3), the Standardized Precipitation Evapotranspiration Index three-month average (SPEI-3), the Standardized Streamflow Index three-month average (SSFI-3) and the Water Crowding Index (WCI). The standardized indices analysed for this profile were first fitted to the historical time series, then the same parameters were used to fit the indices for the future climate scenarios SSP1-RCP2.6 and SSP5-RCP8.5. This approach enabled comparison between the current and future drought conditions. The calculation of the indices was based on the cumulative amounts of the current and the two preceding months, e.g., the three-month cumulative SPEI-3 for June was composed of April, May and June. The analysis was limited to the relevant time periods of the season. This means that the SPI-3, SEI-3 and SPEI-3 were only calculated for the June–October rainy season and the SSFI-3 calculation was restricted to the critical April–June low-flow period. The WCI was calculated based on the annually available water (precipitation minus actual evapotranspiration) per person.

As a proxy for agricultural and hydrological droughts, the annual SPEI-3 and SSFI-3 indices were then used as a basis for the annual loss estimates. They were converted into binary drought maps based on an aridity-dependent threshold (relative to the average annual precipitation/potential evapotranspiration). The resulting threshold varied between -1.3 in the Sudanian part of the country and -0.8 in the Saharan part. The maps were then overlaid with land use, and gridded population and livestock data, to calculate annual drought losses. The aggregated losses at the national level were then used to extract return periods of 1, 2, 5, 10, 25, 50, 100, 250, 500 and 1,000 years. These return periods were smoothened using the “OneWay” spline.[3] The results were used to generate PML curves for each impact category (see figure 18).

3 The “OneWay” spline is a constrained version of the Bessel spline. It always produces monotic results, provided that the source data are monotonic (SRS1 Software, n.d.).

Figure 18: Drought risk assessment process



Data collection

Drought impact modelling uses spatially explicit data, preferably at resolutions of 0.1 degree or higher, to capture variations throughout the country. Data collected by national institutes are not usually spatially explicit, but presented at the regional or departmental level. These data are useful in assessing the quality of available spatially explicit global and regional hazard and exposure data sets. The national data guide the decision on selection of the input data sets when more than one data set per theme is available and inform the definition of vulnerability functions. They are also the reference used to cross-check different data sources' consistency.

For the drought hazard identification, historical series (1979–2016) and future scenarios (SSP1-RCP2.6 and SSP5-RCP8.5 from 2051 to 2100) of meteorological and hydrological data were used: rainfall, potential evapotranspiration, soil moisture and discharge volumes.[4] The damage models use exposure data on population, livestock and land cover (agricultural and pastoral areas).

This drought risk profile considers four defined drought types (meteorological, agricultural, hydrological and socioeconomic) expressed through four exposure categories (population, agricultural land, pastoral land and livestock). These exposure categories per drought type have been defined based on national stakeholders' input and data availability. Since assets such as built-up areas and critical infrastructure are more exposed to floods than droughts, they were not considered for drought risk modelling.

4 To align flood and drought risk modelling, the same dynamic input data have been used (W5E5 and ISIMIP3b data sets): precipitation, evapotranspiration, soil moisture and discharge. Data were preprocessed and provided by the CIMA Research Foundation to the African Risk Capacity Group at dekadal timestep and two arcminutes (~3.7 km) resolution.

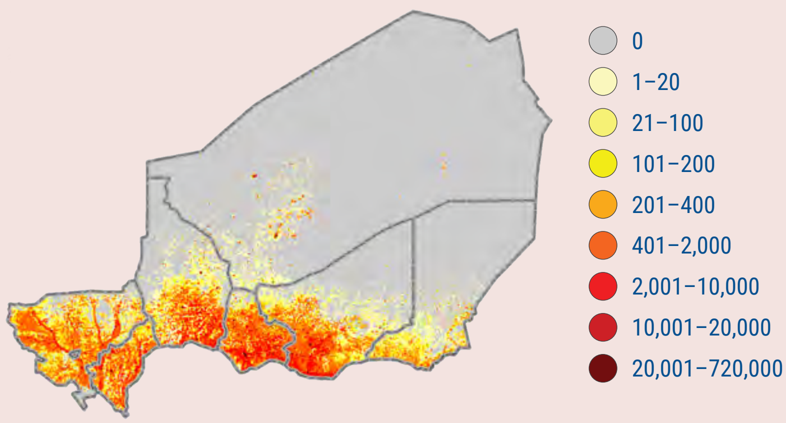
POPULATION

Population estimates were obtained from global data sets, which provide spatial information (population per given area) or information on the relative distribution of population in a given area. The following data sets were evaluated: WorldPop 2020, WorldPop GRID3 2021, Gridded Population of the World (GPWv4r11) 2020, LandScan Global 2022 (Oak Ridge National Laboratory, 2023) and the High Resolution Population Density Maps + Demographic Estimates (HRSL) 2020. Comparison with national census data from INS (2023b) showed that, at the regional level, the LandScan data set correlates best with national census data from 2022 (99.98 per cent), with the lowest mean absolute error (29, 911) and mean absolute percentage error (1.88 per cent) of all evaluated population data sets.

The LandScan data set is available at 30 arcseconds (~1 km) resolution, and cell values represent the estimated population count for each cell. The LandScan data are aligned with the dynamic input data but have a higher resolution, so aggregation is required to match the dynamic input data's alignment and resolution.

The LandScan data were clipped to the dynamic input data, then aggregated with a factor of four to match the dynamic input data's resolution (see figure 19). In this step, population counts were summed up so that population totals remained comparable with national census counts.

Figure 19: LandScan Global 2022 (aggregated)



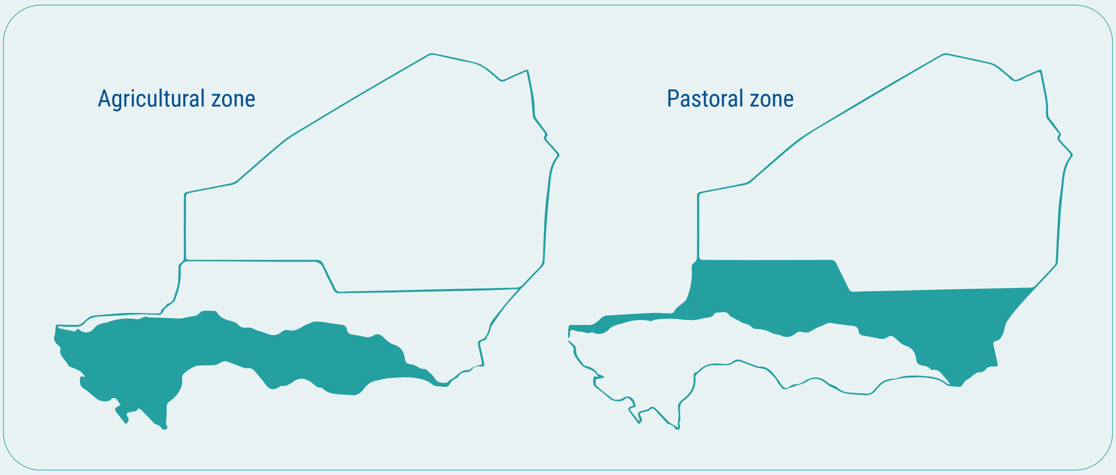
Population growth for future scenarios was determined by combining the updated population projections for 2050 for the SSP2 of the Wittgenstein Centre from 2023 (Wittgenstein Centre, 2023) with LandScan 2022. This resulted in a population growth factor of 2.59 per cent.

The extreme poverty rate of 42.1 per cent was retrieved from national EHCVM II 2021/22 data (INS, 2023b).

AGRICULTURAL AND PASTORAL ZONES

Agricultural and pastoral zones were derived from the agroecological zoning definition used by stakeholders in the country (see figure 20). The shape file was used to assign each pixel to either the agricultural or the pastoral zone.

Figure 20: Agroecological zoning definition



Akasso Folako in Bagaroua Commune, Tahoua Region
Photo credits: Mamoudou Garba

LIVESTOCK

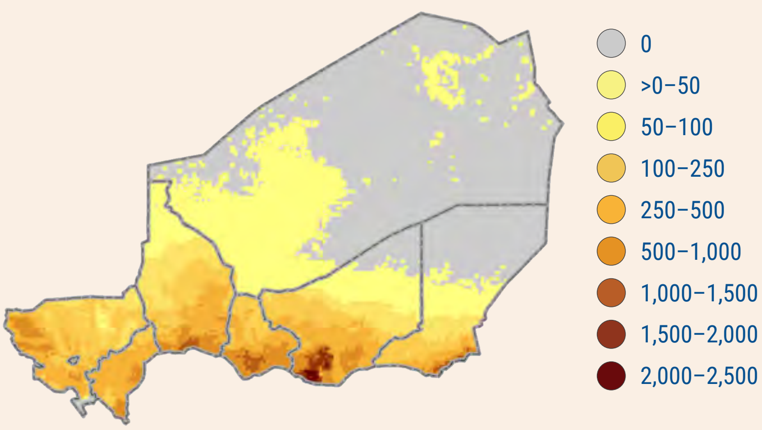
Livestock figures were obtained from the Gridded Livestock of the World database (GLW v4; reference year 2015; [Food and Agriculture Organization of the United Nations [FAO] and Université Libre de Bruxelles, 2022]), which contains gridded livestock densities at 5 arcminutes (~10 km) resolution for the following species: cattle, buffaloes, horses, pigs, sheep, goats, chicken and ducks. Although the GLW data set is updated every five years, no 2020 data set was available at the time of analysis. The data layer for buffaloes contained no data for Niger and was excluded from further analysis.

The layers contain the density of animals per pixel, with weight estimated by the dasymetric method, which provides an estimate of how livestock species may be distributed within census areas. It assigns different weights to different pixels based on high-resolution environmental predictor variables and random forest models. Animal census counts are distributed according to these weights.

