State of Climate in the Arab Region 2024

WEATHER CLIMATE WATER

WORLD METEOROLOGICAL ORGANIZATION

UNITED NATIONS
الاسكوا
ESCWA

Shared Prosperity Dignified Life

Cover photo: The September 2024 rains cause lakes to reappear in Merzouga, attracting wild flamingos, Morocco; source : https://www.instagram.com/reel/DKZqN1TMcY9/?igsh=YzljYTk1ODg3Zg%3D%3D.

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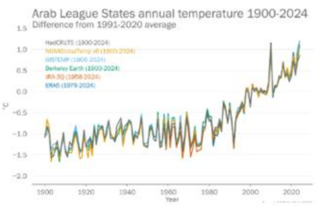
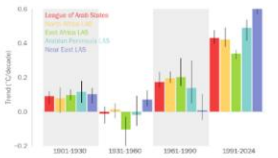
Key Messages

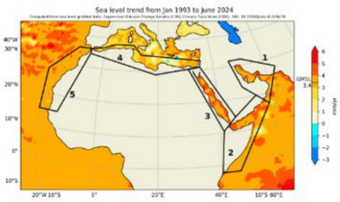
It was the warmest year on record at **1.08 °C** [0.87–1.20] above the 1991-2020 average.



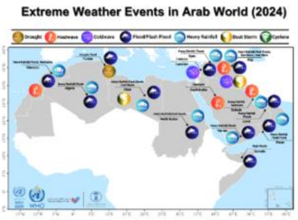
The region is warming at twice the global average rate, with temperatures rising by +0.43 °C [0.40–0.48 °C] per decade from 1991 to 2024, double the rate observed from 1961 to 1990.



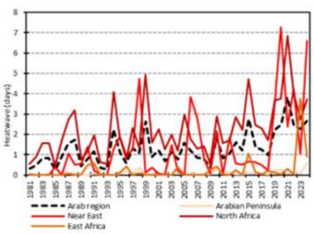
Sea level rise along the Arab region's coastlines exceeds the global average, reaching nearly 4.1 mm/year in the Red Sea.



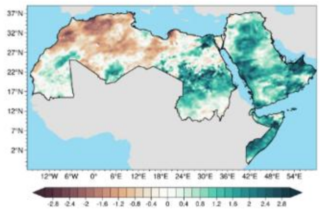
Extreme events in 2024 resulted in over 300 deaths and affected over 3.77 million people across the Arab region. Heatwaves and floods continue to be the most deadly and destructive hazards.



The duration of heatwave days continues to increase across the region, particularly in North Africa and the Near East, with a clear upward trend over the period 1981–2024.

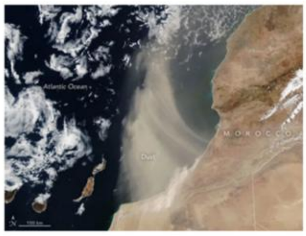


Drought worsened in 2024 in western North Africa after six consecutive failed rainy seasons, particularly over Morocco, Algeria and Tunisia.



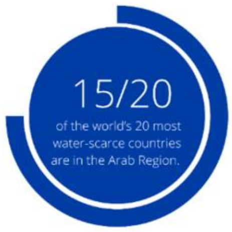
Floods were the most frequently reported disaster in 2024, triggered by extreme rainfall and flash floods in countries such as Morocco, Saudi Arabia, Bahrain, and the United Arab Emirates

The economic cost of climate-related disasters in the region is underestimated, as insured losses do not reflect the full extent of damage, especially to lives, livelihoods, and infrastructure in vulnerable communities.



Strengthening early warning systems and local preparedness remains critical. As of March 2024, **59% of Arab countries had Multi-Hazard Early Warning Systems in place**—above the global average—but implementation gaps remain.

Several countries are **scaling up water security strategies and projects to enhance water security in response to rising climate pressures**, including desalination, wastewater reuse, dam construction, and improved irrigation networks.



Foreword

This is the first WMO report on the State of the Climate in the Arab region to inform decision-making in one of the world's most climate vulnerable regions.

2024 was the hottest year on record for the Arab region – a continuation of a long-term trend which unfortunately shows no sign of ending. Temperatures are rising at twice the global average, and droughts are becoming more frequent and severe—particularly affecting water availability and agriculture.

Extreme events in 2024 resulted in more than 300 deaths, mainly from heatwaves and floods. The true economic and human cost is certainly underestimated. Multi-hazard early warning systems are more important than ever before – this is not a cost but an investment in saving lives and livelihoods. Nearly 60% of Arab countries have such systems in place, above the global average but still not enough.

The report examines how countries are responding to the growing climate threat through a combination of policy frameworks, practical adaptation efforts, and innovative solutions to build long-term resilience. One of the top priorities here is to ensure water security, given that 15 of the world's 20 most water-scarce countries are in the region.

The State of the Climate in the Arab region seeks to support policy-making through rigorous scientific information. It is a truly multi-agency effort, with contributions from National Meteorological and Hydrological Services (NMHSs), WMO Regional Climate Centres (RCCs), the League of Arab States (LAS), the United Nations Economic and Social Commission for Western Asia (ESCWA), specialized United Nations Agencies and International Organizations, and numerous experts and scientists.

I take this opportunity to congratulate the authors for the quality of this report and thank the WMO Members, the United Nations agencies, and the experts and scientists who made an invaluable contribution.

Celeste Saulo
Secretary-General of the World Meteorological Organization

PREFACE

LAS

Climate change is one of the most pressing challenges facing the Arab region today. From rising temperatures and prolonged droughts, to devastating floods and extreme weather events, these impacts are increasing at an alarming rate, threatening communities, ecosystems and economic stability in our region. Although the Arab countries are among the least states responsible for Greenhouse gas emissions are globally, but they are among the most vulnerable to the consequences of climate change.

