CLIMATE RISK COUNTRY PROFILE

TUNISIA

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ACKNOWLEDGEMENTS

This profile is part of a series of Climate Risk Country Profiles developed by Climate Change Group of the World Bank Group (WBG). The country profiles aim to present a high-level assessment of the climate risks faced by countries, including rapid-onset events and slow-onset changes in climate conditions, many of which are already underway, as well as summarize relevant information on policy and planning efforts at the country level.

The country profile series are designed to be a reference source for development practitioners to better integrate detailed climate data, physical climate risks and need for resilience in development planning and policy making.

This effort is managed and led by MacKenzie Dove (Technical Lead, CCKP, WBG), and Pascal Saura (Task Team Lead, CCKP, WBG).

This profile was written by Balsher Singh Sidhu (Climate Change Consultant, CCKP, WBG) and Anna Cabré Albós (Climate Change Consultant, CCKP, WBG).

Unless otherwise noted, data is sourced from the WBG's Climate Change Knowledge Portal (CCKP), the WBG's designated platform for climate data. Climate, climate change and climate-related data and information on CCKP represents the latest available data and analysis based on the latest Intergovernmental Panel on Climate Change (IPCC) reports and datasets. The team is grateful for all comments and suggestions received from climate and development specialists, as well as climate research scientists and institutions for their advice and guidance on the use of climate related datasets.

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FOREWORD

Development progress has stalled in many countries amid low growth, increased fragility and conflict, pandemic-related setbacks, and the impacts of climate change. Droughts, extreme heat, flooding and storms push millions into poverty annually, causing unemployment and risking unplanned internal and cross-border migration. Every year, an estimated 26 million people fall behind due to extreme weather events and natural disasters. These shocks have the potential to push a total of 130 million into poverty by 2030.

The World Bank Group (WBG) is supporting countries to meet these challenges. As part of our vision to end poverty on a livable planet, we are investing in development projects that improve quality of life while creating local jobs, strengthening education, and promoting economic stability. We are also helping people and communities adapt and prepare for the unpredictable and life-changing weather patterns they are experiencing, ensuring that limited development resources are used wisely and that the investments made today will be sustainable over time.

Having access to data that is accurate and easily understandable is of course critical to making informed decisions. This is where the report you are about to read comes in.

Climate Risk Country Profiles offer country-level overviews of physical climate risks across multiple spatiotemporal scales. Each profile feeds into the economy-wide Country Climate and Development Reports and draws its insights from the Climate Change Knowledge Portal, the WBG's 'one-stop-shop' for foundational climate data.

Guided by World Bank Group data and analytics, developing countries can conduct initial assessments of climate risks and opportunities that will inform upstream diagnostics, policy dialogue, and strategic planning. It is my sincere hope that this country profile will be used to inform adaptation and resilience efforts that create opportunities for people and communities around the world.

Valerie Hickey, PhD
Global Director
Climate Change Group
World Bank Group

KEY MESSAGES

Climate change in Tunisia is projected to reduce water availability, accelerate desertification, and intensify extreme weather events, all of which will impact agriculture and livelihoods. Coastal areas face the threat of rising sea levels, increased flooding, and disruptions to fisheries.

Temperatures have been rising at a rate of 0.46°C per decade from 1971 to 2020 and are projected to continue increasing at a rate of 0.35°C per decade from 2000 to 2050 under the SSP3-7.0 scenario, outpacing the global average.

Key temperature-related challenges include a rise in hot days exceeding 35°C, increasing from 57 days annually (nearly 2 months) historically to 84 days per year (almost 3 months) by 2040–2059. Tropical nights, with minimum temperatures exceeding 23°C, are also expected to increase from 55 days per year (nearly 2 months) historically to 89 days per year (almost 3 months) by 2040–2059. Additionally, hot, humid days—detrimental to health—are anticipated to occur more frequently, becoming significant by the end of the century.

Precipitation is declining across the country at a projected rate of 7.9% by 2040–2059 compared to the historical period (1995–2014), with the greatest reductions in the rainier northwestern regions, leading to longer droughts and expanding desertification, even though interannual variability remains very high.

Extreme precipitation events are also expected to become more frequent, with 100-year return period events increasing by 20% by 2050 under SSP3-7.0, raising the risk of floods and landslides.

Desertification will extend into northern regions, threatening food security, while rising sea surface temperatures, sea levels, and storm surges will pose growing risks to coastal cities and the blue economy.

COUNTRY OVERVIEW

Tunisia, the northernmost country in Africa, is located in the Maghreb region and bordered by Algeria to the west, Libya to the southeast, and the Mediterranean Sea to the north and east. Covering 163,610 km², Tunisia's geography is marked by a striking diversity, from fertile coastal plains to mountainous regions in the northwest, and arid desert expanses in the south, including parts of the Sahara (**Fig. 1**).

In the north, the terrain is dominated by the Dorsal, an extension of the Atlas Mountains that runs diagonally across the country from Algeria, providing rugged hills and valleys. This mountainous region gradually flattens into the fertile plains that form the heart of Tunisia's agricultural sector. Moving south, the landscape transitions into the central plains, which are characterized by hot, dry conditions. Further south still, these plains give way to the expansive desert terrain of the Sahara, which covers a significant portion of the country. The southwest is also home to Chott el Djerid, a vast salt lake that sits at 17 meters below sea level, marking the lowest point in Tunisia's topography. Tunisia's most notable river is the Medjerda, the longest river in the country, which flows from Algeria through the northern plains to the Gulf of Tunis. The river is vital for irrigation and agriculture, particularly in the north where the country's most fertile soils are found[1].

With a population of over 12 million[2], Tunisia features a predominantly urbanized society, centered around its capital, Tunis (**Fig. 2**). Tunisia's population and economic activity are heavily concentrated along its 1,148-kilometer Mediterranean coastline, which supports fishing, tourism, key ports, and urban centers. The country is known for its agricultural productivity and a diversified economy spanning agriculture, manufacturing, and tourism. However, rapid urbanization, population growth, and increased irrigation needs have escalated water demand, straining Tunisia's limited water resources.[3]

Climate change is projected to intensify water scarcity in Tunisia. This could lead to a critical imbalance where water demand far exceeds supply, negatively affecting water quality and reducing reservoir storage capacity. Key agricultural sectors, such as olives, cereals, and livestock, are expected to face substantial losses, disproportionately impacting vulnerable populations with limited resources. Tunisia's coastal regions, including densely populated urban areas, are particularly at risk from climate-related hazards such as shoreline erosion, sea-level rise, and flooding. Greater variability in rainfall patterns is anticipated to significantly heighten the frequency of severe floods, turning rare events into regular occurrences.

Tunisia submitted its Nationally-Determined Contribution (NDC) to the UNFCCC in 2016[4], its Third National Communication (NC3) in 2019[5], and the Updated Nationally Determined Contribution in 2022[6], in support of the country's efforts to achieve its economic development goals, strengthen its approach to environmental sustainability and increase its adaptive capacity to climate change. Key focus is on the sustainability of the environment, water resources, energy, agriculture sectors and costal zones, and human and animal health.

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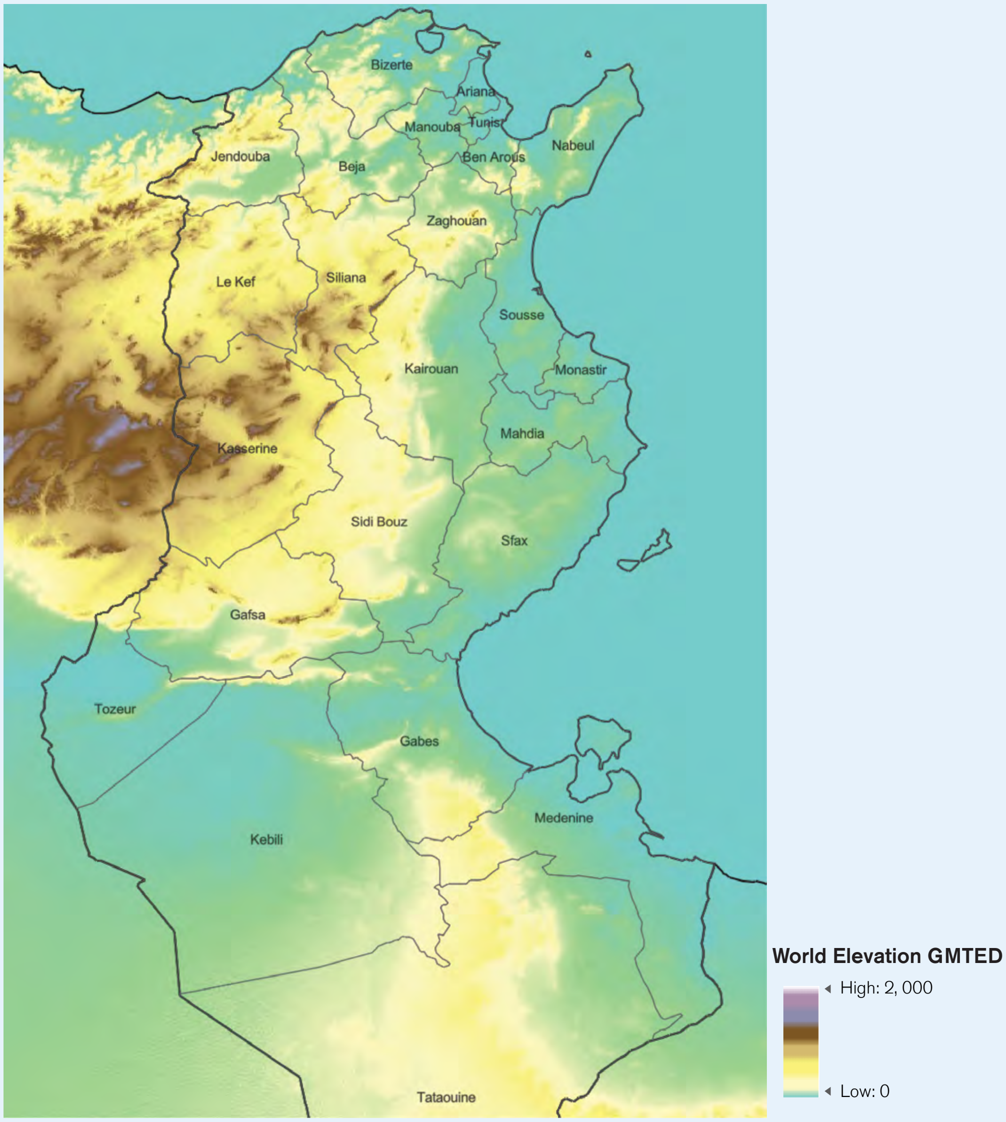
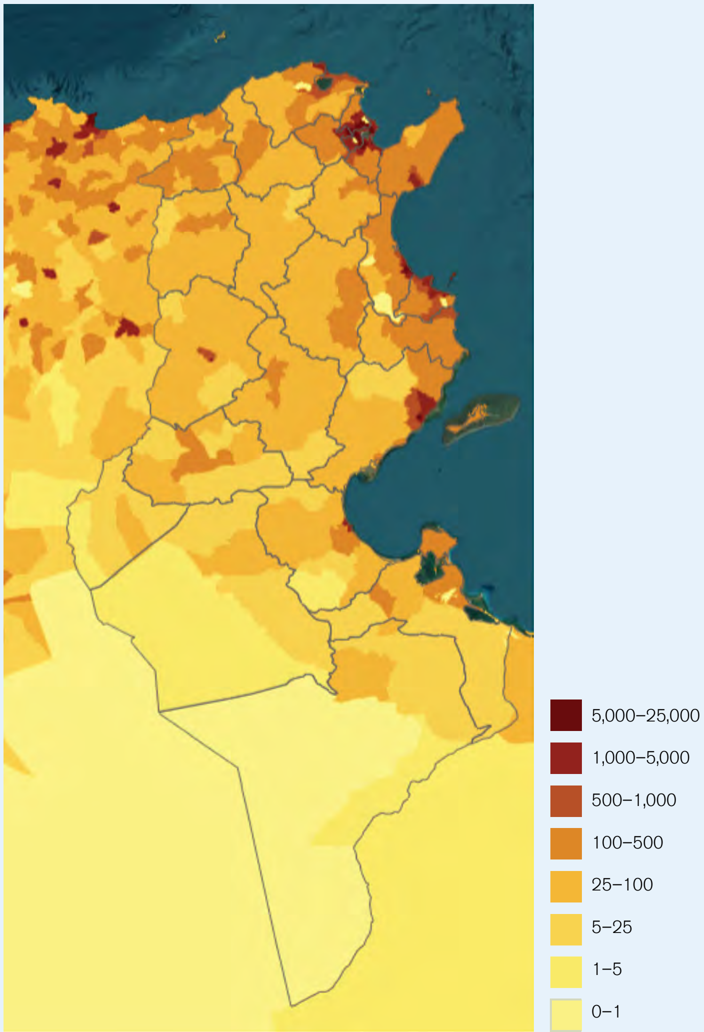
1 Britannica https://www.britannica.com/place/Tunisia
2 World Development Indicators, World Bank
3 World Bank Group. 2023. Tunisia Country Climate and Development Report. CCDR Series https://openknowledge.worldbank.org/entities/publication/66d30db7-bc0f-46fd-89bd-d983914147cc
4 Tunisia. Biennial update report (BUR). BUR 2. https://unfccc.int/documents/180725
5 Tunisia. National Communication (NC). NC 3. https://unfccc.int/documents/196836
6 Updated Nationally Determined Contribution Tunisia (2022) https://unfccc.int/sites/default/files/NDC/2022-08/CDN%20-%20Updated%20-english%20version.pdf