The GLW data layers were clipped to the dynamic input data, converted into Livestock Units (LSUs) using FAO conversion factors for Africa south of the Sahara (FAO, 2023) and summed up to obtain the total LSU per pixel. Since both the cell size of the LSU layer is coarser than the dynamic input data, and alignment changes, an intermediate step of conversion using fishnet polygons with sizes of the LSU and dynamic input data was used. This allowed the downscaling of LSU values relative to their proportional area. The resulting shape file was converted to raster data for further applications (see figure 21).

Comparison with national data from the Ministry of Livestock, Fisheries and Animal Industries showed that the LSU figures can be compared best with national livestock and poultry figures from 2011. Total LSU counts remain comparable with national census counts after downscaling.

Figure 21: Gridded Livestock of the World, 2015 (Livestock Units; aggregated)



Source: Projected livestock numbers under different future scenarios were derived from growth rates from INS (2020).

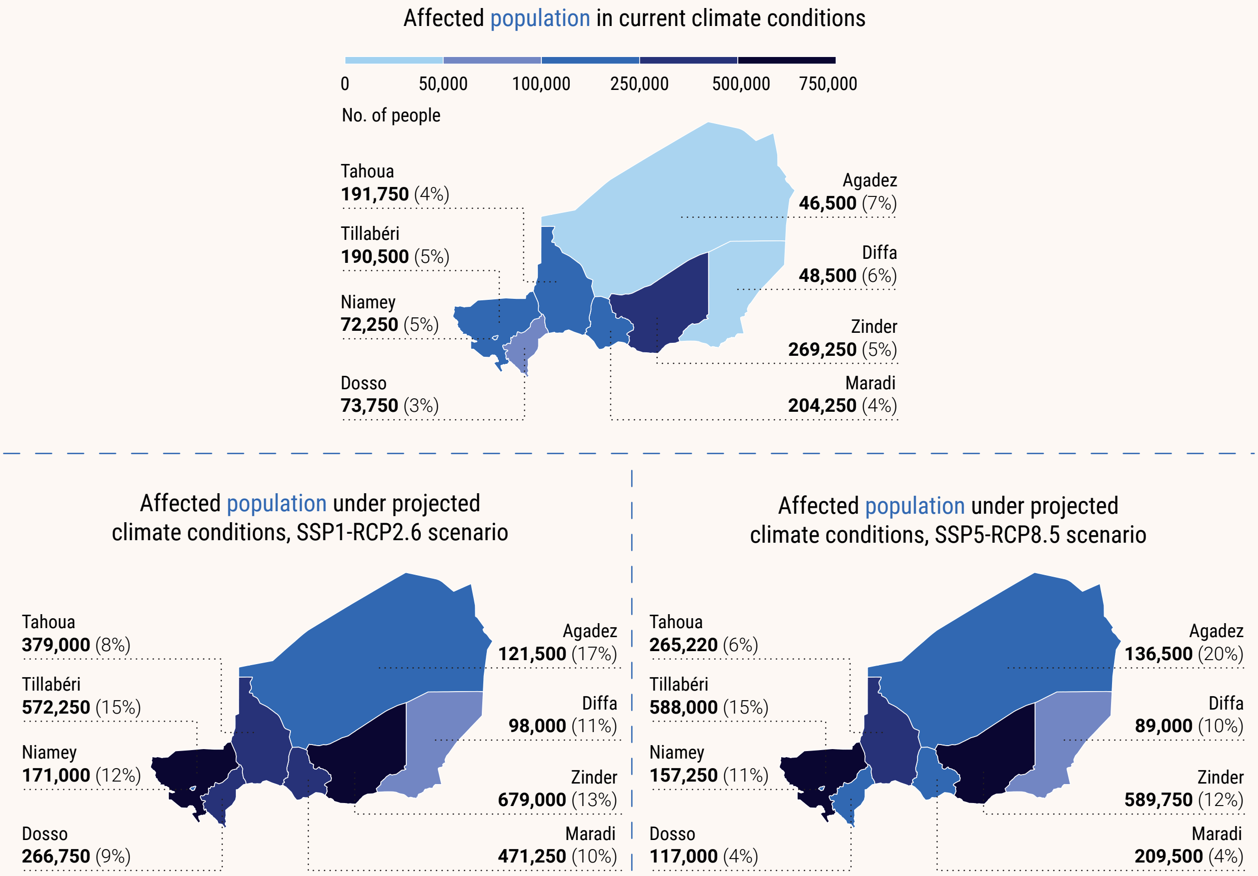
Drought results

Population

The population of Niger is currently 25 million (INS, 2023b). According to the updated population projections for the SSP2 of the Wittgenstein Centre from 2023 (Wittgenstein Centre, 2023), it will reach 63.82 million in 2050. With 6.2 births per woman according to ENAFEME 2021 (INS and Utica International, 2022), Niger has one of the world's highest fertility rates and one of the world's fastest-growing populations. This rapid population growth caused the doubling of cultivated land from 1975 to 2013 and contributes to significant levels of environmental degradation (World Bank, 2023). Population density varies throughout the country; the highest density is in the fertile areas of the south, in major river valleys, including the capital, Niamey, and the Dallols. Due to high poverty levels, reaching 42.1 per cent according to EHCVM II 2021/22 (INS 2023f), the population is extremely vulnerable to climate shocks, including droughts.

Agricultural droughts frequently lead to increased food insecurity, particularly among the poor. Under current climate conditions, results show that 1.12 million people living below the poverty line are affected by drought each year on average. This is approximately 4.46 per cent of the population. The historic baseline scenario has the highest absolute number of affected people in the Zinder Region, as shown in the top map in figure 22. Using the same population numbers and poverty rates, both future scenarios show an increase in people affected throughout the country, with the highest absolute number of affected people in Zinder and Tillabéri (SSP1-RCP2.6 in the middle map and SSP5-RCP8.5 in the bottom map in figure 22).

Figure 22: Number of poor people affected by agricultural droughts using constant population figures and poverty rate

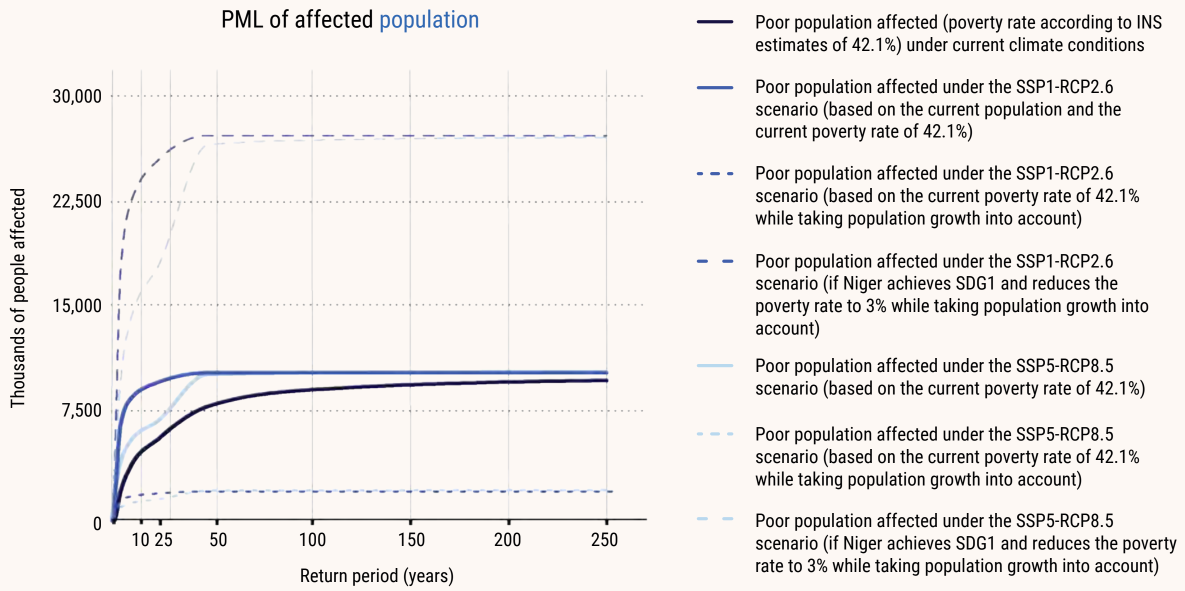


The number of poor people affected by droughts in the future will depend on the country's socioeconomic development and continued population growth. From 2005 to 2021, for instance, the actual number of poor Nigeriens increased despite the national poverty rate's reduction from 62.1 per cent in 2005 to 41.2 per cent in 2021 (INS, 2023f). Under the SSP1-RCP2.6 scenario, with a stable poverty rate of 41.2 per cent and a projected population of 63.82 million in 2050, the number of poor Nigeriens affected by drought will reach 7.22 million per year (11.32 per cent of the population). Under SSP5-RCP8.5, this number will reach 5.56 million annually (8.71 per cent of the projected population).

Poverty projections by the Center for Global Development for low-income countries for 2050 range from 26.10 per cent to 1.09 per cent (Kenny and Gehan, 2023). If Niger succeeds in ending poverty (i.e. no more than 3 per cent people are poor, which is within the poverty projections from Kenny and Gehan [2023] by 2050 [Sustainable Development Goal [SDG] 1]), the average annual number of drought-affected people will decrease to 514,811 (SSP1-RCP2.6) and 396,292 (SSP5-RCP8.5).