This first State of the Climate Report in the Arab Region for 2024 is a qualitative step towards enhancing our collective understanding of climate patterns, associated risks and their social and economic impacts. It provides a reliable scientific assessment based on recent data and regional insight. It is a necessary basis for formulating policies and facilitating the making sound decisions. This report presents an analysis of temperatures, rainfall changes, sea level rise, and climate disasters, based on extensive efforts by experts and specialized entities in the region.

The League of Arab States, realize the importance of building climate resilience, enhancing environmental sustainability and developing regional cooperation. Meeting these challenges requires the concerted efforts of governments, civil society, the private sector and international organizations. This report is a successful example of this cooperation, thanks to the contributions of national meteorological centres, UN agencies and regional institutions.

I would like to thank all the partners and experts who contributed to the preparation of this report, and I call on all stakeholders to use its findings as a springboard for collective action to build a more sustainable and climate-secure future for the Arab region.

Ahmed Aboul Gheit
Secretary General of the League of the Arab States

ESCWA

The annual State of Climate Report for the Arab region is essential to strengthening understanding and developing the response to the rapidly evolving climate landscape in one of the world's most climate-vulnerable regions. With many States in the Arab region already facing increasing drought, intense heatwaves and shifting precipitation patterns, this report provides a critical tool for tracking the severity and frequency of these extreme weather events.

An annual report supports the design of targeted adaptation strategies and offers a shared evidence base to guide investment in key sectors that can advance water security, urban resilience, agricultural productivity and renewable energy. It also fosters regional coordination and informs alignment with international climate commitments to enhance climate resilience. For negotiators in the Arab region, this report serves as a vital resource, offering up-to-date insights into the region's climate challenges, risks and impacts.

This report integrates regional climate projections with observed annual trends, enabling better anticipation of long-term changes. Climate models covering the Arab region project a potential rise in average temperatures of up to 5°C by the end of the century under high-emission scenarios. Rising sea levels also threaten coastal cities. Declining rainfall affects water scarcity and jeopardizes food production. By incorporating climate projections, the report provides an annual snapshot of current conditions, while also serving as a strategic foresight tool that empowers the region to prepare for tomorrow's climate realities.

The United Nations Economic and Social Commission for Western Asia (ESCWA), through its Arab Center for Climate Change Policies, is proud to collaborate with the World Meteorological Organization and the League of Arab States on this annual report series being launched this year with the support of Saudi Arabia. This initiative is part of our joint scientific efforts under the Arab Climate Outlook Forum and our technical support to the Arab Ministerial Council on Meteorology and Climate.

Strengthening the regional knowledge base through collaborative assessments such as this report fosters regional and inter-regional dialogue, informs climate action, and supports States in the Arab region in pursuing climate commitments that are informed and coherent with their sustainable development goals.

Thank you.

Rola Dashti
Executive Secretary of Economic and Social Commission for Western Asia

Overview of the Arab Region

The Arab region comprises 22 countries spanning a large and geographically diverse area of approximately 13 million square kilometres. It includes parts of North Africa, the Near East, the Arabian Peninsula, and East Africa. The region's topography ranges from low-lying plains below 100 m in elevation to mountainous areas exceeding 4,000 m, such as the Atlas Mountains. The climate is predominantly arid to semi-arid, with notable variation across subregions. In North Africa, countries bordering the Mediterranean—Mauritania, Morocco, Algeria, Tunisia, Libya, and Egypt—experience a Mediterranean climate along the coast, with mild, wet winters and hot, dry summers. Inland areas, particularly the Sahara Desert, are hyper-arid, characterized by extreme heat, low precipitation, and significant diurnal temperature ranges. East African countries within the region, including Somalia, Sudan, and Djibouti feature arid to semi-arid conditions with high temperatures and limited rainfall. The Comoros has a tropical, humid climate with rainfall throughout the year. The Near East, including Iraq and the Levant, is shaped by mountains, plateaus, and fertile river valleys. While mountainous areas receive snow in winter, inland zones such as the Syrian Desert remain dry year-round with hot summers and cold winters. The Arabian Peninsula comprises of Saudi Arabia, Yemen, Oman, the United Arab Emirates, Qatar, Bahrain, and Kuwait and is one of the driest areas in the world. Most of the Peninsula consists of hyper-arid desert, with extremely hot summers and erratic rainfall. However, monsoonal influences bring additional precipitation to the mountainous regions of southwest Saudi Arabia, Yemen and Oman.