FIGURE 1. Topography (in meters) (Global Multi-resolution Terrain Elevation Data 2010[7]) and Political Boundaries (World Bank Cartography). Note: Topography is Relevant for Sea Level Rise and Climate – Coastal Regions Near Mountains Capture More Rain.



[7] GMTED2010 https://pubs.usgs.gov/of/2011/1073/

FIGURE 2. Population Density, 2020 (persons per square kilometer), GPWv4[8] 2020, and ADM1 Subnational Boundaries



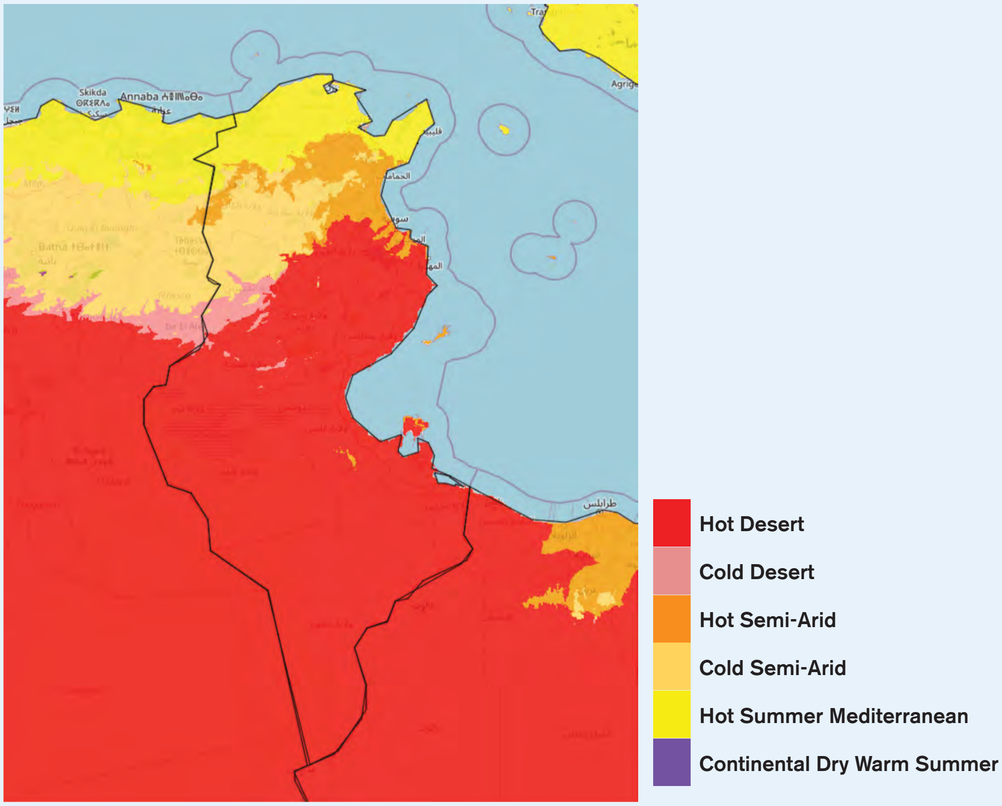
CLIMATE OVERVIEW

Data overview: Historically, observed data is derived from the Climatic Research Unit, University of East Anglia (CRU), CRU TS version 4.08 gridded dataset (data available 1901–2023). The CRU dataset relies on stations data.

[8] GPWv4 Population data, https://www.earthdata.nasa.gov/data/projects/gpw

Tunisia's geography is diverse and has diverse climate zones shaped by the Atlas Mountains and the Mediterranean Sea. According to the Köppen-Geiger Climate Classification (1991–2020)[9], the northern regions experience a Mediterranean climate with hot, dry summers and mild, wet winters. To the south, the climate transitions to semi-arid and eventually to desert (**Fig. 3**).

FIGURE 3. Köppen-Geiger Climate Classification, 1991–2020, from https://koppen.earth/

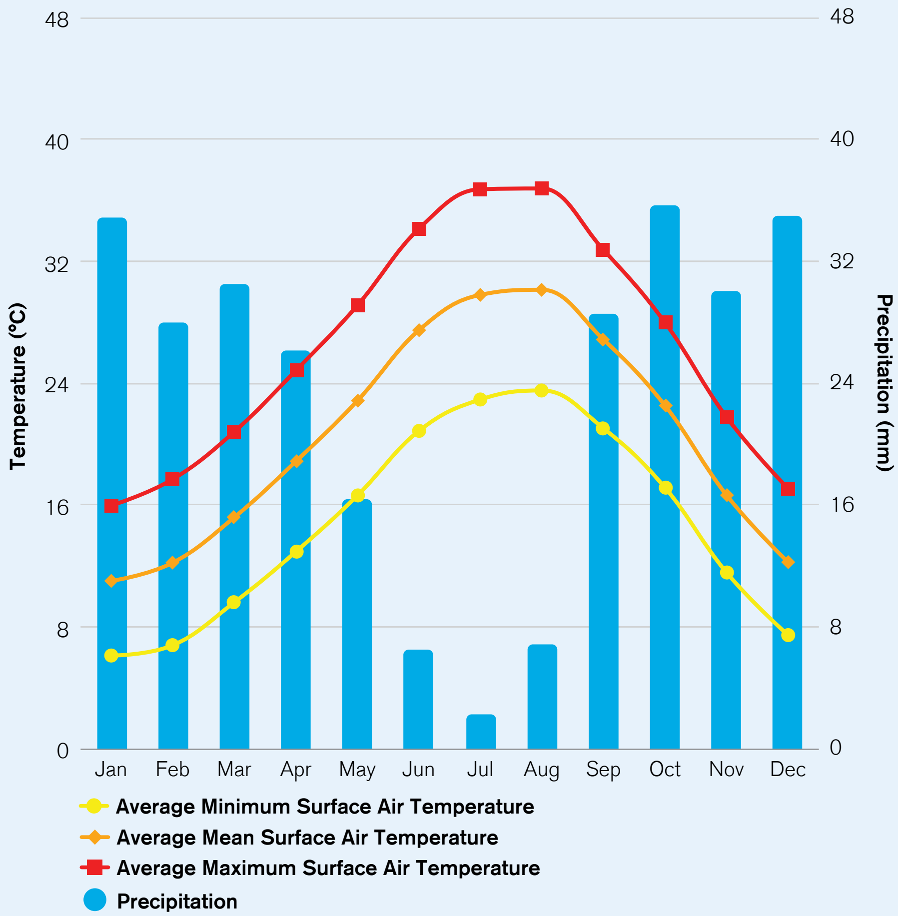


The country is influenced by various wind systems. Cool sea breezes along the northern coast help moderate temperatures and bring increased rainfall, while the Chergui, a hot and dry wind, sweeps across the desert regions. Sunshine is plentiful year-round, particularly in the south, where it is a defining characteristic of the desert climate.

Tunisia's mean annual temperature is 20.51°C, featuring hot summers with average temperatures ranging from 23.5°C (minimum) to 36.76°C (maximum) in August, and mild winters with average temperatures ranging from 6.1°C (minimum) to 15.95°C (maximum) in January. The day-to-night temperature variation ranges from approximately 10°C in winter to around 13°C in summer (**Fig. 4**). Tunisia's mean annual temperature varies across its regions, with a north-to-south gradient reflecting its diverse climate zones, and colder temperatures in the mountainous regions of Le Kef, Siliana and Kasserine. In the north, coastal areas like Ariana and Ben Arous have average temperatures around 19°C, while southern regions like Tataouine and Tozeur experience higher annual temperatures, averaging

[9] Köppen-Geiger Climate Classification (1991–2020) from https://koppen.earth/

FIGURE 4. Monthly Historical Climatology of Average Temperature (minimum, average, and maximum) and Total Precipitation (1991–2020) for Tunisia (CRU dataset)



above 22°C. Minimum annual temperatures range from 10.83°C in the cooler regions like Le Kef in the north to over 16°C in the southern desertic areas. Maximum temperatures show even starker contrasts, reaching over 28°C in the central and southern areas, while remaining lower in the coastal north (See **Table A1**).