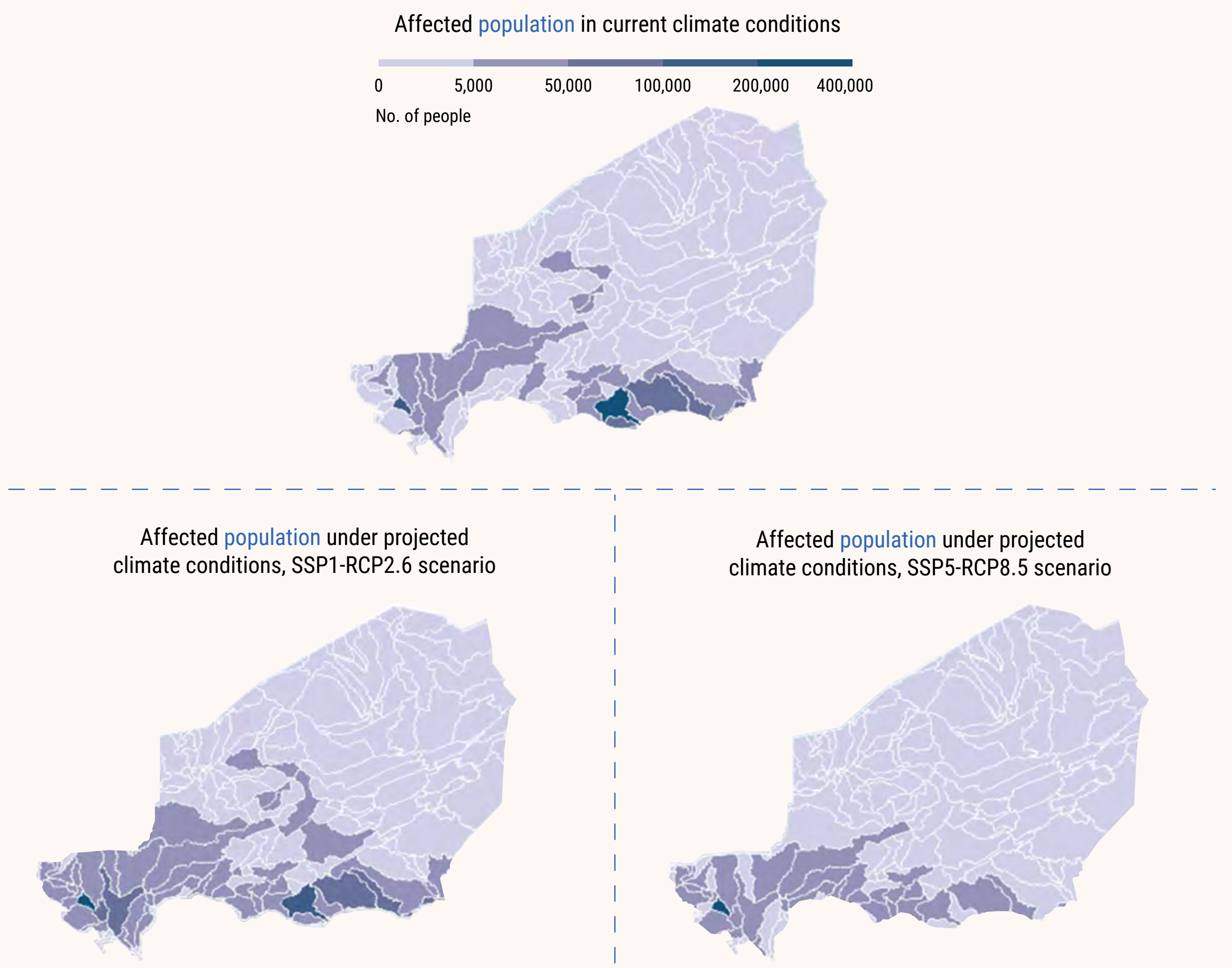
The PML curves (see figure 23) show that under the future scenarios, keeping the population and poverty rates as of today (solid lines), exposure to drought increases. As a long-term average, 3.71 million people living below the poverty line, for instance, are affected once every 10 years under the current climate. This number increases to 8.45 million under the SSP1-RCP2.6 scenario and to 5.32 million under the SSP5-RCP8.5 scenario. Taking population growth into account, the expected losses increase further (dotted line) to 21.96 million and 13.82 million poor people affected, respectively. If Niger reaches SDG1 by 2050, and using a poverty rate of 3 per cent, the expected maximum loss will not exceed 3.75 million and 1.91 million people living below the poverty line, respectively. This shows that population growth and the high poverty rate are the main drivers of change in the number of affected people.

Figure 23: Probable maximum loss curves of affected poor population by agricultural droughts



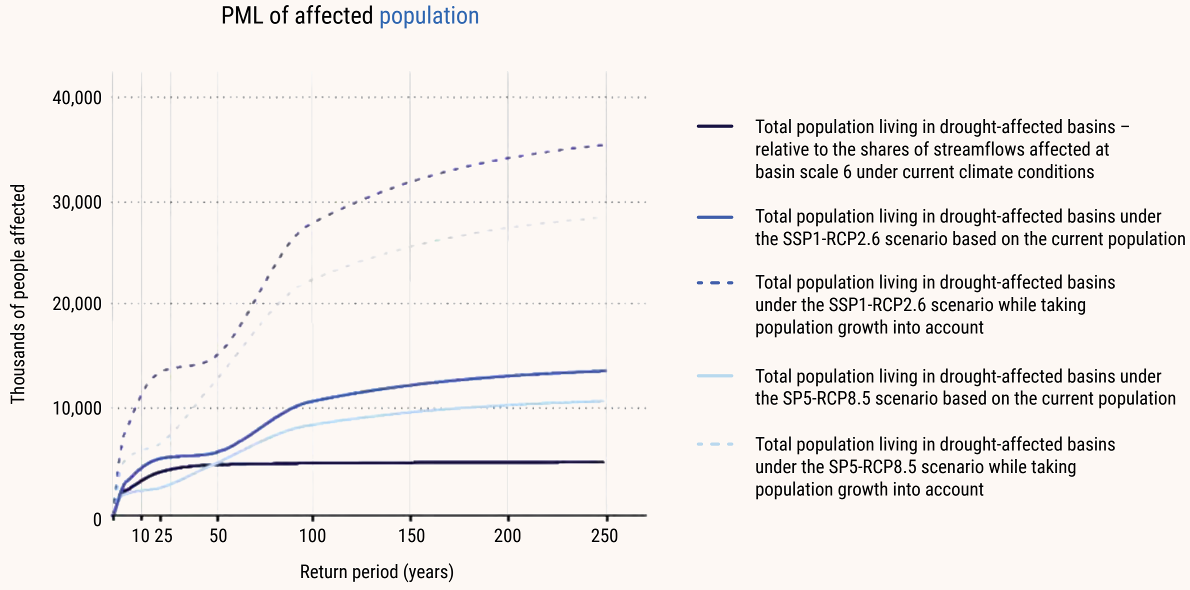
Hydrological droughts within the February–June low-flow period are critical. Impacted assets include irrigated agriculture, pastoral activities and the public water supply. Under current climate conditions, 1.16 million people on average are affected by hydrological droughts per year, with the highest absolute numbers around Niamey and in the south-west of Zinder (see the top map in figure 24). This number will increase to 1.5 million under SSP1-RCP2.6 scenario and to 3.9 million when considering the expected population growth, with increased numbers throughout the country, but especially in all southern basins (see the middle map in figure 24). Under the SSP5-RCP8.5 scenario, hydrological droughts will decrease due to the higher amounts of rainfall projected for this scenario. Assuming a stable population, the annual number of affected people will then decrease to 819,607. Considering the expected population growth, the number of people affected will increase to 2.13 million. The watersheds in the south-east show a reduced number of people affected under the SSP5-RCP8.5 scenario (see the bottom map in figure 24).

Figure 24: Total number of people affected by hydrological droughts using constant population figures



The PML curves in figure 25 show that, compared to the historical scenario and keeping the population as of today (solid lines), more people are exposed to drought under the SSP1-RCP2.6 scenario. Under the SSP5-RCP8.5 scenario, less people are exposed for return periods of up to 52 years, but more are affected beyond return periods of 1 in 53 years. Increasing return periods also increases the number of people affected: in future scenarios, this is more than double that of the historical scenario, with the SSP1-RCP2.6 scenario reaching the highest numbers of people affected for similar return periods. The expected loss for a return period of 100 years is 5.03 million people under the current scenario and 10.69 million and 8.60 million people for the future scenarios SSP1-RCP2.6 and SSP5-RCP8.5, respectively.

Figure 25: Probable maximum loss curves of affected population by hydrological droughts