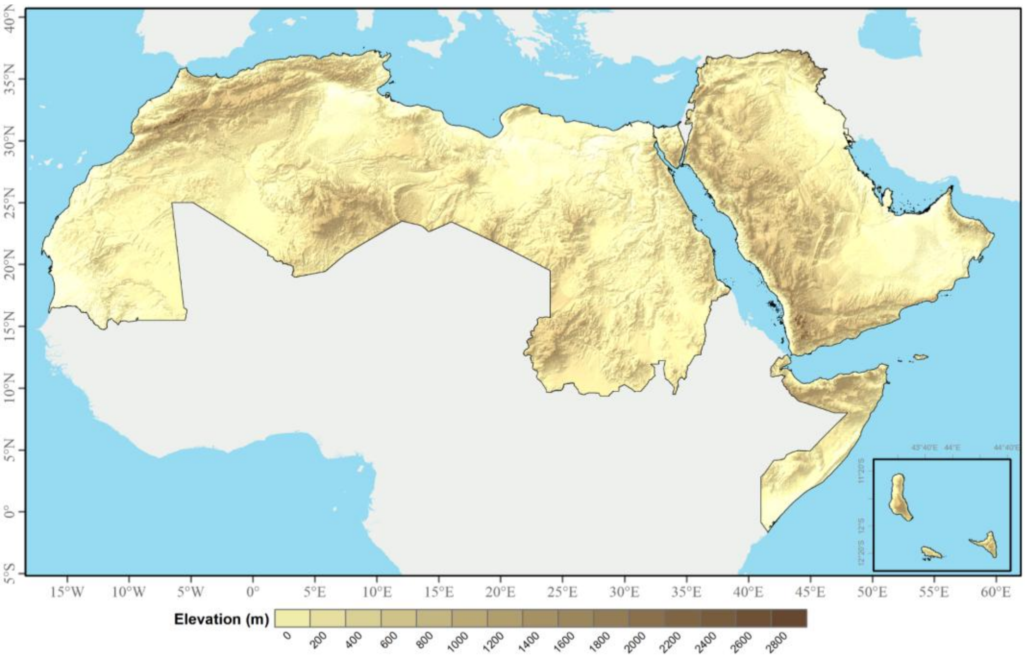


Figure 1. *The geographical location of the Arab region with topography. (Disclaimer: The boundaries depicted in this report are not based on politically or internationally recognized agreements. They are included solely for illustrative purposes to approximately represent the geographical extent of the Arab region).*

The Arab region is among the most climate vulnerable regions in the world[1]. Temperatures are rising at twice the global average, and droughts are becoming more frequent and severe—particularly affecting water availability and agriculture. The region has also seen increasing exposure to climate-related hazards, including floods, heatwaves, and storms. These climate threats intersect with ongoing socio-economic challenges such as rapid urbanization, conflict, poverty, and population growth. In 2023, Libya experienced an unprecedented storm that, combined with aging infrastructure, led to widespread devastation and thousands of deaths. In 2024, historic rainfall caused severe flooding across the UAE and Oman. These events highlight the urgent need to strengthen climate resilience and invest in risk reduction across the region.

Global climate context

The IPCC defines climate change as a change in the climate that persists for an extended period, typically decades or longer. One or more individual years exceeding 1.5°C does not necessarily mean that "pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels," as the Paris Agreement states, is out of reach. Therefore, the exceedance of 1.5°C and 2.0°C warming levels (as referred to in the Paris Agreement) should be understood as an exceedance over an extended period, typically decades or longer, although the Agreement itself does not provide a specific definition.

The global annual mean near surface temperature in 2024 was 1.55 °C [1.42 °C to 1.68 °C] above the 1850–1900 preindustrial average and 1.19 °C [1.15 °C to 1.24 °C] above the 1961–1990 baseline. The global mean temperature in 2024 was the highest on record for the period 1850–2024 according to all six datasets that WMO uses to monitor global mean temperature, beating the previous record of 1.45 °C [1.32 °C to 1.57 °C] set in 2023. Each of the years from 2015 to 2024 was one of the 10 warmest years on record.

Atmospheric concentrations of the three major greenhouse gases reached new record observed highs in 2023, the latest year for which consolidated global figures are available, with levels of carbon dioxide (CO_2) at 420.0±0.2 parts per million (ppm), methane (CH_4) at 1934±2 parts per billion (ppb) and nitrous oxide (N_2O) at 336.9 ± 0.1 ppb – respectively 151%, 265% and 124% of pre industrial (before 1750) levels (Figure 2). Real time data from specific locations, including Mauna Loa (Hawaii, United States of America) and Kennaook/Cape Grim (Tasmania, Australia) indicate that levels of CO_2, CH_4 and N_2O continued to increase in 2024.

The rate of ocean warming over the past two decades (2005–2024), is more than twice that observed over the period 1960–2005, and the ocean heat content in 2024 was the highest on record. Ocean warming and accelerated loss of ice mass from the ice sheets contributed to the rise of the global mean sea level by 4.7 mm per year between 2015 and 2024, reaching a new record observed high in 2024. The ocean is a sink for CO_2. Over the past decade, it absorbed about one quarter of the annual emissions of anthropogenic CO_2 into the atmosphere. CO_2 reacts with seawater and alters its carbonate chemistry, resulting in a decrease in pH, a process known as "ocean acidification".

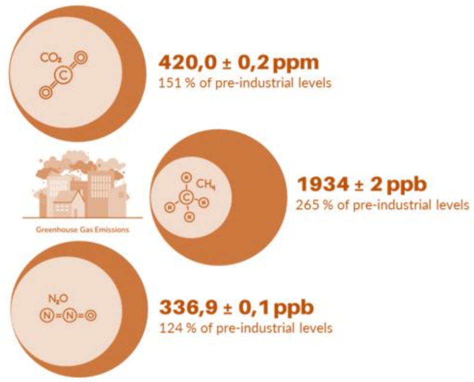


Figure 2. *Annual atmospheric concentration of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) in 2023. Beige circles represent pre-industrial concentrations and brown circles those of 2023.*

Regional climate

The following sections analyze key climate indicators in the Arab region during 2024. One particularly important indicator is temperature, which is described in terms of anomalies or departures from a reference period. For global mean temperature, the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC)[2] *uses the reference period 1850–1900 to calculate anomalies compared to pre-industrial levels. However, this pre-industrial reference period cannot be used in all regions as a baseline due to insufficient data before 1900. Instead, the 1991–2020 climatological standard normal reference period is used to compute anomalies for temperature and other indicators. Regional temperature anomalies can also be expressed relative to the reference period 1961–1990. This is a fixed reference period recommended by WMO for assessing long-term temperature change. In the present report, exceptions to using these baseline periods for calculating anomalies, where they occur, are explicitly noted.*

TEMPERATURE ANOMALIES AND TRENDS

Temperatures in 2024 were the highest on record across the Arab region, with an anomaly of 1.08°C [0.87–1.20°C] above the 1991–2020 average, based on the mean from six datasets[3]. Relative to the 1961–1990 baseline, the anomaly reached 1.94°C [1.76–2.09°C][4]. The year ranked first across five individual datasets—Berkeley Earth, ERA5, GISTEMP, JRA-55, and NOAAGlobalTemp—and second in HadCRUT5. The year 2010 ranked second, with a temperature anomaly of 1.02°C [0.85–1.12°C] above the 1991–2020 average. The period from 2014 to 2024 contains eleven of the twelve warmest years on record for the region, based on the multi-dataset mean (Figure 3).