The average annual precipitation totals 281 mm. Precipitation is concentrated between September and April especially in the northern part of the country. Tunisia's precipitation patterns show significant regional variations influenced by its diverse geography. The northwestern regions, including Jendouba (>900 mm annually), Beja, Bizerte, and Le Kef (>700 mm), typically experience higher annual rainfall owing to their proximity to the Mediterranean Sea and their location near mountainous areas, supporting agriculture and vegetation. The northeastern Mediterranean regions receive less rainfall, ranging from 528 mm in Ariana (north) to 258 mm in Sfax (more to the south), but still amount to a significant total. The southern desert regions receive very little precipitation annually; they are situated in Tunisia's arid zone, where rainfall is scarce, and evaporation rates are high. In the northern and mountainous regions, precipitation primarily peaks in January. In contrast, the southern regions, characterized by more erratic rainfall patterns, typically experience their precipitation peak in early fall (September or October). Across all regions, precipitation reaches its lowest levels during the summer, in July (See **Table A2**).

Tunisia's weather patterns and drought conditions are heavily influenced by natural climate variability, particularly the North Atlantic Oscillation (NAO) and the Mediterranean Oscillation[10]. The NAO, a dominant atmospheric pressure pattern over the North Atlantic Ocean, alternates between positive and negative phases. During a positive NAO phase, Tunisia experiences drier-than-average conditions.

TEMPERATURE AND PRECIPITATION HISTORICAL AND PROJECTED TRENDS

Data overview: Historical observed data is derived from the ERA5 reanalysis collection from ECMWF (1950–2023). Modeled future climate data is derived from CMIP6, the Coupled Model Intercomparison Project, Phase 6. This risk profile focuses primarily on SSP3-7.0[11], which projects a doubling of CO2 emissions by 2100, a global temperature change of approximately 2.1°C by mid-century (2040–2059) and 2.7°C (likely 2.1°C to 3.5°C) by the end of the century (2080–2099), with respect to pre-industrial conditions (1850–1900).

Historical Temperature Changes

Between 1971 and 2020, Tunisia has experienced a notable warming trend (0.46°C/decade). The IPCC AR6 reports on Africa[12] and the Mediterranean region[13] support these findings, noting that the Mediterranean region is a climate change hotspot, as it is warming faster than the global average, and noting that the "mean and seasonal temperatures have increased at twice the global rate over most regions in north Africa due to human-induced climate change". The average temperature rise per decade is between 0.35°C and 0.49°C across different governorates, with the highest increases in interior northern regions like Kairouan and Siliana (north) and the southern desertic regions, which are seeing temperature increases close to 0.5°C per decade. Both minimum and maximum temperatures are rising especially during spring and summer, with the minimum night temperatures (Tmin) increasing more slowly than maximum day temperatures (Tmax). Certain regions, such as Tozeur, Kairouan and Siliana, have seen maximum temperature trends reaching almost 0.6°C per decade, underscoring the increasing intensity of heat, particularly in the interior parts of the country. The northern interior regions of Siliana, Kairouan, and Le Kef have seen summer temperatures rise by 0.75°C to 0.8°C per decade. See **Table A1** for historical changes in temperature across regions.

[10] Criado-Aldeanueva, F., & Soto-Navarro, J. (2020). Climatic Indices over the Mediterranean Sea: A Review. *Applied Sciences, 10*(17), 5790. https://doi.org/10.3390/app10175790

[11] Climate scientists may prioritize SSP4.5 and SSP8.5 to cover a range of potential futures, but SSP8.5 is frequently avoided in policy discussions due to its extreme nature. SSP3-7.0 is understood as a balanced compromise—sufficiently pessimistic yet in line with current policies. Note that patterns of change are generally consistent across scenarios, differing only in timing and impact intensity. For example, impacts projected under SSP3-7.0 by 2070 (2.8°C warming) are projected to occur by 2060 under SSP5-8.5, given the same level of warming. This approach allows scenarios to be translated by focusing on the warming signal rather than specific timelines. Please see the attached tables, which illustrate the relationship between warming levels and future periods for different scenarios. For more information see: IPCC AR6 https://data.ceda.ac.uk/badc/ar6_wg1/data/spm/spm_08/v20210809/panel_a

[12] IPCC AR6 Ch. 9 (Africa) https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-9/

[13] IPCC AR6 cross-chapter 4 (Mediterranean region) https://www.ipcc.ch/report/ar6/wg2/chapter/ccp4/

Projected Temperature Changes

Future climate projections for Tunisia indicate a significant warming across all regions, more pronounced in summer than in winter, consistent with historical trends. According to CMIP6 scenarios, the average national temperature is expected to rise from 20.21°C during the historical period to 21.9°C by 2040–2059 (21.25°C, 10th percentile, 22.92°C, 90th percentile), with an average increase of 0.38°C per decade from 2000 to 2050 (a slower rate than historically). This warming is relatively uniform in the interior regions, while it is slightly lower in the coastal areas (approximately 0.35°C per decade). The central interior regions, including Kasserine and Sidi Bouz, are projected to experience the highest rates of warming, at around 0.41°C per decade.

The minimum temperature nationwide increases from 14.93°C (1995–2014) to 16.55°C (15.97°C, 17.52°C) for the period 2040–2059. The 2000–2050 projected trend is 0.35°C per decade. The maximum temperature increases from 25.52°C to 27.24°C (26.44°C, 28.37°C) for the same periods, and the projected trend is higher, 0.40°C per decade. Similar to the historical period, maximum temperatures are projected to rise more rapidly than minimum temperatures, with the most pronounced increase occurring during summer at a rate of 0.52°C per decade.

See **Table A3** for projected changes in temperature across regions. Projected warming under SSP2-4.5 and SSP1-2.6 is lower, and under SSP5-8.5, higher (**Fig. 5**).

FIGURE 5A. Projected Average Mean Surface Air Temperature for Different Climate Change Scenarios as Labeled

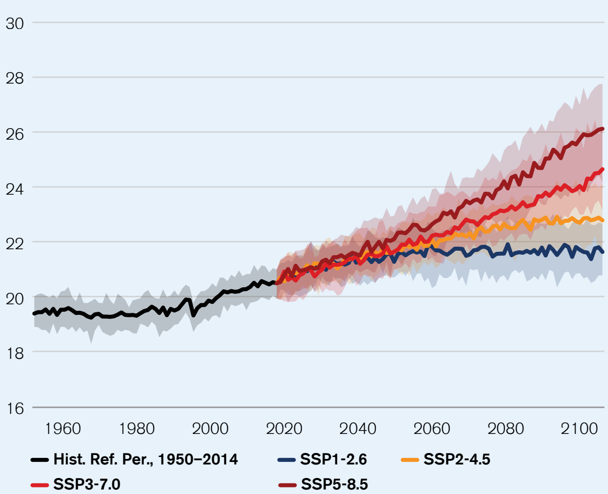
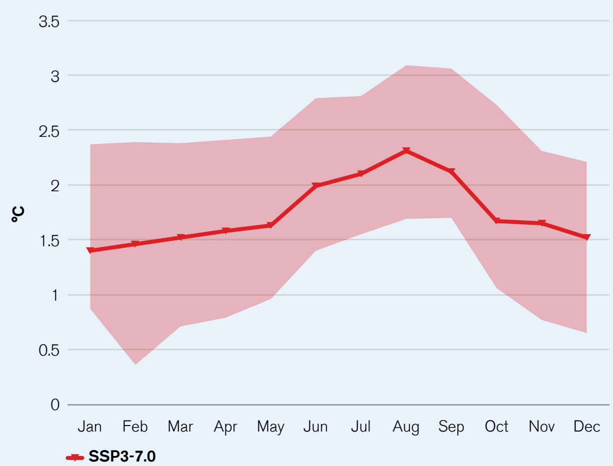


FIGURE 5B. The Projected Monthly Anomaly of the Average Mean Surface Air Temperature for 2040–2059 (relative to the reference period 1995–2014) Under SSP3-7.0, Along with the 10th–90th Percentile Dispersion Across Models



Historical Precipitation Changes

Between 1970 and 2020, precipitation in Tunisia decreased by 8.91 mm per decade, corresponding to a 3.18% decline per decade relative to the reference period (1995–2014). However, this decline is not statistically significant at the national level and is not evident over longer timescales (1950–2020) or in more recent decades (1990–2020) (**Fig. 6**). During 1970–2020, much of the country experienced this decline, with significant decreases observed in the southern regions of Tozeur, Kebili, Gabes, Medenine, and Tataouine. These areas showed more pronounced percentage reductions, exceeding an 8% decrease in Tozeur and Kebili. This trend places increased pressure on water management strategies, particularly in agriculture-dependent areas that rely heavily on seasonal rainfall. See **Table A2** for historical changes in precipitation across regions.

FIGURE 6A. Tunisia's Annual Precipitation Between 1951 and 2023 and Decadal Trends for Different Periods as Indicated

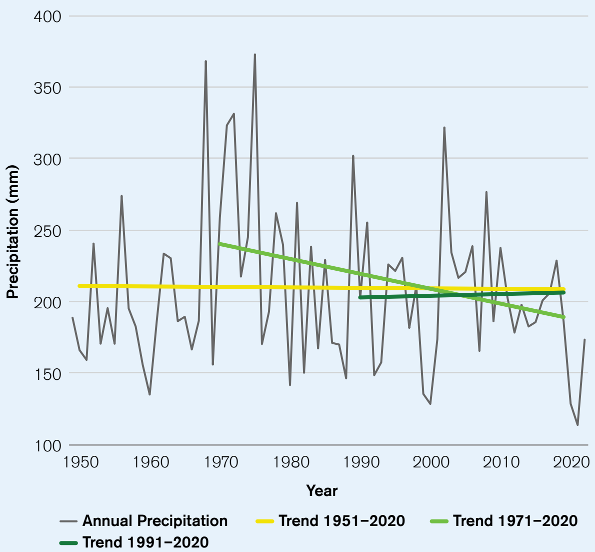
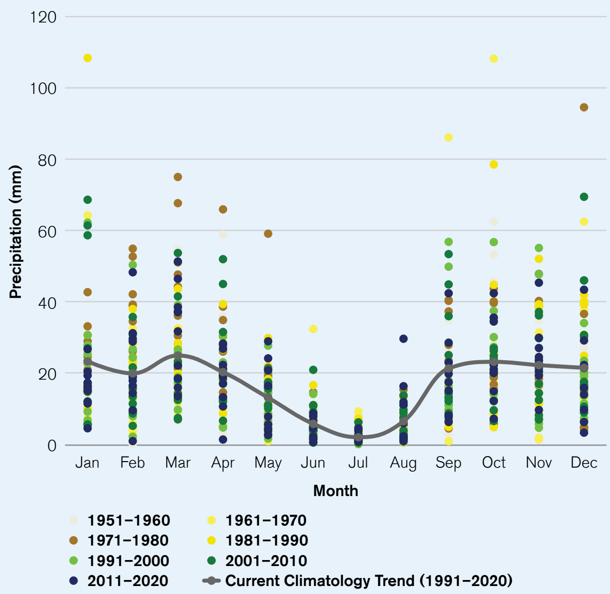