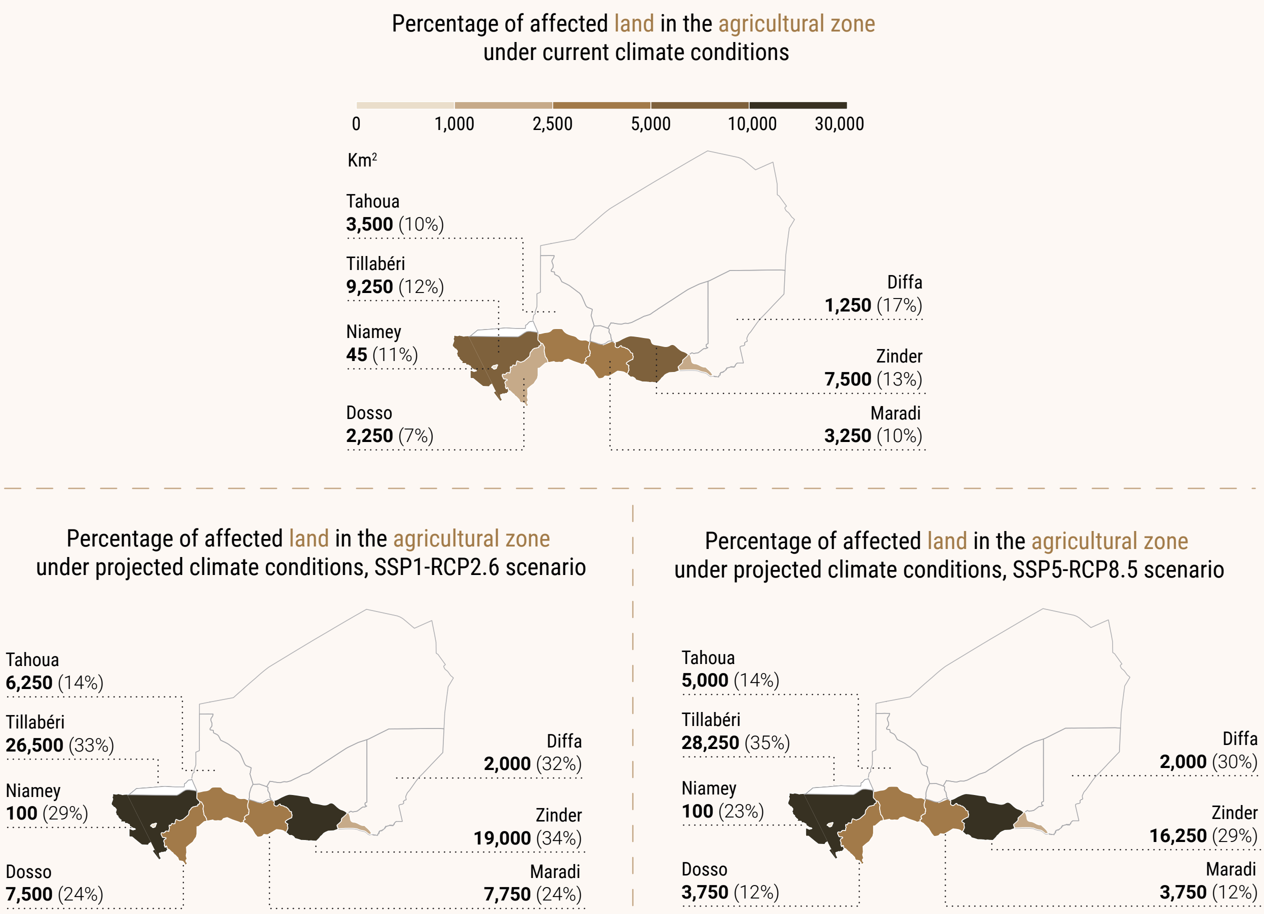


Agriculture

Agriculture in Niger is predominantly rain-fed, with millet, sorghum and cow peas being the most important rain-fed crops (CNEDD, 2022). These crops occupy more than 16.4 million hectares and near 90 per cent of the total cultivated area (Niger, Ministry of Agriculture, Directorate of Statistics, 2023a). The significance of irrigated agriculture is growing, and the expansion of irrigation systems is strategically important in strengthening national food production and resilience to food crises and disasters (High Commission for the 3N Initiative, 2021). Irrigated crops mainly include market garden crops, grains and tubers (Niger, Ministry of Agriculture, Directorate of Statistics, 2023b) and are largely cultivated in river valleys and wetlands.

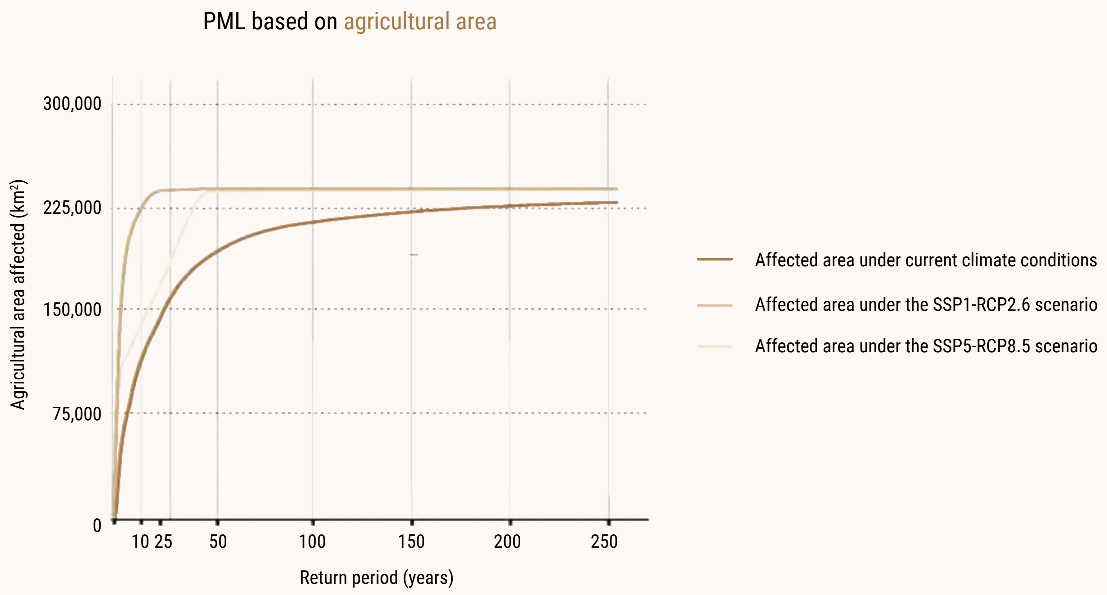
Agricultural activities are concentrated in the southern part of the country, where close to 90 per cent of the population live. Under current climate conditions, 2.69 million ha of land in the agricultural zone is affected by drought every year. In the future, the annually affected land area is projected to more than double. 6.94 million ha of land will be affected annually under the projected climate conditions of the SSP1-RCP2.6 scenario and 5.91 million ha of land per year will be affected under the SSP5-RCP8.5 scenario. In Tillabéri, the land area annually affected by droughts will triple under both future scenarios (see figure 26). This equates to 2.66 million ha/year under the SSP1-RCP2.6 scenario and 2.82 million ha/year under the SSP5-RCP8.5 scenario.

Figure 26: Area in the agricultural zone affected by agricultural droughts



The PML curves in figure 27 show that, compared to the historical scenario, for similar return periods, larger areas of agricultural land are exposed to drought under the SSP5-RCP8.5 scenario, and even more under the SSP1-RCP2.6 scenario.

Figure 27: Probable maximum loss curves of affected area by agricultural droughts in the agricultural zone

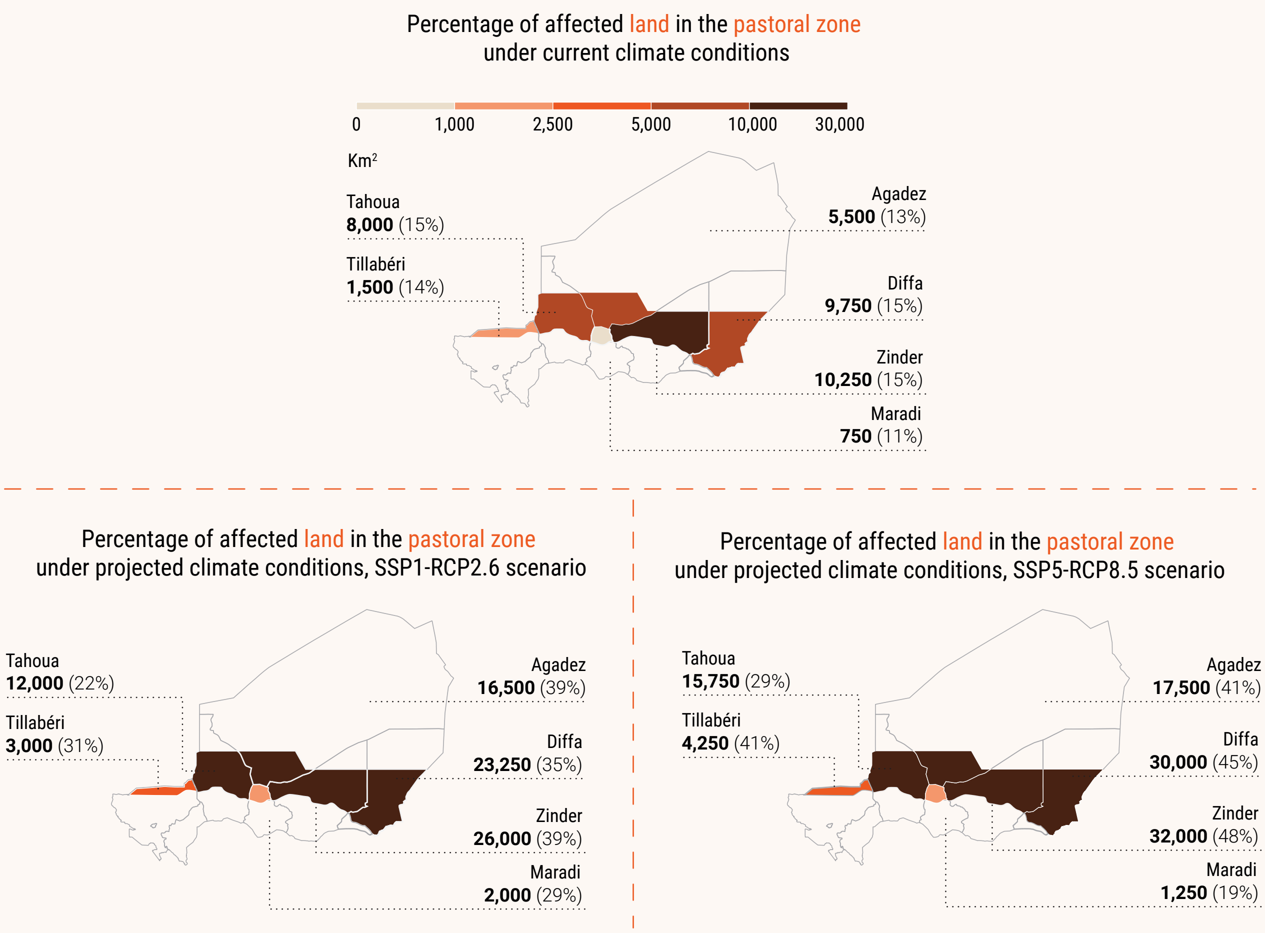


Livestock production

The livestock population in Niger is approximately 57.33 million animals (INS, 2022). 87 per cent of the population practice animal husbandry, either as a main or a secondary livelihood activity (Niger, Ministry of Livestock, Fisheries and Animal Industries, 2010; Feed the Future Innovation Lab for Livestock Systems, Management Entity, 2022). Three different livestock systems can be distinguished: those in the pastoral, agropastoral and agricultural zones (World Bank, 2013). In the pastoral zone, extensive pasturing, nomadism and transhumance dominate (World Bank, 2013; Jamart, 2010). In the agropastoral zone, agriculture is expanding, and agriculture and livestock keeping coexist. Transhumance remains the dominant form of animal husbandry. Livestock herding is the main activity of about 60 per cent of households, and 26 per cent of households practice a combination of animal husbandry and farming (World Bank, 2013). In the agricultural zone, livestock keeping is predominantly sedentary and embedded in the agricultural system (World Bank, 2013; Feed the Future Innovation Lab for Livestock Systems, Management Entity, 2022). In past decades, Niger's national herd size has increased, leading to overgrazing, pressure on pastural areas and land degradation (World Bank, 2023). From 2005 to 2022, for instance, livestock doubled from approximately 7.81 million to 15.25 million LSU (Niger, Ministry of Agricultural Development and Ministry of Animal Resources, 2007; INS, 2022).