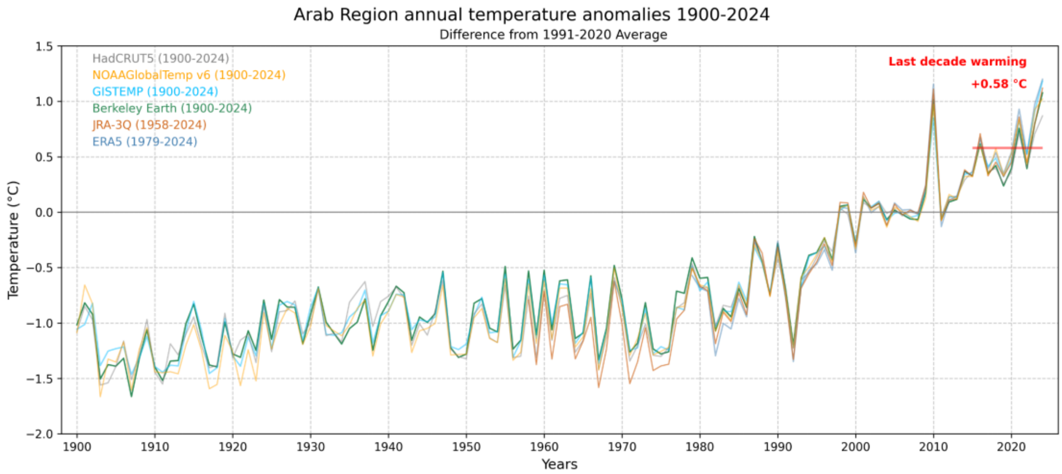


Figure 3. *Temperature anomalies (in °C) with respect to the 1991–2020 reference period for the Arab Region from 1900 to 2024, based on six data sets, including observational data sets (HadCRUT5 [black], NOAAGlobalTemp [yellow], GISTEMP [light blue], and Berkeley Earth [green]) and reanalyses (JRA-55 [orange], and ERA5 [dark blue]). (Data source: WMO regional dashboard)*

The rate of warming in the Arab region has accelerated in recent decades, reaching approximately twice the global average between 1991 and 2024. During this period, regional temperatures[5] rose by about 0.43°C per decade [0.40–0.48°C], compared to a global land–ocean warming rate of around 0.2°C per decade. National-level studies from several Arab countries also report faster warming compared to global averages (Salman et al., 2018)[6]; (Driouech et al., 2021)[7].

All four subregions show a consistent and increasing warming trend (Figure 4). From 1961 to 1990, the regional warming rate was approximately 0.17°C per decade [0.14–0.23°C], underscoring the sharp rise in recent decades. The last decade (2015–2024) was 0.58°C warmer than the 1991–2020 average and 1.44°C warmer than the 1961–1990 baseline. If the current warming rate continues, mean temperature increase in the Arab region could reach 1.8°C with respect to 1991-2020 average by 2050.

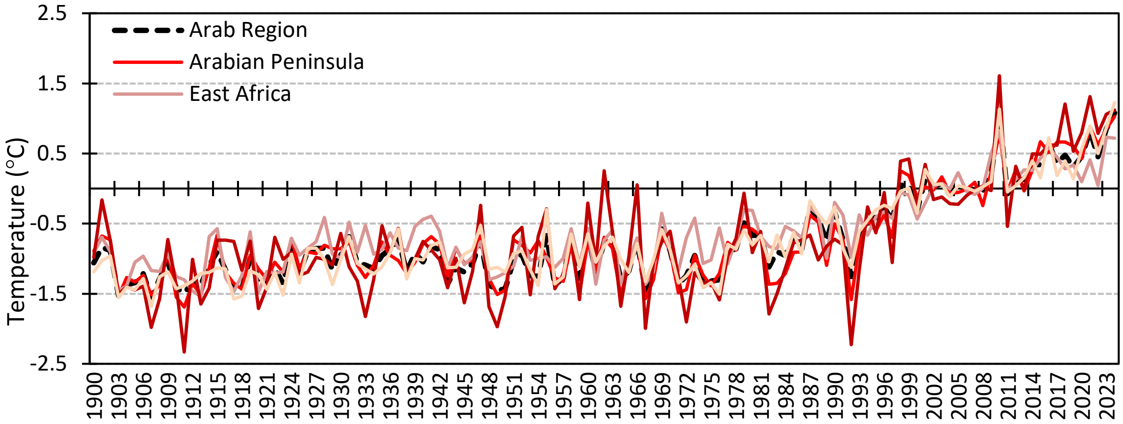


Figure 4. *Temperature anomalies (in °C) with respect to the 1991–2020 reference period for the Arab region and four subregions (see Figure 1) from 1900 to 2024, based on the ERA5 dataset used in Figure 3.*

Temperature trends are also analysed by sub-region, reflecting geographic and climatic patterns across North Africa, East Africa, Near East, and the Arabian Peninsula. North Africa and Arabian Peninsula experienced their warmest year on record in 2024, with a maximum temperature anomaly of 1.23 °C above the 1991-2020 average over North Africa (2.07 °C relative to a 1961-1990 baseline). The Near East recorded the highest anomaly with reference to the 1961-1990 baseline, at 2.08 °C. In contrast, 2024 was the third warmest year on record for East Africa and Near East.