FIGURE 6B. Tunisia's Variability in Average Monthly Precipitation 1951–2020. Note the High Interannual Variability



Projected Precipitation Changes

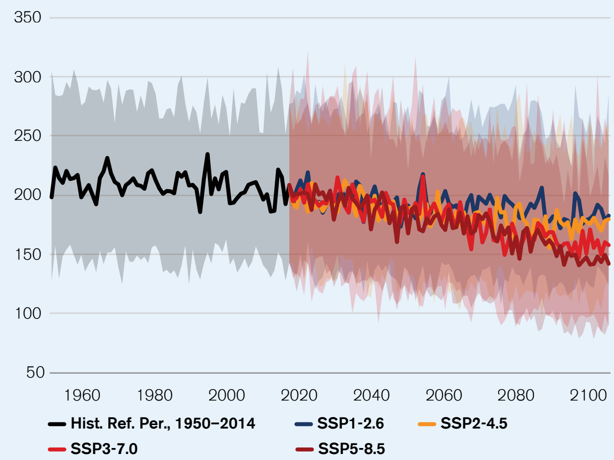
Under SSP3-7.0, Tunisia's average annual precipitation is projected to decline consistently across the country. It is expected to decrease from 207.97 mm (169.47 mm at the 10th percentile, 249.39 mm at the 90th percentile) during the historical period (1995–2014) to 191.54 mm (128.33 mm, 258.39 mm) for 2040–2059, representing a 7.90% reduction. However, this decrease is not statistically significant due to high interannual variability. The precipitation trend is most pronounced—but not robust across CMIP6 models—in the northwestern region (**Fig. 7**), where rainfall is typically highest.

From 2000 to 2050, the anticipated trend is a decrease of 3.06 mm per decade, equivalent to a 1.47% reduction per decade relative to the historical period. This decline is smaller than the decadal trend observed historically. Northern regions are expected to experience reductions exceeding 1.5% per decade, consistent with historical patterns, while southern regions are projected to see minimal changes in precipitation, contrasting with historical trends.

Precipitation changes are projected to become significant (above the high natural variability) soon for desertic regions, interior regions, and northern mediterranean regions (2050 maximum) and a decade later or so for eastern mediterranean coastal regions.

See **Table A4** for projected changes in precipitation across regions.

FIGURE 7. Projected Annual Precipitation for Different Climate Change Scenarios as Labeled, Along with the 10th–90th Percentile Dispersion Across Models



IMPACTS OF A CHANGING CLIMATE

Hot Days

Hot days pose significant risks to both human and animal health, increasing the likelihood of heat-related illnesses, while also heightening the threat of wildfires, damaging crops, straining water supplies, increasing irrigation needs, and driving up energy demand, all of which can disrupt infrastructure, ecosystems, food security, and livelihoods.

The frequency of extreme temperature events is projected to increase significantly. The number of hot days, where maximum temperatures exceed 35°C, is expected to rise from 57.02 days per year (nearly 2 months annually) during the historical period to 83.54 days per year (almost 3 months) by 2040–2059 under SSP3-7.0. Note that the southern interior regions of Tozeur, Kebili, and Tataouine already experience approximately 3 months per year with temperatures exceeding 35°C. Tunisia is projected to experience an increase of 6.19 additional hot days per decade between 2000 and 2050. This rise is particularly pronounced in the interior regions east of the mountains—Kairouan, Sidi Bouzid, and Gafsa—where the trend exceeds 7 additional hot days per decade (**Table A3**).

Seasonally, this implies that July and August, which historically experienced about half the month with maximum temperatures above 35°C, will see nearly 25 days per month at these temperatures by mid-century. Additionally, June and September are projected to experience half of the month with such extreme heat. Extremely high temperatures, exceeding 40°C, will also become more common, with up to 10 days of such heat during July and August by 2040–2059 (**Fig. 8**).

FIGURE 8A. Historical (1995–2014) Monthly Number of Hot Days at Different Temperature Thresholds

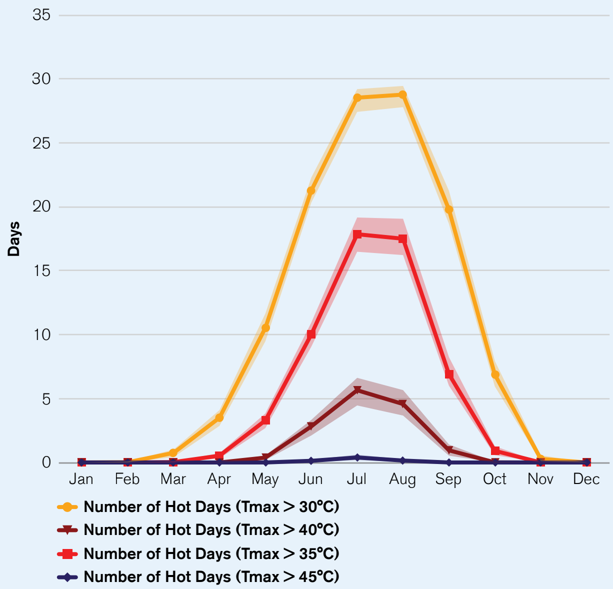
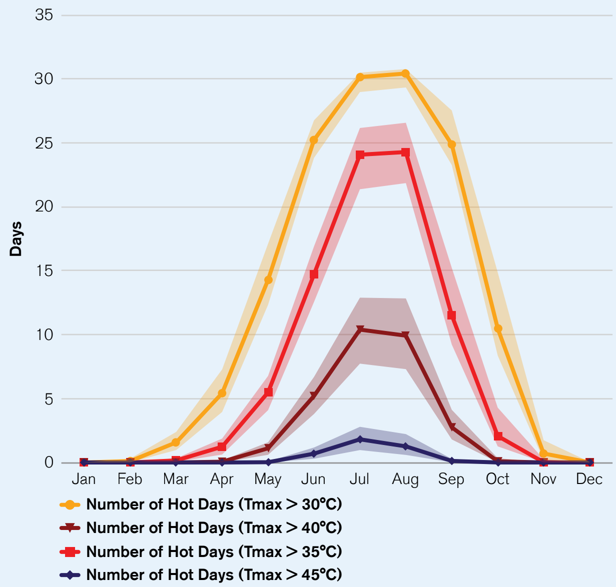


FIGURE 8B. Projected (2040–2059, SSP3-7.0) Monthly Number of Hot Days at Different Temperature Thresholds



Next, we examine the percentage of the population at high health risk due to extremely hot temperatures. High-risk areas are locations where the 50-year return level[14] of the annual number of days with maximum temperatures exceeding 40°C is greater than 20[15]. At the national level, population exposure to dangerous level of hot temperatures increases significantly, rising from 10% during 1975–2025 to 67% in 2050–2099 (centered around 2075). In the arid southern regions, a large portion of the population is already exposed to dangerous levels of extremely hot days (Tmax > 40°C) from 1975 to 2025. Specifically, Tatouine is at 87%, Tozeur at 92%, and Kebili at 100%. This exposure is expected to increase throughout the 21st century, reaching over 98% by mid-century in Gafsa, Tozeur, and Tataouine, and nearly 100% by 2075 in Gabes. Northern interior areas will start experiencing these extreme conditions by mid-century. By 2050, nearly 100% of Sidi Bouz will be exposed, while Kairouan will see 65% exposure. Le Kef, Kasserine, and Sfax will have exposure rates of 32%, 39%, and 39%, respectively, with these regions likely to be fully exposed by 2075. By the same year, the northern regions of Jendouba, Beja, and Manouba will face significant exposure, with 55%, 76%, and 94% of their populations affected, respectively. Coastal northern regions, including Bizerte, Ariana, Tunis, and Ben Arous, will also experience population exposure by 2075, though to a lesser extent, as their coastal location provides some protection from extreme heat (**Table A5**).

[14] A 50-year return level refers to an event that is expected to occur, on average, once every 50 years.

[15] Population dataset: Gridded Population of the World, Version 4: GPWv4; Revision 11, Dec 2018. For each pixel (at approximately 25 km resolution), the return level for a given return period is calculated by fitting a Generalized Extreme Value (GEV) distribution. A pixel is classified as "too risky" (1) if the return level exceeds the specified threshold, and "not too risky" (0) otherwise. The reported population exposure represents the percentage of the total population in each region that is exposed to risk (1).

Hot Nights

Hot nights pose risks to sleep quality, human health, and agricultural crops, as the lack of cooling during the night can exacerbate heat stress on plants, hindering growth and reducing yields, while also increasing the risk of heat-related illnesses, higher energy consumption, and greater strain on power grids.

The number of hot nights, or tropical nights, is projected to rise rapidly. The number of tropical nights, where nighttime (minimum) temperatures exceed 23°C, is expected to rise from 54.62 days per year (nearly 2 months annually) during the historical period to 88.66 days per year (almost 3 months) by 2040–2059 under SSP3-7.0. Tunisia is projected to experience an increase of 7.28 additional hot nights per decade between 2000 and 2050, particularly in Mediterranean northeastern regions Ariana, Tunis, Ben Arous, Nabeul, Sousse, Monastir and Mahdia (>9 additional tropical nights per decade). In the south, where tropical nights are already prominent, Kebili is projected to experience 118.52 tropical nights annually by 2050, up from 87.75 during the historical period (**Table A3**).

Seasonally, this indicates that July and August, which historically experienced over half the month with nighttime temperatures exceeding 23°C, will see more than 25 days per month at these temperatures by mid-century. Furthermore, tropical nights will increasingly extend into spring and fall. Even hotter tropical nights, with temperatures exceeding 26°C, are expected to become more frequent, reaching up to 15 days during July and August by 2040–2059, along with nearly 5 days with nighttime temperatures surpassing 29°C (**Fig. 9**).