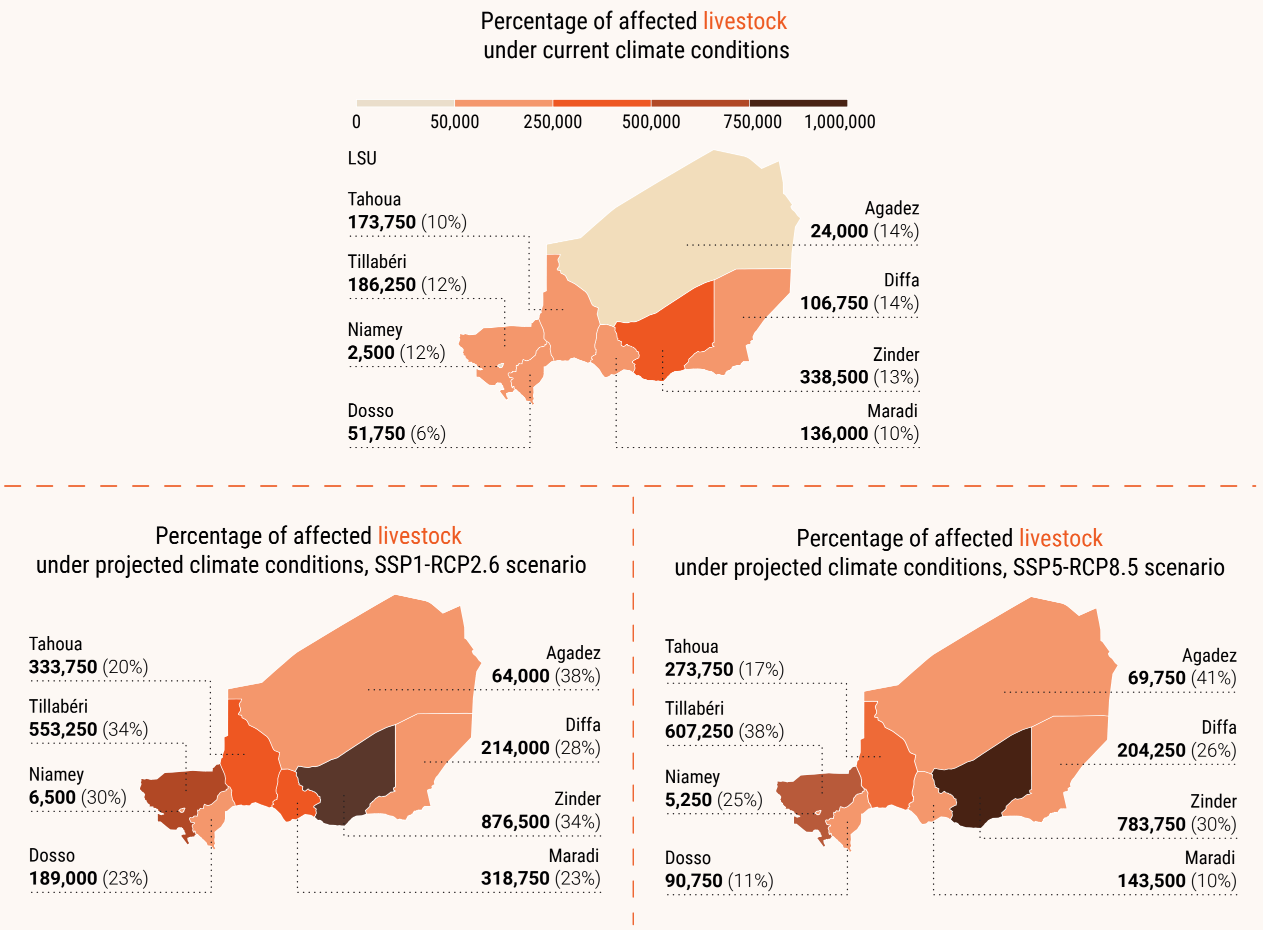
Under current climate conditions, 35,672 ha of land in the pastoral zone are affected by drought each year. In the future, this is expected to more than double: under the SSP1-RCP2.6 scenario, 82,691 ha of land will be affected each year. Under the SSP5-RCP8.5 scenario, the drought-affected area will increase to 100,496 ha per annum. The most significant increases are projected for Agadez, Diffa, Tillabéri and Zinder (see figure 28). In these regions, the drought-affected area is expected to double under the SSP1-RCP2.6 scenario and triple under the SSP5-RCP8.5 scenario.

Figure 28: Area in the pastoral zone affected by agricultural droughts



Numbers of drought-affected livestock are also expected to increase in both the pastoral and agricultural zones. Due to uncertainties regarding the national herd size's increase, these projections are less predictable. Assuming a stable herd size, the number of affected livestock will increase from 1.05 million to 2.64 million LSUs under the SSP1-RCP2.6 scenario, and to 2.25 million LSUs under the SSP5-RCP8.5 scenario (see figure 29). By assuming a continued annual increase in herd size of 4.02 per cent (growth rate based on livestock data for 2005 and 2022) (INS, 2022), the number of affected livestock will multiply to 7.95 million LSUs and 6.78 million LSUs, respectively.

Figure 29: Number of Livestock Units affected by agricultural droughts



The PML curves in figure 30 show that, compared to the historical scenario, for similar return periods, larger areas of pastoral land are exposed to drought under both the SSP1-RCP2.6 and the SSP5-RCP8.5 scenarios. The PML curves for affected livestock in figure 31 show that for similar return periods, higher numbers of livestock are affected, with higher estimates under the SSP1-RCP2.6 scenario than under the SSP5-RCP8.5 scenario.

Figure 30: Probable maximum loss curves of affected area in the pastoral zone by agricultural droughts

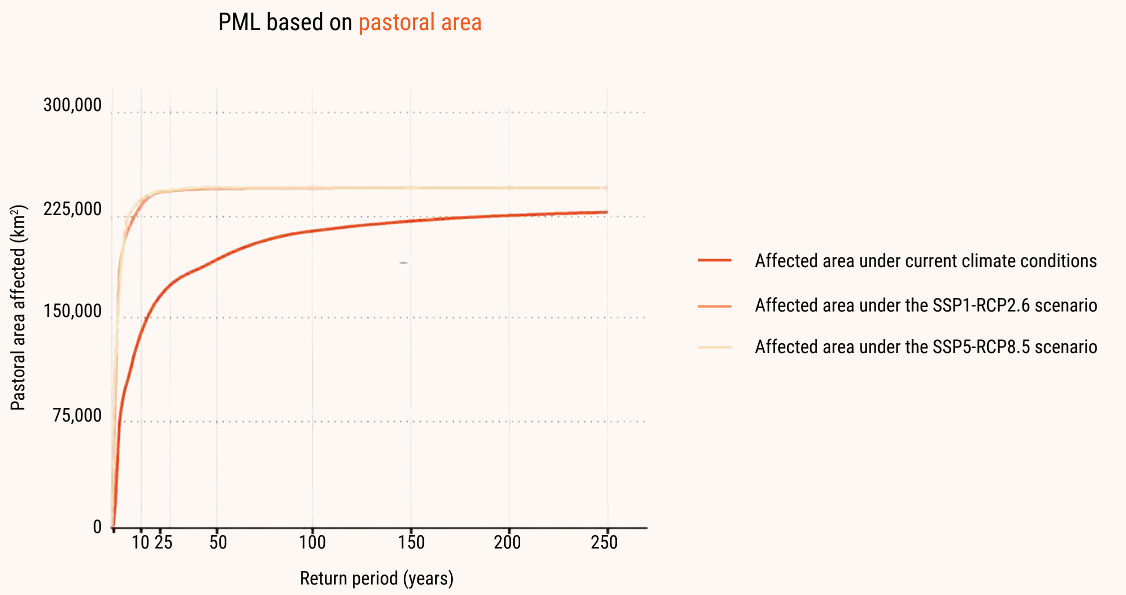
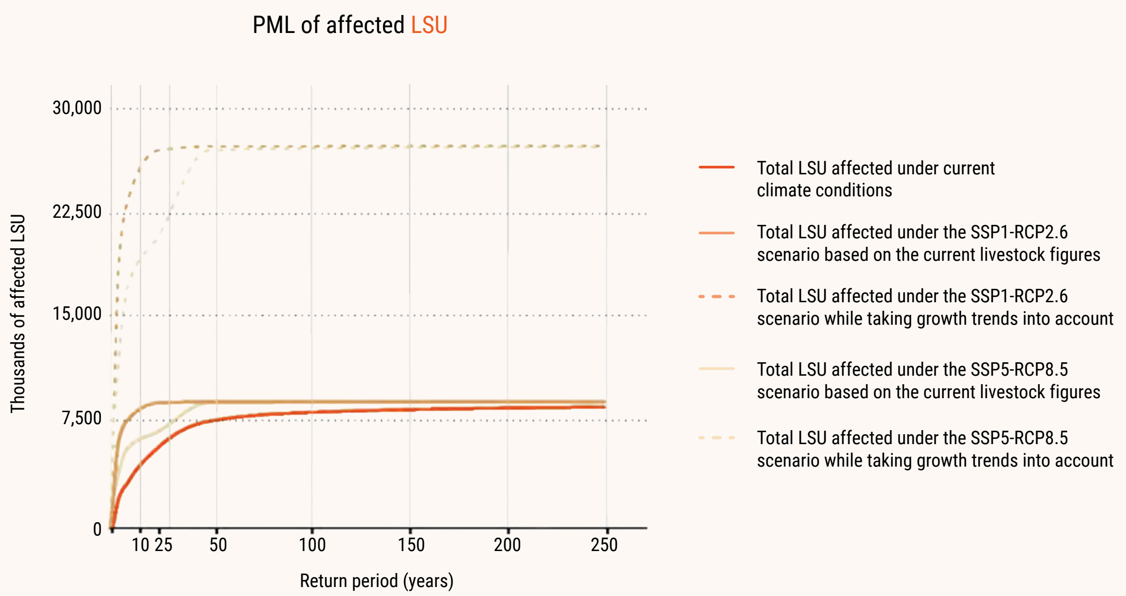