All four subregions show an increasing temperature trend over the past 60 years compared to the period before 1960 (Figure 5). The Near East and Arabian Peninsula show the fastest recent warming, with trends of approximately +0.60°C and +0.49°C per decade, respectively, between 1991 and 2024—compared to +0.01°C and +0.14°C per decade from 1961 to 1990. East Africa had the slowest recent warming among the subregions, at +0.34°C per decade between 1991 and 2024. Overall, the warming trend in the Arab region from 1991–2024 is more than the double the rate observed for 1961–1990.

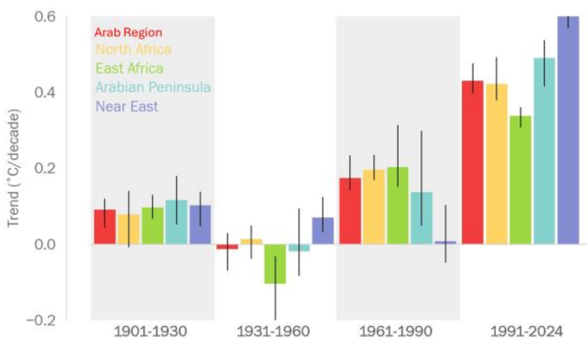


Figure 5. *The area average temperature trends (in °C per decade) for the Arab region and its sub-regions: Arab region (red), North Africa (orange), East Africa (green), Near East (tealish blue), and the Arabian Peninsula (cyan) over four 30-year sub-periods: 1901–1930, 1931–1960, 1961–1990, and 1991–2024. The trends were calculated using different data sets, including observational data sets (HadCRUT5, NOAAGlobalTemp, GISTEMP, and Berkeley Earth) and reanalyses (JRA-55 and ERA5). The black vertical lines indicate the range of the six estimates.*

	Base period 1991–2020	Base period 1961–1990	Trends in °C/decade 1991-2024
North Africa	**1.23 °C** [1.00 °C–1.40 °C]	**2.07 °C** [1.94-2.18°C]	**0.42 °C** [0.38-0.49]
East Africa	**0.72 °C** [0.42 °C–1.02 °C]	**1.48 °C** [1.23-1.76°C]	**0.34 °C** (0.31-0.36]
Near East	**1.12 °C** [1.03 °C–1.27 °C]	**2.08 °C** [1.91-2.25°C]	**0.6 °C** [0.57-0.63]
Arabian Peninsula	**1.03 °C** [0.90-1.16°C]	**1.99 °C** [1.67-2.42°C]	**0.49 °C** [0.42-0.54]
Arab Region	**1.08 °C** [0.87-1.20°C]	**1.94 °C** [1.76-2.09°C]	**0.43 °C** [0.40-0.48]

Table 1. *Near-surface air temperature anomalies (in °C) for 2024 relative to the 1991–2020 and 1961–1990 reference periods. Anomalies for the whole Arab Region and for each sub-region have been calculated using six different data sets, including observational data sets (HadCRUT5, NOAAGlobalTemp, GISTEMP, and Berkeley Earth) and reanalyses (JRA-55 and ERA5). The range of anomalies among these data sets is given in the brackets.*

In 2024, all Arab sub-regions recorded temperatures above the 1991–2020 average (Figure 6). The highest temperature anomalies were recorded in North Africa. Temperatures exceeded 2.0°C above the 1991–2020 average in Northern Algeria, the Atlas Mountains in Morocco, and most of Tunisia. Temperature anomalies ranging from 1.4°C to 1.6°C were observed across the southern Arabian Peninsula over Rub Al-Khali's desert in Saudi Arabia, Oman, Yemen, Jordan and Syria. The lowest temperature anomalies of the year were observed in central Sudan and the southeastern corner of the Arabian Peninsula.

Based on the ERA5 dataset, 11 of the 22 countries in the Arab region recorded their warmest year on record in 2024. These include Algeria, Bahrain, Libya, Syria, Lebanon, Morocco, Tunisia, Yemen, Qatar, Comoros, and Sudan. The highest national temperature anomaly was observed in Algeria, at +1.64°C above the 1991–2020 average. In contrast, Sudan recorded the lowest anomaly among these countries, at +0.58°C relative to the same baseline.