FIGURE 9A. Historical (1995–2014) Monthly Number of Tropical Nights at Different Temperature Thresholds

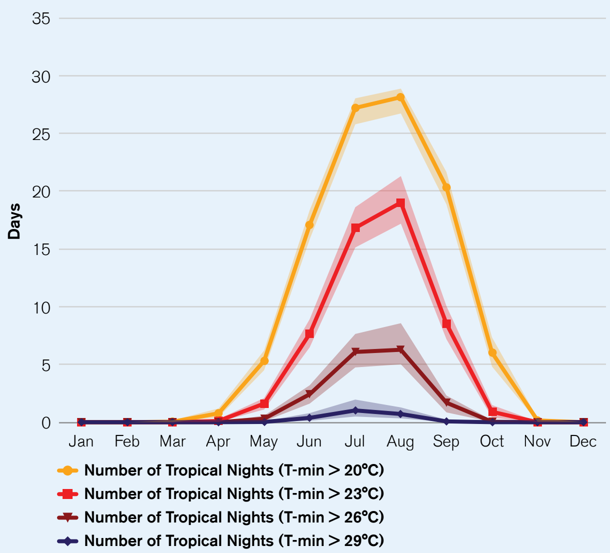
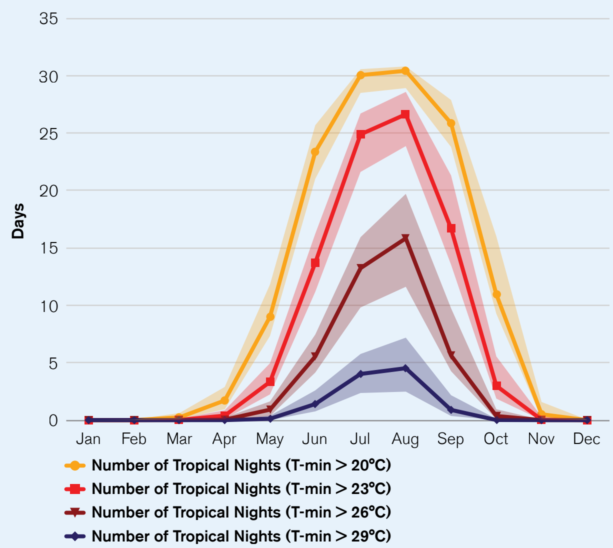


FIGURE 9B. Projected (2040–2059, SSP3-7.0) Monthly Number of Tropical Nights at Different Temperature Thresholds



Next, we examine population exposure to hot nights. High-risk areas are locations where the 50-year return level of the annual number of days with night temperatures exceeding 26°C is greater than 30. In the arid southern regions (Gafsa and further south), a significant portion of the population is already exposed to dangerous levels of hot nights (Tmin > 26°C), with nearly 100% exposure in Tozeur and Kebili during the historical period, rising to 100% across the entire south by 2050. In the central regions, Sidi Bouzid and Sfax are projected to reach 53% and 83% exposure by 2050, respectively, and 100% by 2075. While the northern regions were not exposed to such extreme nighttime temperatures historically, some areas will begin experiencing these conditions by mid-century, including Sousse (66%), Monastir (49%), Ariana (39%), Nabeul (33%), Mahdia (33%), and Kairouan (21%). Nearly total exposure is expected in these regions by 2075 (**Table A5**). The northwestern mountainous areas will see significant population exposure only by 2075, with Le Kef (83%), Siliana (72%), Kasserine (48%), and Jendouba (26%) affected. The remaining northern regions—Beja, Bizerte, Manouba, Tunis, and Ben Arous—are anticipated to face almost total exposure by 2075, though they will experience little to no exposure before that time.

Humid Heat

The Heat Index is a measure of perceived temperature that combines both air temperature and humidity[16]. When both are high, the Heat Index rises, significantly increasing the risk to human health. In such conditions, the body's ability to cool itself through sweating is impaired, which can lead to heat-related illnesses or even fatalities.

The dangerous heat index is projected to become increasingly relevant by the end of the century. During the historical period (1995–2014), only Tozeur and Kebili recorded heat index values exceeding 35°C, with 15 and 9 days, respectively. By 2040–2059, this is expected to rise to 51 days for Tozeur and 38 days for Kebili, increasing further to 95 and 84 days by the end of the 21st century (2080–2099). By then, on average, Tunisia will experience over two months each year with a dangerous heat index. Additionally, the eastern Mediterranean regions, from Sousse to Medenine, and Tatouine, will also face more than two months of dangerous heat index conditions annually. Even the mountainous areas of Le Kef, Kasserine, and Siliana are projected to experience 15 days of dangerous heat index by the end of the century (**Table A3**). This significant increase in extreme heat and humid events underscores the escalating risk of heat-related impacts on human health.

High-risk areas are locations where the 50-year return level of the annual number of days with heat index exceeding 35°C is greater than 20. Historically, only the low-lying desert regions of Kebili and Tozeur have seen more than 50% of the population exposed. While most areas are currently unaffected, forecasts indicate that by 2035 (central year), all desert regions and coastal areas up to Sousse will be impacted, with risks extending to northern regions by 2075. By that time, only the northern mountainous areas of Le Kef, Kasserine, and Siliana are expected to have some population remaining unexposed. Specifically, Le Kef and Siliana are projected to have a 75% exposure rate, while Kasserine is expected to see 37% exposure by 2075. This increase in heat and humidity may exacerbate heat stress, posing significant public health risks (**Table A5**).

Furthermore, exposure to dangerous wet-bulb temperatures—an alternative measure of heat and humidity[17]—becomes widespread across coastal regions from Bizerte to Medenine only in the latter half of the 21st century

[16] Heat Index as defined by US-National Weather Service - Steadman R.G., 1979: The assessment of sultriness, Part I: A temperature-humidity index based on human physiology and clothing science. J. Appl. Meteorol., 18, 861–873, doi: http://dx.doi.org/10.1175/1520-0450

[17] Stull R., 2011: Wet-bulb temperature from relative humidity and air temperature. J. Appl. Meteorol. Climatol., 50(11), 2267–2269, doi: 10.1175/JAMC-D-11-0143-1

(by 2075), with no significant exposure observed prior to that period. The exposure is particularly high in Ariana (82%) and Ben Arous (78%) by 2075 (**Table A5**). High-risk areas are locations where the 50-year return level of the annual number of days with wet bulb temperatures exceeding 27°C is greater than 15.

Drought

In addition to declining overall rainfall, the frequency and intensity of dry periods are changing. The maximum yearly number of consecutive dry days[18], indicating prolonged dry spells, is 108 days historically, based on ERA5 data (1991–2020). This value shows considerable interannual variability, ranging from 80 to 150 days, and has not changed significantly in recent decades, except in the eastern regions of Kairouan, Sousse, and Mahdia. In these areas, the number of consecutive dry days has shortened by approximately 3 days per decade from 1971 to 2020, reaching 52, 72, and 76 days, respectively, by the 1991–2020 period. Most of the rest of Tunisia has experienced an increase in consecutive dry days, but these changes are not significant when compared to the natural interannual variability.

Into the future (CMIP6 models), the maximum number of consecutive dry days is projected to increase slightly nationwide, from 112 days historically to 114 days by 2040–2059 (under SSP3-7.0). This increase is most pronounced in northern regions such as Beja, Bizerte, and Manouba, where more than 2 additional dry days per decade are expected—equivalent to 10 extra days over 50 years. Other northern regions are projected to experience around 1.5 additional dry days per decade. The trend remains insignificant in the southern regions (**Table A4**).

Conversely, consecutive wet days (CWD)[19], representing sustained rainy periods, show minimal changes across most regions. Nationally, the average remains at approximately 5 days. Northwestern areas like Jendouba, Beja, and Bizerte maintain an average of about 11 consecutive wet days, while the southern desert regions experience only 3 to 4 consecutive wet days (**Table A4**).

Many regions in Tunisia already endure prolonged droughts, with most areas experiencing 100% population exposure—a trend that is expected to continue in the future. High-risk areas are locations where the 50-year return level of consecutive dry days in a year exceeds 90. The mountainous northwestern regions, including Jendouba, Siliana, Le Kef, and Kasserine, are exceptions. During the historical period, these regions showed exposure rates of 56%, 33%, 24%, and 18%, respectively. By 2035 (2010–2059), these rates are projected to increase to 73%, 53%, 59%, and 31%. By the end of the century, exposure rates are expected to approach 100% in these areas, except for Kasserine, which is projected at 84%. As a result, droughts are anticipated to persist or intensify through 2075 (2050–2099), leading to extended dry spells. This will likely strain water resources, reduce agricultural productivity, and heighten the risk of desertification across Tunisia (**Table A6**).

[18] The largest number of consecutive dry days (<1 mm) each year.
[19] The largest number of consecutive wet days (>1 mm) each year.

Extreme Precipitation

In a warmer world, the potential of air to carry moisture goes up exponentially, and thus the potential for heavier precipitation goes up. As expected, the Future Return Period of Largest 1-Day Precipitation is decreasing almost everywhere in Tunisia. This means that intense precipitation events will likely recur more frequently (e.g. the return period will decrease), which can negatively affect the flooding risk, and be dangerous for infrastructure, human safety, or agriculture. Flash floods will become more frequent due to intense rain events combined with overall drier conditions. The largest fractional change is projected for rare 100-yr return periods events, which will be 20% more frequent by 2050 under the SSP3-7.0 scenario (1.20 in **Table 1**), and twice as frequent by the end of the century. However, the uncertainty in the prediction is large (**Table 1**), especially for very rare 100-yr events. The northeastern coastal regions such as Ben Arous or Ariana are the most affected with even larger fractional changes. In Tunisia, the 100-year return level for the largest 1-day precipitation is 54 mm, equivalent to the amount of rainfall that would typically accumulate over 1.5 months during winter, condensed into a single day.

TABLE 1. Future (2035–2064) and (2070–2099) Return Period (years) for Extreme Precipitation Events that Correspond to the Return Levels for the Largest Single-Day Event During the Historical Period (1985–2014) for SSP3-7.0. Change in Future Exceedance Probability Expressed as Change Factor for Extreme Precipitation Events that Correspond to the Return Levels for the Largest Single-Day Event During the Historical Period (1985–2014) for Future (2035–2064) and (2070–2099) SSP3-7.0.

Time Period	Historical Return Period (1985–2014, center 2000)					
1985–2014 center 2000	5-yr	10-yr	20-yr	25-yr	50-yr	100-yr
	Future Return Period (years) - Median (10th, 90th)					
2035–2064 center 2050	4.89 (3.13–7.53)	9.45 (5.37–17.12)	18.18 (8.86–39.86)	22.48 (10.35–52.18)	43.70 (16.29–124.41)	86.20 (25.15–304.55)
2070–2099 center 2085	4.54 (3.03–6.91)	8.10 (4.92–14.77)	14.69 (7.54–33.05)	17.65 (8.58–42.46)	30.55 (12.57–93.16)	52.17 (18.20–200.49)
	Change in Future Annual Exceedance Probability (change factor) - Median (10th, 90th)					
2035–2064 center 2050	1.03 (0.63–1.53)	1.07 (0.56–1.78)	1.12 (0.47–2.15)	1.13 (0.44–2.28)	1.17 (0.35–2.81)	1.20 (0.29–3.50)
2070–2099 center 2085	1.11 (0.66–1.60)	1.25 (0.63–1.96)	1.39 (0.58–2.44)	1.45 (0.56–2.63)	1.69 (0.50–3.39)	2.00 (0.44–4.58)

Fractional Change Above 1 Indicates Increased Probability and Decreased Return Period. For Example, a Fractional Change of 1.20 Indicates a 20% Increase in the Probability of Suffering 100-Year Extreme Precipitation Events in the Future, or 1.2 More Likely.