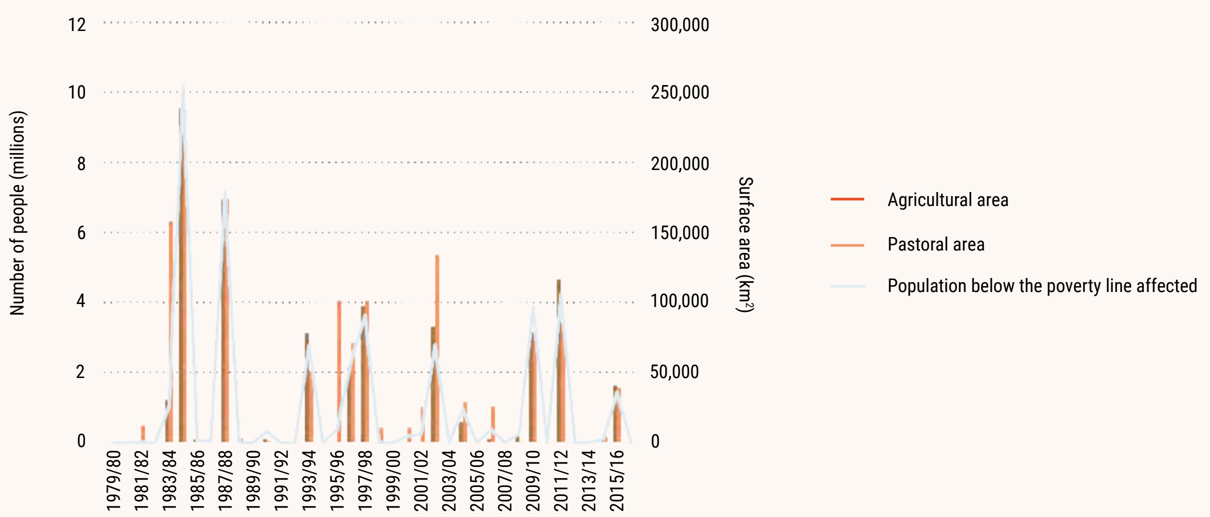
Figure 31: Probable maximum loss curves of affected Livestock Units by agricultural droughts



Detection of major historical drought years

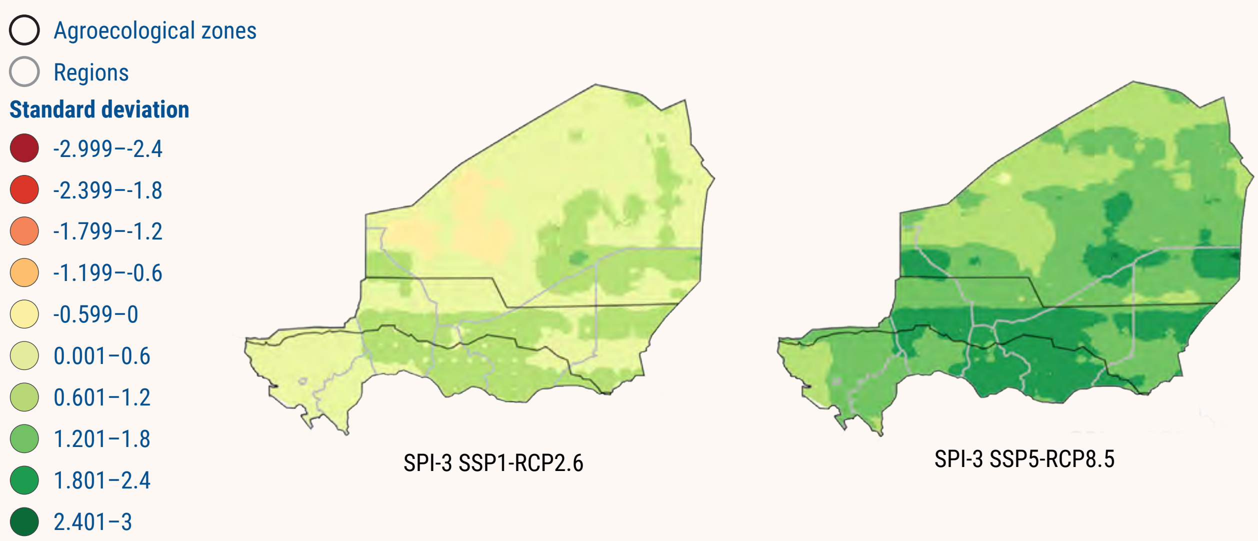
The model results for population, agricultural and pastoral land affected indicate that the historical years of 1983/84, 1984/85, 1993/94, 1996/97, 1997/98, 2002/03, 2009/10 and 2011/12 were among the most drought-prone (see figure 32). Comparison of the model results with available governmental data on agricultural production from 1985 to 2016, and on the number of villages facing agricultural deficits from 2001 to 2016, confirms major deficits for each of these years. The only exception is 2002/03, for which the government data show no agricultural shortfalls. The model also fails to detect the years 1990/91 and 2000/01, the agricultural seasons of which were defined by major crop failures. Although no governmental data were available for 1983/84 or 1984/85, Sahelian countries received among the lowest rainfall amounts ever recorded during those years, and the impacts of these regional drought events are well documented.

Figure 32: Detection of major historical drought years



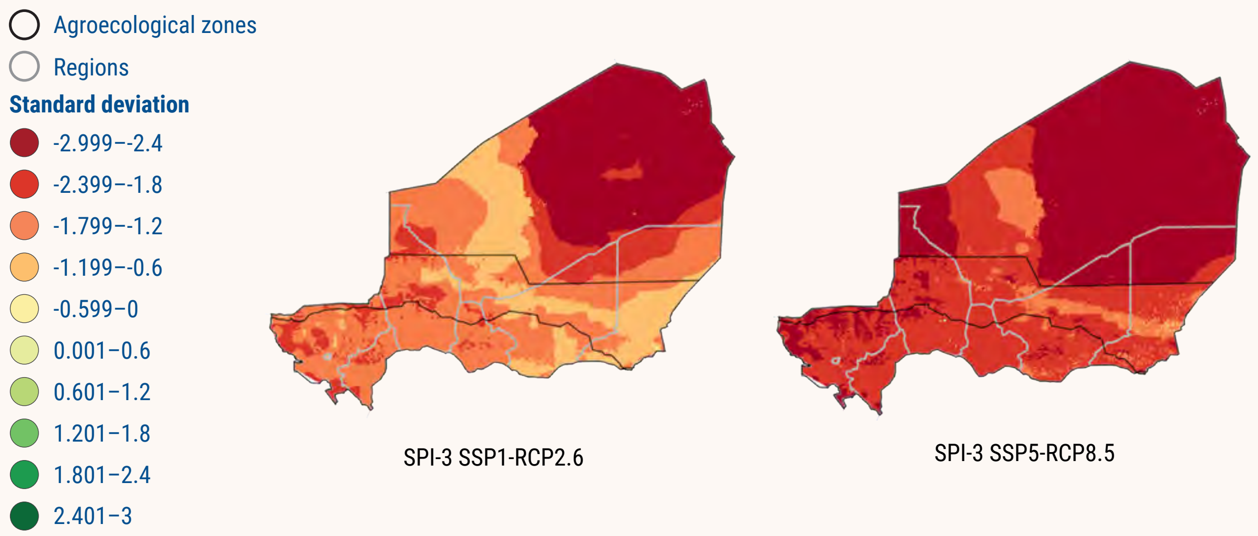
Hazard index

Figure 33: Standardized Precipitation Index three-month average



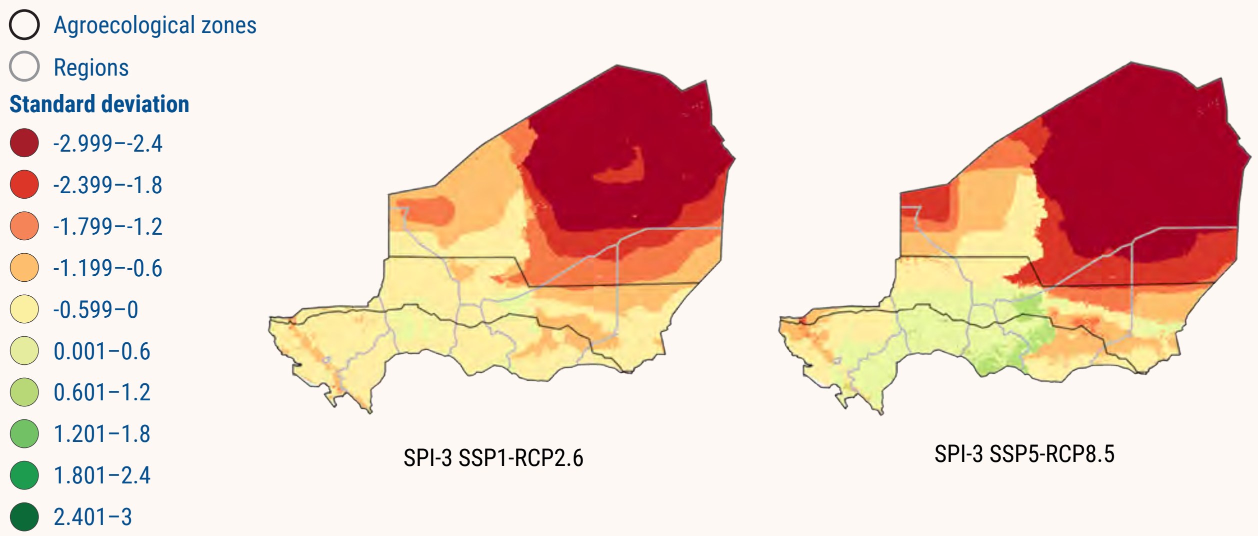
The means of the annual SPI-3 values for the June–October rainy season of the projected time series for 2051–2100 show that under both future scenarios, rainfall amounts will increase (see figure 33). The highest precipitation increases are projected for Diffa, Maradi, Tahoua and Zinder. In these regions, median SPI-3 values are projected to increase by more than 0.6 standard deviations on average under the SSP1-RCP2.6 scenario and by more than 1.7 standard deviations under the SSP5-RCP8.5 scenario.