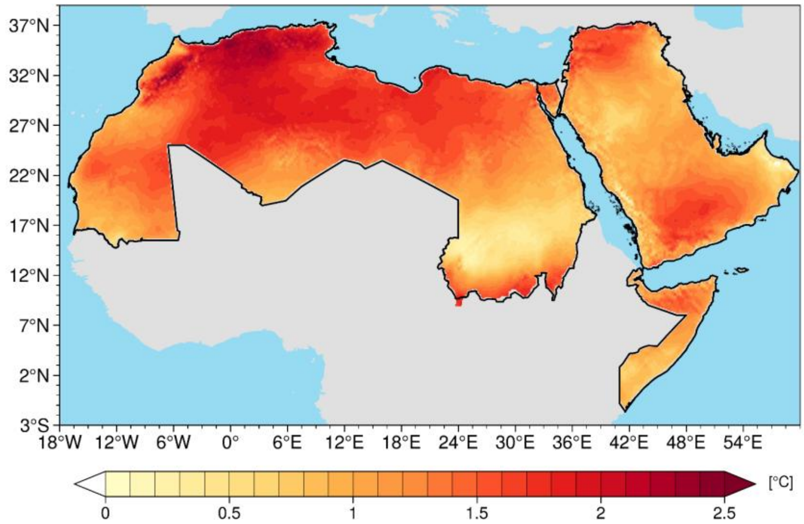


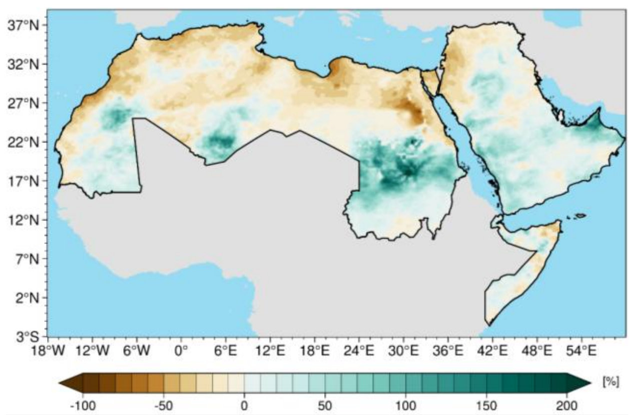
Figure 6. Near-surface air temperature anomalies for 2024 relative to the 1991–2020 average. Anomalies are calculated using the ERA5 dataset.

PRECIPITATION

In 2024, annual precipitation exceeded the 1991–2020 average across much of the southern and eastern parts of the Arab region (Figure 7). Totals reaching 150% to 200% of above normal were recorded in northern Sudan and parts of the Arabian Peninsula, including the United Arab Emirates, the southwestern coastal areas of Saudi Arabia, and Yemen.

In contrast, a marked rainfall deficit affected most of North Africa, including coastal areas of Morocco, northern Algeria, and Libya, where precipitation deficits reached 40% below the 1991–2020 average. Below-normal annual rainfall also prevailed over eastern Egypt, western parts of Near East countries, and areas of Somalia. Northwestern Africa experienced drought conditions for the sixth consecutive year, though intense rainfall events late in 2024 brought partial relief in parts of Algeria and Tunisia. Intense wet spells also led to widespread pluvial flooding in several countries of the Arabian Peninsula, including parts of Saudi Arabia, Bahrain, and the United Arab Emirates.

Over the period 1981-2024, East Africa showed a positive trend in annual precipitation, while North Africa has exhibited a negative trend since 2010, with pronounced deficits over the past 6 years.



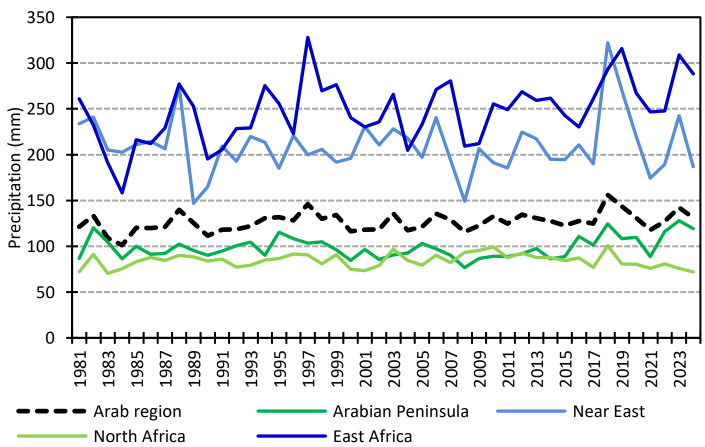


***Figure 7 a)** Spatial distribution of the anomaly of annual total precipitation (%) in 2024 relative to the average of 1991-2020 derived from the Rainfall Estimates from Rain Gauge and Satellite (CHIRPS) dataset.*

***b)** Time series of the areal average annual precipitation over the Arab region and its four subregions using CHIRPS data from 1981 to 2024.*

SEA LEVEL

In 2024, global mean sea level continued to rise at a sustained rate of 3.45 ± 0.3 mm per year over the satellite altimetry period from January 1993 to December 2024, driven by ocean warming and land ice melt. However, the rate of rise varies regionally due to differences in ocean thermal expansion and, to a lesser extent, salinity changes [8,9].

Altimetry-based observations from January 1993 to June 2024 show that sea levels in oceanic areas surrounding the Arab region have been rising at rates higher than the global average (Figure 8). The Red Sea, Arabian Gulf, and Somali coast all experienced an estimated rate of approximately 4.0 mm per year, significantly above the global mean. In contrast, the lowest regional rate—around 3.0 mm per year—was observed along the Mediterranean coast of North Africa (Table 2).