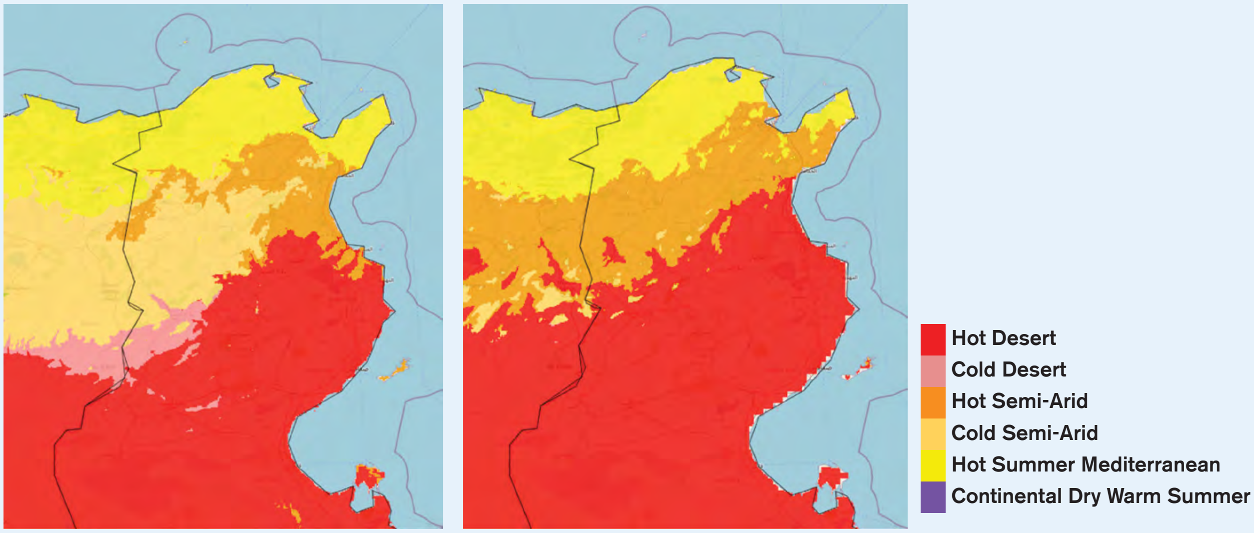
High-risk areas are locations where the 50-year return level of the highest monthly total precipitation exceeds 250mm. The only regions affected, now and in the future, are Jendouba (35%) and Beja (9%). The population exposed to large rain events stays stable through the 21st century in these two regions.

Desertification, Sand and Dust Storms

Desertification, typically driven by anthropogenic pressures such as urbanization and agriculture, poses one of the highest risks in Tunisia. The impact of human activities on the land has accelerated the degradation of arid and semi-arid areas, leading to a loss of productive soil and increased vulnerability to desert expansion. With climate change, warming is projected to further intensify desertification across the country, exacerbating the already critical situation.

As temperatures rise and precipitation patterns shift, only a smaller region of Tunisia is expected to retain its Mediterranean climate, where rainfall remains significant (**Fig. 10**). This shrinking zone of Mediterranean climate will become increasingly crucial for sustaining agriculture and human habitation, highlighting the urgent need for sustainable land management practices and climate adaptation strategies to mitigate the impacts of both desertification and climate change.

FIGURE 10. Köppen-Geiger Climate Classification, Historical 1991–2020 and Projected 2071–2099 Under SSP3-7.0, from https://koppen.earth/



Sand and dust storms originating from the Sahara Desert can affect Tunisian cities and agriculture. While sandstorms have a limited reach, dust storms can reach thousands of kilometers. Saharan dust storms can affect Tunisia's cities, European countries and even cross the Atlantic Ocean, affecting air quality, and hence human's health, agriculture and infrastructure. Historically, significant dust events in Northern Africa have been associated with drought conditions and increased wind speeds caused by changes in the pressure-temperature gradient[20].

[20] Clifford et al. (2019). A 2000 Year Saharan Dust Event Proxy Record from an Ice Core in the European Alps, JGR Atmospheres, 124, 23, DOI: https://doi.org/10.1029/2019JD030725

Research suggests that the main driver for decadal variability in dust storms is the Atlantic Meridional Oscillation AMO[21]. Climate science indicates that future warming will lead to less frequent but more intense dust events. The decreased frequency is attributed to the expected weakening of winds, possibly linked to a slowdown in tropical circulation[22]. However, the storms will be more intense due to greater dust availability resulting from increased drought occurrences.

Sea Surface Temperatures

The Mediterranean Sea maintains a relatively warm average sea surface temperature of 19.2°C[23]. Sea surface temperatures typically range from around 15°C in late winter (Feb–March) to approximately 26°C in late summer (August) (historical, 1995–2014, multi-model CMIP6 average). These high temperatures in late summer are known to trigger sudden large, localized storms around late summer and early fall that might affect the northern region of Tunisia. With climate change, the Mediterranean basin is already suffering more marine heatwaves. Under the scenario SSP3-7.0, sea surface temperatures are projected to increase 0.7°C (0.5°C, 10th percentile, 1.1°C, 90th percentile) near-term (2021–2040), 1.3°C (1°C, 1.8°C) by mid-century (2041–2060), and 2.8°C (2°C, 3.6°C) long term (2081–2100). The increase in temperatures is slightly higher during summer than winter.

Sea Level Rise

According to altimetry (satellite) data, sea level rose 9 centimeters total from 1993 to present on average in Tunisia[24].

Under the SSP3-7.0 scenario, sea level is expected to rise 16 centimeters total from 2020 to 2050, with a likely range from 10 to 23 centimeters. This means that sea level rise is projected to increase by 0.23 meters by 2050 and 0.68 meters by 2100 under the SSP3-7.0 scenario, relative to the historical period (1995–2014) (**Fig. 11**).

Over the next two decades, sea level rise is expected to occur at a similar rate regardless of emissions, scenarios, or warming levels. However, beyond this period, high-emission scenarios project significantly greater increases in sea level. Despite uncertainties, it is certain that sea levels will continue to rise across all scenarios for centuries, underscoring the need for long-term planning. Sea level rise could reach 0.3 m above historical conditions before 2050 in all scenarios, and 0.5 m during the second half of the 21st century[25]. "Under the SSP3-7.0 scenario, there is a 92% chance of exceeding half meter of global sea level rise and 9% chance of exceeding 1 meter of global sea level rise by 2100"[26].

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[21] Shao, Klose, and Wyrwoll (2013). Recent global dust trend and connections to climate forcing, JGR Atmospheres, 118, 19, DOI: https://doi.org/10.1002/jgrd.50836

[22] Evan et al. (2016). The past, present and future of African dust, Nature 531, 493–495, DOI: https://doi.org/10.1038/nature17149

[23] IPCC AR6 WGI Interactive Atlas https://interactive-atlas.ipcc.ch/.

[24] NASA https://earth.gov/sealevel/sea-level-explorer/

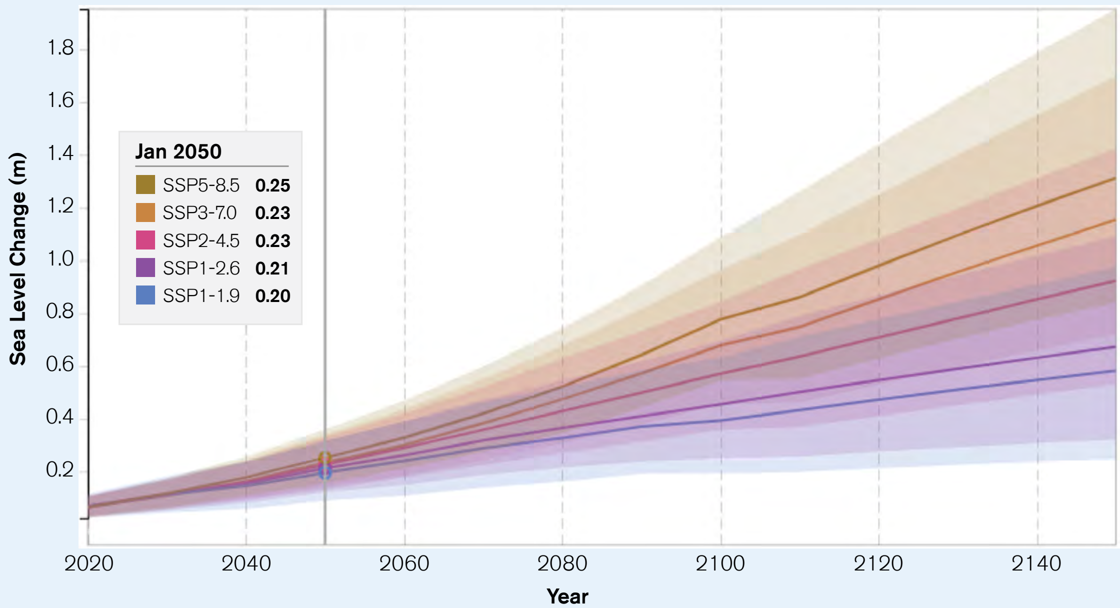
[25] NASA https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool?lat=37&lon=%2011&data_layer=scenario

[26] NASA https://earth.gov/sealevel

"On average across the coastlines of Tunisia there were 27 days total exceeding the minor high water level between 1980 and 1990, and 46 between 2005 and 2015"[27]. The minor high-water level is defined as 40 cm above the average high tide (mean higher high water, MHHW) and serves as an indicator of potential flooding impacts.

Sea level rise and coastal inundation will pose an increasing threat to Tunisia's coastal zones, particularly along stretches with sandy beaches. Hzami et al. (2021)[28] illustrates the coastal vulnerability index, which is particularly high along all the eastern Mediterranean coast in Tunisia. This index was calculated considering factors such as geomorphology, coastal slope and elevation, shoreline retreat rate, sea-level rise, mean wave height, and mean tide range. Coastal vulnerability is further amplified when combined with high population density or significant infrastructure.

FIGURE 11. Projected Total Sea Level Change Under Different SSP Scenarios Relative to the Historical Baseline (1994–2014). The Shaded Ranges Show Uncertainties at 17th–83rd Percentile Ranges. Data Reflects the Grid at 37°N, 11°W (along Tunisia northeast corner). Data from NASA Sea Level Projection Tool[29].



[27] NASA https://earth.gov/sealevel
[28] Hzami et al. 2021. Alarming coastal vulnerability of the deltaic and sandy beaches of North Africa. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7840745
[29] NASA https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool?lat=37&lon=%2011&data_layer=scenario

Food Security

Food security, and hence water security, is increasingly affected by climate change and desertification as temperatures rise and droughts intensify. Drought hazard is already high in Tunisia (Carrao et al., 2016[30]), and the number of moderate-to-severe drought days is projected to increase further especially in the Mediterranean region and North African countries, including Tunisia (Pokhrel et al. 2021[31]).