Figure 34: Standardized Evapotranspiration Index three-month average



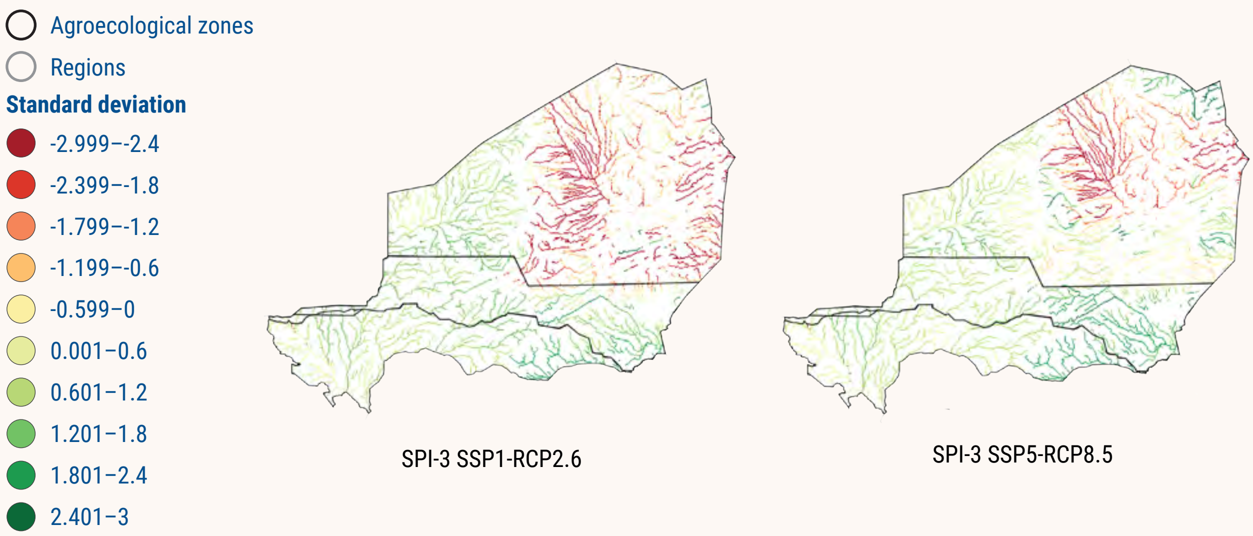
The means of the annual SEI-3 values for the June–October rainy season of the projected time series for 2051–2100 show that in the future, potential evapotranspiration will increase (see figure 34), making the climate hotter. In the agricultural and pastoral zones combined, average SEI-3 values will increase by approximately 1.4 standard deviations under the SSP1-RCP2.6 scenario and by more than 2 standard deviations under the SSP5-RCP8.5 scenario.

Figure 35: Standardized Precipitation Evapotranspiration Index three-month average



The means of the annual SPEI-3 values for the June–October rainy season show that under the SSP1-RCP2.6 scenario, the climate will be drier (see map on the left in figure 35). In the agricultural and pastoral zones combined, average SPEI-3 values will decrease by approximately 0.4 standard deviations. Under the SSP5-RCP8.5 scenario (see map on the right in figure 35), some parts of the Niger basin are projected to be less dry, although most of the country is projected to be drier. In Maradi, SPEI-3 values increase by up to 0.45 standard deviations and in Diffa and parts of Zinder, values decrease by up to 1.5 standard deviations.

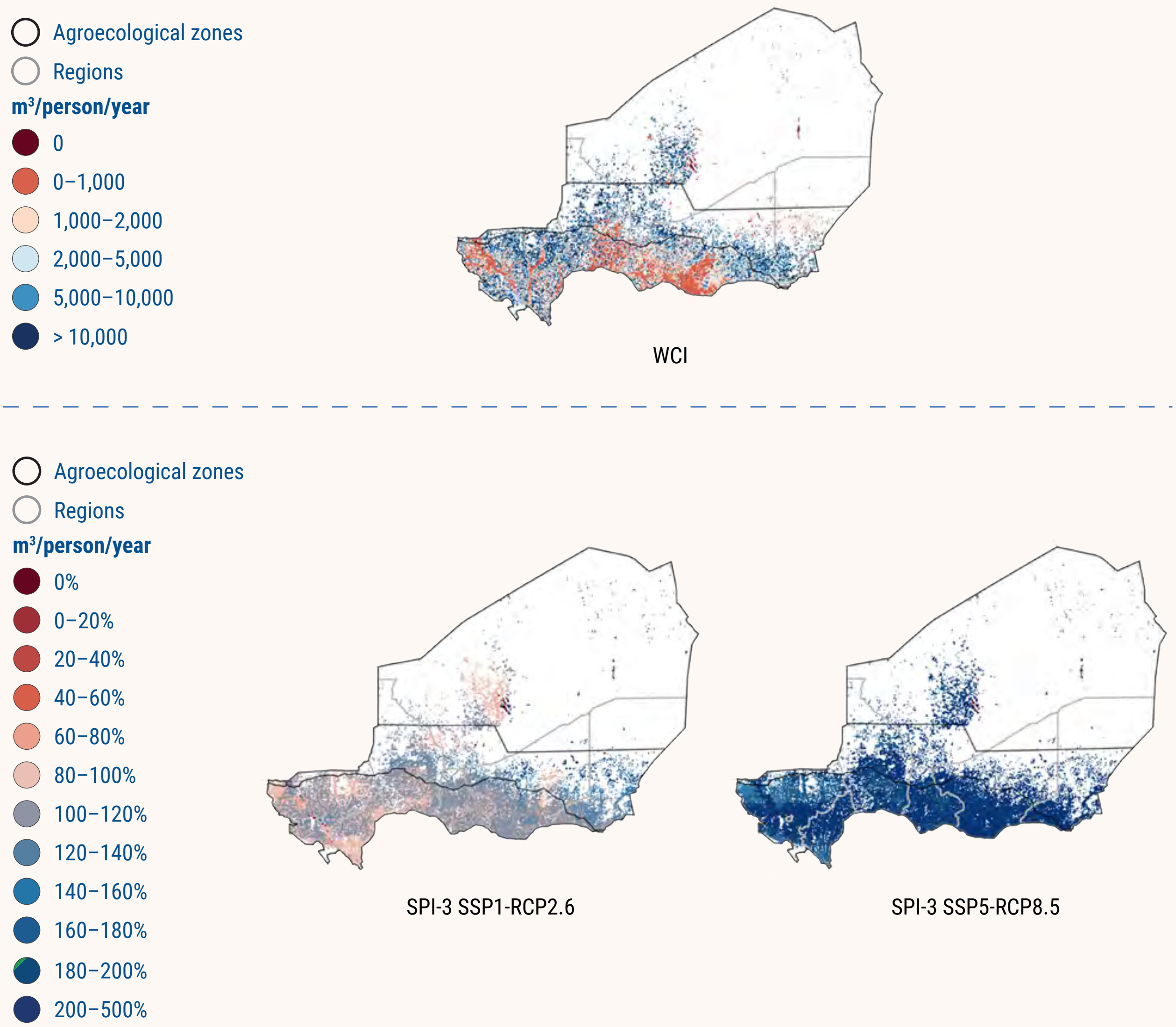
Figure 36: Standardized Streamflow Index three-month average



The means of the annual SSFI-3 values from April to June show that under the SSP1-RCP2.6 scenario, in large parts of the country, streamflow amounts will be comparable to the current ones (see map on the left in figure 36). In Agadez, streamflow projections show a decrease of more than a standard deviation. For the SSP5-RCP8.5 scenario (see map on the right in figure 36), SSFI-3 projections also show a decrease for Agadez, and an increase for all other parts of the country, particularly Diffa and Zinder. A mean increase of more than a standard deviation is projected for these regions.

The WCI measures the water available (precipitation minus actual evapotranspiration) per person per year. An area is water-scarce if less than 1000 m^3 is available per person per year (Falkenmark, Lundqvist and Widstrand, 1989). The maps in figure 37 show that under the current climate, the areas characterized by water scarcity are mostly located in the fertile parts of the south, the valley of the Niger River and the major seasonal river valleys of the Dallol Bosso and Dallol Maouri in south-west Niger. Assuming a stable population, the water availability per person will remain stable under the SSP1-RCP2.6 scenario and at least double in more half of the country under the SSP5-RCP8.5 scenario. Factoring in population growth, the water availability per person will at least halve in more than 90 per cent of the country under the SSP1-RCP2.6 scenario. Under the SSP5-RCP8.5 scenario, the water availability per person will decrease in close to 80 per cent of the country .

Figure 37: Water Crowding Index (WCI) using constant population figures



Key messages – floods

- The country faces a significant increase in flood risk due to climate change. The southern part, bordering Nigeria and Chad, is most susceptible. The Niger River and its tributaries are also prone to flooding.
- Floods are expected to displace more people. Under the worst-case scenario (SSP5-RCP8.5) and considering population growth, the number of people affected annually could reach 1 million. Tillabéri Region is expected to be the most affected.
- Floods will cause substantial economic losses, damaging homes, businesses and critical infrastructure. The built-up sector, particularly housing, is most at risk. Niamey and Tillabéri are expected to suffer the most significant losses.
- Agricultural land, crucial for Niger's food security, will be affected by floods. Croplands, especially those growing pearl millet and cow peas, are vulnerable. Diffa and Zinder Regions are expected to see the most significant impacts.
- Critical infrastructure, including roads, schools and health facilities, will be damaged by floods. Tillabéri and Diffa are expected to see the most damage to roads. Disruptions to education and health-care services can worsen due to floods.