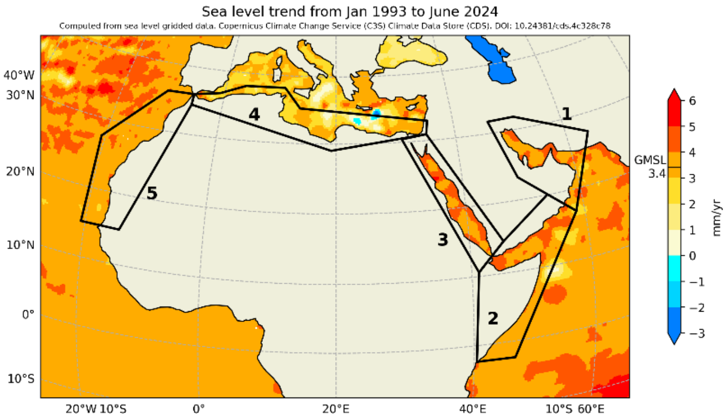


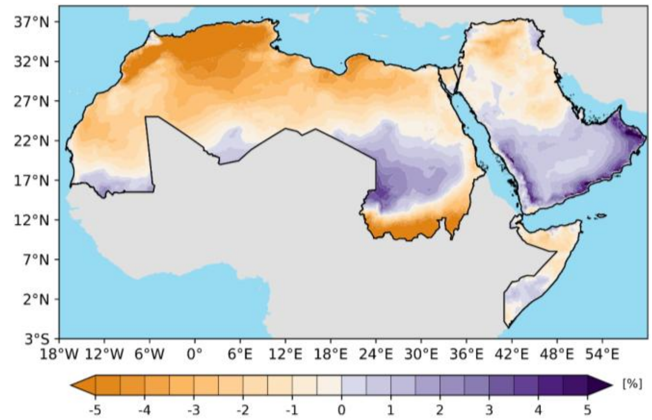
Figure 8. Spatial distribution of sea-level[10] trends in the five coastal regions of the Arab region covering the period from January 1993 to June 2024: Arabian Gulf (1), Somalia (2), Red Sea (3), South Mediterranean (4), and NW Africa (5). The global mean trend is 3.4 mm/year. The boxes represent subregions where the rates of area-averaged sea-level change are provided in Table 2.

Box number	Ocean Area	Trend in sea-level rise (mm/year)
1	Arabian Gulf	4.0 ± 0.2
2	Somalia	4.0 ± 0.2
3	Red Sea	4.1 ± 0.2
4	South Mediterranean	3.0 ± 0.1
5	NW Africa	3.6 ± 0.2
-	**Global**	**3.4 ± 0.3**

Table 2. The rate of area-averaged sea-level change (from the coast to 50 km offshore) over the period from January 1993 to June 2024, according to satellite measurements. Subregions are defined in Figure 8.

HUMIDITY

In 2024, relative humidity levels across the Arab region showed significant variation compared to the 1991-2020 average (Figure 9a). Most of the Arab region experienced a decrease in relative humidity, ranging from -0.5% to -5.5%. The lowest values were observed in North African countries, where temperatures were highest in 2024. Areas with reduced humidity saw accelerated soil moisture loss, exacerbating heat stress on crops. In contrast, increased relative humidity was observed in parts of the southern Arabian Peninsula and central Sudan, where positive rainfall anomalies were observed (see Precipitation section). The largest increase in relative humidity in 2024, exceeding 5%, was observed in the southeastern corner of the Arabian Peninsula. The combination of elevated temperature and humidity were particularly pronounced during the warmer months, leading to heightened heat stress for the population.
Over the period 1981–2024, all subregions exhibit a statistically significant decreasing trend in relative humidity at the 95% confidence level (Figure 9b). The strongest decline was observed in the Near East (−0.8% per decade), while the weakest was in the Arabian Peninsula (−0.3% per decade). North Africa and East Africa recorded intermediate declines of −0.5% and −0.7% per decade, respectively. Overall, the Arab region shows an average decline of −0.5% per decade. Declining humidity levels can exacerbate drought conditions and compound heat-related impacts, with important consequences for water management, agriculture, and public health planning.



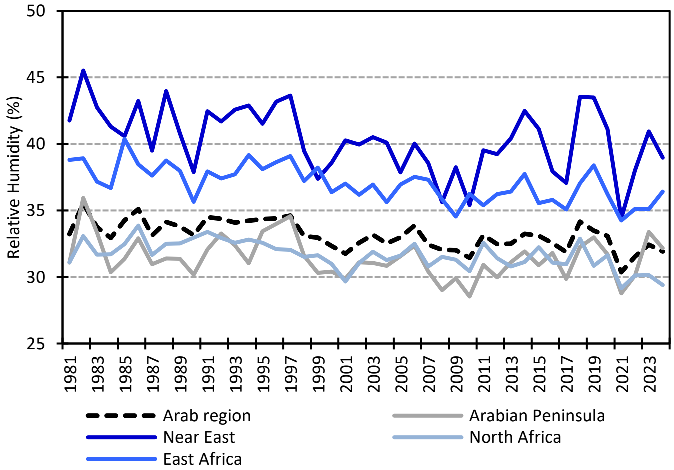


Figure 9 a) *Spatial distribution of the relative humidity anomaly (%) for 2024 compared to the average of 1991-2020, prepared using ERA5 Land mean temperature and due point temperature.*

b) *Time series of the areal average annual relative humidity (%) for the period 1981-2024, prepared using ERA5 Land mean temperature and due point temperature.*

Extreme events

In 2024, 35 extreme weather and climate events were reported across the region (Figure 10). These events were associated with over 300 fatalities and affected approximately 3.77 million people.

Floods were the most frequently reported hazard, with 22 events, including six flash floods. North Africa was the most affected subregion, followed by the Arabian Peninsula. Heatwaves were the second most frequently reported event, with five occurrences recorded across multiple countries. The following sub-sections provide additional details on the type, location, and impacts of extreme events during 2024.