These factors are projected to alter agricultural productivity and disrupt the seasonal cycle of crops. Furthermore, increased evaporation rates and warming will heighten the demand for irrigation, posing challenges in a country already facing severe water scarcity. The renewable shallow aquifers in the Northern Mediterranean regions, already facing salinization, are projected to warm due to climate change (Benz et al., 2024[32]). This warming could lead to new challenges related to health and water quality.

Due to climate change, sheep in Tunisia are projected to experience increasing heat stress. According to Thornton et al. (2021)[33], sheep will endure two to four additional months of heat stress annually by the end of the 21st century compared to 2000 depending on the region. This projection is under the extreme SSP5-8.5 scenario, with an estimated warming of approximately 4.5°C by the end of the century (compared to the pre-industrial period).

By 2090–2099, marine animal biomass along Tunisia's coast is projected to decline by up to 40% along the Mediterranean coast under the high-emissions scenario RCP8.5 (compared to 1990–1999 levels) (Tittensor et al., 2021[34]). These projections reflect the impact of climate change alone.

Note that this summary provides a broad overview of external sources and is not an exhaustive list.

Natural Hazards

Climate change is now recognized to have a significant impact on disaster management efforts and poses a significant threat to the efforts to meet the growing needs of the most vulnerable populations. EM-DAT[35] shows flood as the most relevant natural hazard (from 1980 to now). Think Hazard[36] identifies river floods, urban floods, coastal floods, extreme heat, and wildfires as the highest natural risks, followed by earthquakes, landslides, tsunamis, and water scarcity, categorized as medium risk—most of which are closely linked to the climate crisis.

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[30] Carrao, Naumann, Barbosa (2016). Mapping global patterns of drought risk: An empirical framework based on sub-national estimates of hazard, exposure and vulnerability. Global Env. Change, Volume 39, Pages 108–124, DOI: https://doi.org/10.1016/j.gloenvcha.2016.04.012

[31] Pokhrel et al. (2021). Global terrestrial water storage and drought severity under climate change. Nat. Clim. Chang. 11, 226–233, DOI: https://doi.org/10.1038/s41558-020-00972-w

[32] Benz et al. (2024). Global groundwater warming due to climate change. Nat. Geosci. 17, 545–551, DOI: https://doi.org/10.1038/s41561-024-01453-x

[33] Thornton et al. (2021). Increases in extreme heat stress in domesticated livestock species during the twenty-first century. Global Change Biology, Volume 27, 22, 5762–5772, DOI: https://doi.org/10.1111/gcb.15825

[34] Tittensor et al. (2021). Next-generation ensemble projections reveal higher climate risks for marine ecosystems. Nat. Clim. Chang. 11, 973–981, DOI: https://doi.org/10.1038/s41558-021-01173-9

[35] The International Disaster Database https://www.emdat.be/

[36] Think Hazard, GFDRR, https://thinkhazard.org/en/report/248-tunisia

ANNEX – TABLES: HISTORICAL AND PROJECTED CHANGES ACROSS REGIONS

Historical Climate and Changes Across Regions

Table A1 and A2 show the variations in historical temperature and precipitation across Tunisia's districts.

TABLE A1. Historical a) Air Surface Temperature Averages (1991–2020), CRU, and b) Trends per Decade (1971–2020), ERA5, for Temperatures (in deg C), Colored According to Intensity. The Decadal Trend is Bolded Whenever Significant at a 90% level. The Regions are Organized Approximately from North to South and from West to East.

Region	Historical Air Surface Temperature Averages (1991–2020) (degrees C)					Trend per Decade (1971–2020)		
	Temp	Min Temp (night temp)	Max Temp (day temp)	Coldest Month (January) temp	Warmest Month (July or August) temp	(degrees C/ decade)	Min Temp	Max Temp
Tunisia	20.51	14.74	26.33	11	30.11	**0.46**	**0.43**	**0.52**
Jendouba	17.67	11.83	23.56	9.59	26.85	**0.38**	**0.3**	**0.45**
Beja	18.43	12.77	24.14	10.16	27.49	**0.42**	**0.36**	**0.51**
Bizerte	18.71	13.52	23.96	11.01	27.44	**0.36**	**0.33**	**0.41**
Manouba	19.06	13.63	24.54	11.02	28.02	**0.42**	**0.39**	**0.49**
Ariana	19.15	14.14	24.21	11.04	28.02	**0.35**	**0.33**	**0.37**
Tunis	19.22	14.16	24.32	11.02	28.12	**0.39**	**0.37**	**0.44**
Ben Arous	19.23	14.16	24.34	11.04	28.14	**0.41**	**0.39**	**0.47**
Nabeul	19.26	14.96	23.6	11.67	27.83	**0.38**	**0.39**	**0.37**
Le Kef	16.99	10.83	23.2	8.1	26.97	**0.43**	**0.35**	**0.55**
Siliana	17.65	11.65	23.68	8.76	27.54	**0.47**	**0.4**	**0.58**
Zaghouan	18.98	13.48	24.52	10.67	28.24	**0.45**	**0.42**	**0.53**
Kairouan	19.44	13.46	25.46	10.75	28.96	**0.49**	**0.44**	**0.59**
Sousse	20.07	14.67	25.53	11.79	29.17	**0.45**	**0.43**	**0.49**
Monastir	20.19	15.44	25.01	12.11	28.96	**0.44**	**0.43**	**0.45**
Mahdia	20.01	14.84	25.23	11.83	28.84	**0.47**	**0.46**	**0.49**
Kasserine	17.16	11.04	23.32	7.55	27.72	**0.42**	**0.36**	**0.53**
Sidi Bouz	19.48	13.51	25.5	10.38	29.12	**0.44**	**0.39**	**0.53**
Sfax	19.98	14.72	25.3	11.7	28.78	**0.46**	**0.44**	**0.49**
Gafsa	19.89	13.76	26.08	9.84	30.21	**0.44**	**0.38**	**0.55**
Tozeur	22.1	15.88	28.37	11.36	32.79	**0.46**	**0.35**	**0.58**
Kebili	22.11	16.19	28.08	11.72	32.21	**0.48**	**0.45**	**0.56**
Gabes	20.75	15.61	25.94	11.72	29.86	**0.48**	**0.45**	**0.53**
Medenine	21.55	16.54	26.6	12.67	30.29	**0.46**	**0.46**	**0.45**
Tataouine	22.14	16.1	28.22	11.63	31.79	**0.48**	**0.48**	**0.5**

TABLE A2. a) Historical Data (1991–2020), CRU and b) Decadal Trend (1971–2020), ERA5, for Annual Precipitation (in mm), c) Historical Annual Maximum Number of Consecutive Dry Days (daily accumulated precipitation < 1 mm), ERA5, and d) Historical Annual Number of Consecutive Wet Days (daily accumulated precipitation ≥ 1 mm), ERA5, Color-Coded by Intensity. Interannual Variability is Expressed as the Standard Deviation of Annual Total Values from 1990 to 2020 (ERA 5). Significant Decadal Trends, at the 90% Confidence Level, are Highlighted in Bold.

	Historical Precipitation Yearly Averages (1991–2020)					Precipitation Trend per Decade (1971–2020)		Hist Drought Days	Hist Wet Days
Regions	**Total PR (mm)**	**Interannual Variability (mm)**	**Min (mm) (July)**	**Max (mm)**	**Month max**	**Trend (mm)**	**Trend (% respect hist)**	**CDD (days)**	**CWD (days)**
Tunisia	280.56	21.09	2.29	35.65	Oct	–8.91	–3.18	107.72	4.12
Jendouba	933.01	59.07	4.1	72.56	Jan	–14.48	–1.55	46.61	8.89
Beja	760.53	53.03	4.04	69.57	Jan	–11.89	–1.56	50.35	7.71
Bizerte	700.28	57.71	2.8	102.11	Jan	–18.62	–2.66	60.82	8.18
Manouba	604.9	51.56	3.57	111.35	Jan	–9.54	–1.58	56.4	6.3
Ariana	527.91	53.79	3.21	32.52	Jan	–12.86	–2.44	71.49	7.12
Tunis	510.48	53.24	3.51	30.85	Jan	–11.08	–2.17	66.1	6.32
Ben Arous	509.06	52.34	3.56	143.85	Jan	–11.96	–2.35	67.38	6.07
Nabeul	483.54	52.76	2.8	56.33	Dec	–8.09	–1.67	75.07	6.57
Le Kef	740.25	48.3	6.84	54.72	Jan	–9.83	–1.33	36.36	6.3
Siliana	699.16	49.45	7.11	17.12	Jan	–8.24	–1.18	37.77	6.12
Zaghouan	551.57	51.69	5.28	102.98	Jan	–8.08	–1.46	55.85	5.58
Kairouan	422.45	40.39	5.71	52.17	Oct	–3.34	–0.79	52.18	4.64
Sousse	382.49	44.09	4.35	84.85	Oct	–6.76	–1.77	70.15	4.66
Monastir	334.28	41.77	3.09	55.41	Oct	–7.49	–2.24	72.46	5.08
Mahdia	303.48	35.53	2.99	34.11	Oct	–5.36	–1.77	76.16	4.55
Kasserine	461.39	33.32	8.46	66.96	Jan	–9.41	–2.04	39.11	5.13
Sidi Bouz	308.44	30.3	4.44	44.8	Oct	–4.95	–1.60	62.44	4.24
Sfax	258.08	28.59	2.27	39.58	Oct	–9.32	–3.61	94.04	4.12
Gafsa	211.48	23.73	2.83	94.12	Sept	–6.03	–2.85	76.2	3.66
Tozeur	102.69	18.59	0.59	56.01	Sept	**–8.29**	**–8.07**	120.25	3
Kebili	105.54	14.56	0.18	14.56	Oct	**–8.68**	**–8.22**	146.33	2.9
Gabes	183.33	22.58	0.79	17.21	Oct	**–11.24**	**–6.13**	124.47	3.61
Medenine	165.53	24.33	0.21	70.06	Oct	**–10.71**	**–6.47**	135.66	3.79
Tataouine	92.13	13.34	0.07	71.49	Oct	**–5.16**	**–5.60**	162.46	2.77

Projected Climate and Changes Across Regions

Table A3 and A4 show the variations in CMIP6 historical and projected temperature and precipitation related variables across Tunisia's districts.

TABLE A3. CMIP6 Simulated Historical Averages (1994–2015), Mid-Century SSP3-7.0 Projections (2040–2059), and Decadal Trends (2000–2050) for a) Average Surface Air Temperature, b) Number of Hot Days per Year with Tmax > 35°C, c) Number of Tropical Nights per Year with Tmin > 23°C, and d) Number of Days with Heat Index > 35°C (only for 2040–2059 and 2080–2099, as values are projected to be zero before).