Photo credits: caritas.org

Key messages – drought

- Agricultural production primarily relies on rainfall; 80 per cent of Niger's population is employed in the agricultural sector, therefore droughts have a vast socioeconomic impact.
- Smallholder farms are particularly vulnerable, as impacts can reduce their food supply and increase hunger and poverty.
- Drought risk projections are more complex, with some areas potentially experiencing less drought in the future.
- Drought hazard impacts on agricultural activities are also substantial. Under current climate conditions, 2.69 million ha of land in the agricultural zone is affected by drought every year. The annual figure of affected land area is predicted to more than double.

Recommendations

- Focus on flood risk mitigation and preparedness efforts in the most vulnerable areas, including the southern border regions, the Niger River Basin, and the Tillabéri, Diffa, Zinder and Maradi Regions.
- Implement robust early warning systems to alert communities about impending floods and allow for evacuation and protection measures.
- Improve the resilience of infrastructure to floods, including buildings, roads, schools and health facilities.
- Encourage farmers to adopt drought-resistant crops and water-saving irrigation techniques to minimize flood risk and improve food security. Consider coordination with the insurance sector on innovative products to help protect agriculture systems, for example, through drought-resilient seeds, etc.
- Build the capacity of farmers and pastoralists to adopt climate change adaptation measures such as Banquettes (sylvo-agricultural), Zaïs and half-moons (agricultural).

Annex

Probabilistic risk assessment: methodology

The key to understanding disaster risk is recognizing that disasters are an indicator of development failures, meaning that disaster risk is a measure of development's sustainability (UNDRR, 2015). Many different and complementary methods and tools are available for analysing risk. These range from qualitative to semi-quantitative and quantitative methods: expert elicitation, historical analysis, deterministic or scenario analysis, and probabilistic risk analysis.

These methodologies are closely linked with the application that they are intended for. However, some methodologies have a higher information content and allow more flexibility in their practical use. One of these is the probabilistic risk assessment approach, which was used to develop this disaster risk profile for floods and droughts. This approach has been used by UNDRR and other disaster risk reduction stakeholders to develop quantitative risk profiles at the national and subnational levels.

The probabilistic risk assessment is based on a modelling approach to best predict possible present and future scenarios, considering the spatial and temporal uncertainties involved in the analysis process. Probabilistic disaster risk profiles consider all possible risk scenarios in a certain geographical area. A realistic set of all possible hazardous events (scenarios) that might occur in a region, including rare, catastrophic events, is simulated. This means that both low-frequency, high-impact events and high-frequency, low-impact events are calculated, and their probability of occurrence is included in the assessment. Events that have never been historically recorded but that may occur under projected climate conditions are also considered in the risk analysis. This feature is useful in the context of climate change, which is increasing uncertainty about future hazard patterns. Societies must calculate the possible impacts of uncertain patterns to be prepared. There is no valid alternative to a probabilistic analysis to address this uncertainty in a usable, quantitative way.

For each event, defined through the probability that an event of a certain magnitude will occur, potential impacts are computed in terms of number of people, assets affected or economic losses, considering publicly available information on hazard, exposure and vulnerability.

Finally, loss statistics are computed and summarized through quantitative risk metrics, such as: the AAL and the PML (see figure 38).

Figure 38: Annual average loss and probable maximum loss

AAL

The expected loss per year, averaged over many years.

PML

The likelihood of a certain scenario producing an estimated amount of losses.

While there may be little or no loss over a short period of time, the AAL also accounts for much larger losses that occur less frequently. The AAL can represent the funds required annually to cumulatively cover the average disaster loss over a long period. The PML describes the maximum loss that could be expected corresponding to a given likelihood, expressed in terms of annual probability of exceedance or its reciprocal, the return period. When referring to economic losses, the PML is relevant to define the size of reserves that should be available to insurance companies or governments to manage losses of individual events.

Uncertainties in the hazard forcing, exposure and vulnerability data that permeate the different steps of the computations can be explicitly quantified and considered when computing the final metrics (AAL and PML).

These risk metrics can be calculated at both the regional and national levels, and by sector and administrative unit, which allows for a geographic and quantitative comparison of disaster losses, both within a country and/or between countries. These analyses and comparison exercises are an important step of the risk awareness processes, key in pushing for risk reduction, risk adaptation and risk management mechanisms to be implemented.

The added value of a probabilistic risk assessment is often misunderstood, as audiences tend to view it as a highly technical method that is difficult to apply or understand. These difficulties create challenges in communicating risk results. A probabilistic disaster risk profile should be seen as a risk diagnosis instrument, as it provides indications on possible hazardous events and their impacts. Both past and probable future events have been considered in a comprehensive risk assessment exercise.

Probabilistic risk assessment: risk scenarios

The disaster risk profile for Niger provides a comprehensive view of hazard and risk for floods and droughts in a changing climate, with projections for the period 2051–2100. They are based on the climate scenarios presented in the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report 2021 (IPCC, 2022) that cover a range of possible future developments of anthropogenic drivers of climate change. This framework combines different levels of greenhouse gases and other radiative forces that might occur by 2100, so called "Representative Concentration Pathways" (RCPs) with a set of SSPs that describe five different ways in which the world might evolve (Riahi and others, 2017; O'Neill and others, 2020):

- SSP1: Sustainability; a world shifting gradually towards a more sustainable path, emphasizing more inclusive development.
- SSP2: Middle of the Road; a world where trends broadly follow their historical patterns.
- SSP3: Regional Rivalry; a world characterized by resurgent nationalism, and concerns about competitiveness and security.
- SSP4: Inequality, a world characterized by unequal investments in human capital, combined with increasing disparities in economic opportunity and political power.
- SSP5: Fossil-fuelled Development: the "economic optimism" scenario, characterized by a push for economic and social development coupled with the exploitation of abundant fossil fuel resources and the adoption of resource- and energy-intensive lifestyles worldwide.

The different levels of greenhouse gases and other radiative forces in the RCPs will result in the following very likely temperature increases in the twenty-first century (see table 1):

Table 1: Temperature increase during the twenty-first century

	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100	
Scenario	Best estimate (ºC)	Very likely range (ºC)	Best estimate (ºC)	Very likely range (ºC)	Best estimate (ºC)	Very likely range (ºC)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 1.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.5	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

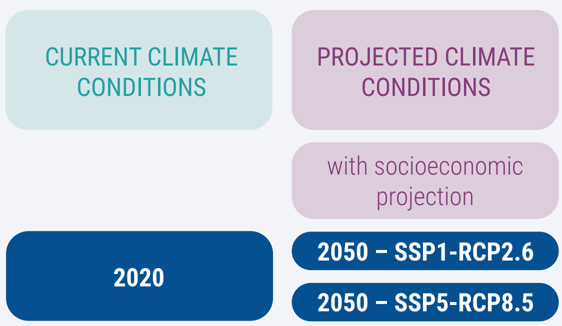
Source: IPCC (2022).

In this risk profile, three different time series were considered (see figure 39)[5]:

- Under current climate conditions: with disaster risk assessed using the observed climate conditions in the 1979–2016 period.
- Under projected climate conditions – lower boundary, "optimistic" scenario: with disaster risk being assessed under projected climate conditions to 2100, considering the IPCC SSP1-RCP2.6 scenario, designed with the aim of simulating a development that is compatible with the 2°C target at the global level, assuming that climate mitigation measures are being taken .
- Under projected climate conditions – upper boundary, "pessimistic" scenario: with disaster risk being assessed under projected climate conditions to 2100, considering the IPCC SSP5-RCP8.5 scenario, which foresees high radiative forcing by the end of the century, driven by the economic success of industrialized and emerging economies. This leads to a projected increase of more than 4°C at the global level by the end of the twenty-first century.

The flood impacts are estimated for each projected climate condition and for the indicators of estimated affected population and losses in the housing, service and industrial sectors. The drought impacts are estimated for each projected climate condition and indicators are used for affected population and losses in the agricultural and livestock sector. The future population estimates are based on population projections for the SSP2 "Middle of the Road" scenario, where trends broadly follow historical patterns. According to these projections, the population in Niger will reach 63.82 million by 2050 (Wittgenstein Centre, 2023).

Figure 39: Current and projected climate conditions



5 See https://www.isimip.org/about/.

Probabilistic risk assessment: risk components

HAZARD

A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.

To best predict possible flood scenarios, a modelling chain composed of climate, hydrological and hydraulic models, combined with available information on rainfall, temperature, humidity, wind and solar radiation, has been used. For drought, different indices are used to characterize the drought hazard across the hydrological cycle. A set of mutually exclusive and collectively exhaustive possible hazard scenarios that may occur in the country, including the most catastrophic ones, is generated and expressed in terms of frequency, extent of the affected area and intensity in different locations.

EXPOSURE

People, property, systems or other elements present in hazard zones that are subject to potential losses.

Losses caused by floods and droughts are assessed in relation to population and a series of critical sectors (education, health, transport, housing, and the productive and agricultural sectors). Publicly available global and national data enable the location of these elements at high resolution for the whole country. The total number of people is considered in both current (2023) and projected (2050) climate scenarios. The critical sectors are characterized in terms of their economic value (in USD) or area affected using the most updated information available.

VULNERABILITY

Conditions determined by physical, social, economic and environmental factors or processes that increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

Direct losses for different at-risk elements are evaluated using vulnerability functions. This links hazard intensity to the expected loss (economic loss or number of affected people). Vulnerability functions are differentiated by the typology of exposed elements. They also consider local factors, such as typical construction typologies for infrastructures or crop seasonality for agricultural production. For floods, vulnerability is a function of water depth. For agricultural production, vulnerability is a function of the season when a flood occurs. For agricultural drought, losses are computed in terms of affected population, agricultural and pastoral area, and affected livestock. A similar approach is used for hydrological drought, the evaluation of which focuses on people affected.

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