	Average Surface Air Temperature (degrees C)			Number of Hot Days per Year with Tmax > 35°C (days)			Number of Tropical Nights per Year with Tmin > 23°C (days)			Number of Days per Year with HeatIndex > 35°C (days)	
Regions	**1994–2015**	**2040–2059**	**Trend**	**1994–2015**	**2040–2059**	**Trend**	**1994–2015**	**2040–2059**	**Trend**	**2040–2059**	**2080–2099**
Tunisia	20.21	21.9	0.38	57.02	83.54	6.19	54.62	88.66	7.28	19.85	60.2
Jendouba	17.48	19.12	0.37	12.87	30.54	4.54	8.27	33.29	4.95	2.7	25.82
Beja	18.32	19.9	0.35	18.76	41.77	5.51	10.29	43.17	6.69	4.41	36.06
Bizerte	18.71	20.21	0.33	6.3	18.69	2.87	24.58	63.01	7.99	5.76	40.88
Manouba	19.14	20.66	0.35	19.85	47.03	6.08	17.93	57.73	8.17	7.89	47.4
Ariana	18.98	20.51	0.35	3.13	10.08	1.39	41.99	84.88	9.11	6.96	47.82
Tunis	19.04	20.58	0.36	8.08	22.69	3.27	28.1	72	9.38	7.67	49.83
Ben_Arous	18.93	20.49	0.36	8.04	25.15	3.89	20.49	63.62	9.29	6.5	48.17
Nabeul	18.88	20.42	0.35	0.9	4.31	0.75	39.01	83.73	9.88	4.8	45.9
Le_Kef	17.18	18.91	0.39	28.38	55.68	6.68	6.38	28.41	4.55	1.12	17.32
Siliana	17.29	18.98	0.37	20.36	45.18	6.06	5.67	28.52	4.73	1.19	17.81
Zaghouan	18.67	20.28	0.36	19.74	47.52	6.6	10.86	46.64	7.46	4.6	40.59
Kairouan	19.21	20.88	0.38	38.19	68.93	7.3	21.37	59.08	8.04	9.25	46.52
Sousse	19.84	21.45	0.36	27.09	53.86	6.23	35.8	79.5	9.47	14.22	61.49
Monastir	20.04	21.58	0.35	17.27	44.1	6.5	41.51	83.7	9.27	15.17	63.83
Mahdia	20.15	21.72	0.36	26.45	54.71	6.7	40.37	83.13	9.26	17.24	65.75
Kasserine	16.86	18.64	0.41	29.47	57.15	6.77	7.63	29	4.41	0.88	12.87
Sidi_Bouz	19.59	21.3	0.41	47.56	79.37	7.29	32.91	72.6	8.22	12.1	51.73
Sfax	20.25	21.87	0.38	26.07	52.96	6.26	57.88	96.61	8.26	21.58	71.07
Gafsa	19.85	21.6	0.4	59.65	89.91	7.09	55.56	91.69	7.86	15.99	56.62
Tozeur	22.29	24.06	0.38	100.62	124.97	5.63	105	130.52	5.58	51.13	94.93
Kebili	21.79	23.52	0.38	92.49	118.83	6.03	87.75	118.52	6.78	37.92	84.39
Gabes	20.67	22.35	0.39	46.36	76.53	6.96	65.63	103.02	8.09	26.57	74.64
Medenine	20.97	22.58	0.36	36.71	63.53	6.06	67.79	105.03	7.98	27.06	75.47
Tataouine	21.41	23.14	0.39	88.02	115.82	6.44	73.65	109.69	7.74	22.04	67.69

TABLE A4. CMIP6 Simulated Historical Averages (1994–2015), Mid-Century SSP3-7.0 Averages (2040–2059), and Trends per Decade (2000–2050) for a) Precipitation, b) Maximum Number of Consecutive Dry Days (CDD), and c) Maximum Number of Consecutive Wet Days (CWD). The Table also Indicates the Year of Emergence for the Precipitation Trend (the year when precipitation change arises significantly above natural variability, calculated from 2005 to 2100). For CWD, We Only Show the Historical Value as the Trend is Insignificant. Trend is Reported by Decade or Percentage (with respect to the historical period).

	Precipitation (mm)						Consecutive Dry Days (days)			CWD (days)
Regions	1994–2015	2040–2059	% Change (hist to 2050)	Trend	Trend (%)	Year of Emergence	1994–2015	2040–2059	Trend	1994–2015
Tunisia	207.97	191.54	–7.90	–3.06	–1.47	2036	111.85	114.28	1.15	5.26
Jendouba	687.47	616.12	–10.38	–13.38	–1.95	2041	43.27	51.79	1.8	11.71
Beja	531.87	480.01	–9.75	–11.03	–2.07	2045	50.52	58.98	2.28	10.44
Bizerte	569.44	515.15	–9.53	–10.95	–1.92	2044	59.15	68.37	2.41	11.17
Manouba	414.27	373.29	–9.89	–7.54	–1.82	2046	60.85	69.11	2.24	9.13
Ariana	474.64	428.06	–9.81	–8.19	–1.73	2052	72.6	78.62	1.64	9.84
Tunis	435.26	392.85	–9.74	–7.47	–1.72	2051	69.53	75.48	1.43	9.14
Ben_Arous	421	379.39	–9.88	–7	–1.66	2052	69.09	75	1.33	8.8
Nabeul	441.61	398.97	–9.66	–7.67	–1.74	2056	72.44	80.33	1.96	9.49
Le_Kef	429.72	381.86	–11.14	–8.19	–1.91	2039	39.58	48.91	1.73	8.49
Siliana	441.4	395.49	–10.40	–8.14	–1.84	2046	40.76	47.27	1.61	8.57
Zaghouan	403.41	363.53	–9.89	–6.29	–1.56	2052	58.5	64.4	1.6	8.17
Kairouan	322.36	297.19	–7.81	–5.59	–1.73	2059	63.15	68.18	1.32	6.69
Sousse	317.52	292.88	–7.76	–5.5	–1.73	2062	77.84	81.43	1.46	7.1
Monastir	326.27	307.69	–5.69	–5.33	–1.63	2066	80.08	84.43	1.23	7.19
Mahdia	268.65	253.63	–5.59	–3.77	–1.40	2067	84.95	87.81	1.12	6.25
Kasserine	322.98	291.44	–9.77	–6.17	–1.91	2042	41.78	48.92	1.59	6.68
Sidi_Bouz	230.76	216.29	–6.27	–3.61	–1.56	2060	71.17	77.15	1.65	5.52
Sfax	208.96	199.08	–4.73	–2.49	–1.19	2069	93.59	96.82	1.19	5.4
Gafsa	159.36	148.01	–7.12	–2.67	–1.68	2042	87.19	91.01	1.37	4.49
Tozeur	98.88	93.8	–5.14	–0.97	–0.98	2023	126.79	128.73	1.43	3.48
Kebili	82.22	78.69	–4.29	–0.37	–0.45	2005	148.82	147.53	0.49	3.28
Gabes	136.54	132.18	–3.19	–1.28	–0.94	2060	118.19	118.67	0.43	4.35
Medenine	135.3	129.84	–4.04	–0.5	–0.37	2062	131.44	133.46	0.8	4.66
Tataouine	67.12	63.68	–5.13	–0.1	–0.15	2005	170.74	169.13	0.87	3.09

Population Exposure Across Regions

Table A5 shows the variations in CMIP6 historical and projected population exposure to temperature related variables across Tunisia's districts. Note that the time periods used for population exposure are longer than those in the previous tables, which focus on climatologies. As a result, these periods are not directly comparable. The longer time frames are necessary because a minimum of 50 years of data is required to fit extreme events using Generalized Extreme Value (GEV) distributions.

TABLE A5. For Each Admin1 District, Percent of the Population at High Health Risk for Three Periods: Retrospective (1975–2024, centered on 2000), Future (2010–2059, centered on 2035), and Distant Future (2050–2099, centered on 2075), Under SSP3-7.0. High-Risk Areas are defined as locations where the 50-year return level of the number of days in a year with a) maximum temperatures surpassing 40°C exceeds 20 days, b) night temperatures surpassing 26°C exceeds 30 days, c) a heat index surpassing 35°C exceeds 20 days, d) with wet bulb temperatures surpassing 27°C exceeds 15 days (showing data from 2075 onwards as previous periods have zero).

	Hot Days (Tmax > 40°C)			Tropical Nights (Tmin > 26°C)			Heat Index > 35°C			Wet Bulb Temperature > 27°C
Regions	2000	2035	2075	2000	2035	2075	2000	2035	2075	2075
Tunisia	9.82	29.26	67.15	8.9	34.64	92.49	2.43	36.77	95.1	0
Jendouba	0	0	54.77	0	2.75	25.68	0	0	100	2.67
Beja	0	0	76.36	0	0.06	92.73	0	0	100	0.04
Bizerte	0	0	5.77	0	7.81	100	0	0	100	42.8
Manouba	0	0	93.82	0	0	100	0	0	100	3.67
Ariana	0	0	17.14	0	38.85	100	0	0	100	82.86
Tunis	0	0	28.49	0	3.73	100	0	0	100	71.51
Ben Arous	0	0	7.6	0	0	100	0	0	100	78.53
Nabeul	0	0	0	0	32.59	100	0	0	100	69.6
Le Kef	0	32.02	100	0	0	82.78	0	0	69.1	0
Siliana	0	1.66	100	0	0	72.3	0	0	71.91	0
Zaghouan	0	0	51.5	0	0	100	0	0	100	0.02
Kairouan	0	65.39	99.91	0	21.23	99.34	0	43.16	99.34	0
Sousse	0	25.23	74.45	0	66.34	100	0	75.73	100	21.56
Monastir	0	6.04	52.38	0	48.55	100	0	98.97	100	47.62
Mahdia	0	26.01	76.25	0.23	31.54	100	0	100	100	35.85
Kasserine	0	39.12	100	0	4.08	48.26	0	0	37.09	0
Sidi Bouz	0	98.67	100	0	53.07	100	0	54.72	100	6.01
Sfax	0	38.69	79.01	8.94	83.35	100	0	100	100	57.49
Gafsa	63.53	98.09	100	34.04	92.1	100	1.42	52.96	100	0
Tozeur	92.1	100	100	100	100	100	88.68	91.37	100	0
Kebili	100	100	100	94.85	100	100	59.49	100	100	7.75
Gabes	43.41	77.79	96.2	41.18	100	100	0.53	100	100	52.44
Medenine	30.87	45.58	78.58	36.93	100	100	3.18	100	100	59.54
Tataouine	87.2	99.99	100	53.26	100	100	3.81	98.6	100	5.92

CLIMATE RISK COUNTRY PROFILE

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