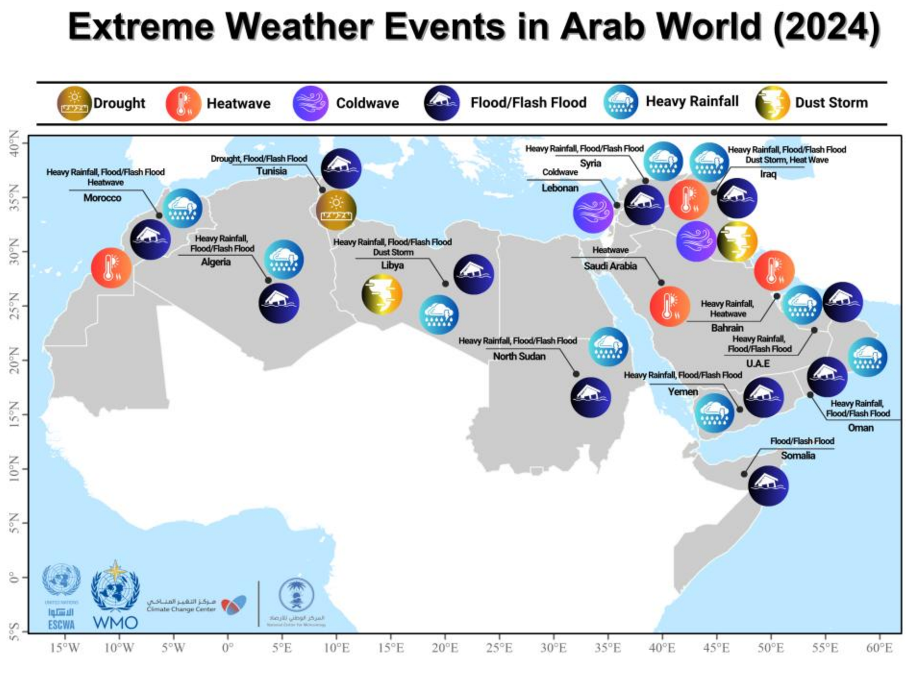


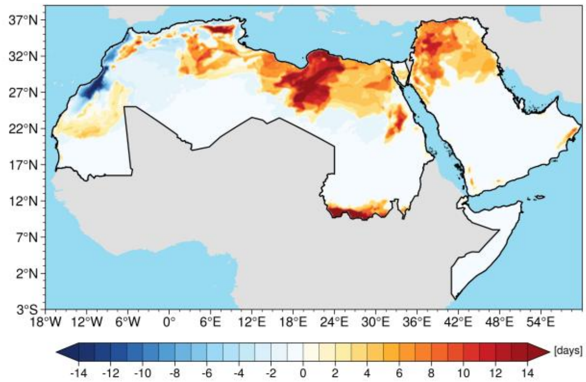
Figure 10. *Extreme weather and climate events, including heatwaves, cold waves, floods, cyclones, and heavy rainfall in the Arab region derived from EM-DAT and the WMO Regional Extreme Events Dashboard in 2024.*

Heatwaves

The Middle East and North Africa are among the hottest regions in the world, and climate projections indicate a continued intensification of summer heat extremes in both subregions [11].

In 2024, significant heatwave conditions were observed across the Near East and northern parts of the Arab region, particularly in Syria, Iraq, Jordan, Egypt, Libya, and eastern Algeria. The far southern regions of Sudan were also affected. The longest durations were recorded in southern Sudan, where heatwaves exceeded 14 consecutive days, followed by central and northern Libya, which experienced several heatwaves lasting between 12 and 14 days (Figure 11a).

The number of annual heatwave days has increased across all four subregions of the Arab region, with a more pronounced upward trend in recent years—especially in North Africa and the Near East (Figure 11b). This reflects a shift toward more extreme and prolonged heat events. In 2024, the number of days with maximum temperatures exceeding 50°C ranged from 6 to 12 in southeastern parts of the Near East, particularly Iraq. Elsewhere, such extreme temperatures were recorded on 1 to 2 days in Kuwait and northeastern Saudi Arabia.



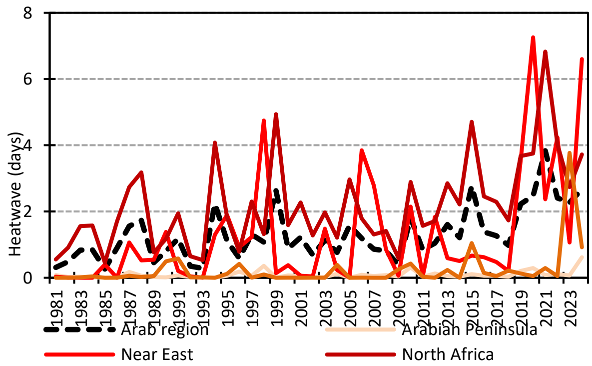


Figure 11 a) *Spatial distribution of the anomaly of the number of heatwave days (in days) for 2024 compared to the 1991-2020 average, prepared using ERA5 Land temperature.*

b) *Time series of the areal average annual number of heatwave days (in days) over the Arab region using ERA5-Land temperature from 1981 to 2024.*

Droughts

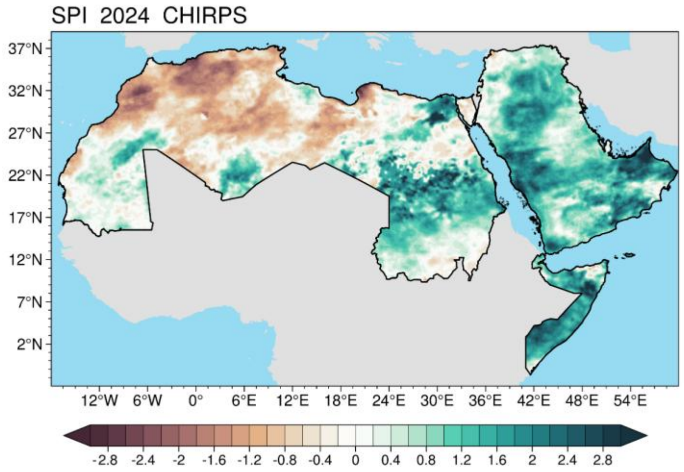
Drought is among the most prevalent extreme events in the Arab region. In 2024, drought conditions were most prevalent in northern Africa, including mainly Morocco, Algeria, Tunisia, and parts of Libya. Extreme meteorological drought conditions, defined by areas Standardized Precipitation Index (SPI) [12] below 2.0, were observed in northwest Algeria and northern Morocco, with 2024 being the sixth dry year in a row in Morocco. Although not as widespread as in North Africa, drought conditions were also recorded in Syria and Iraq in 2024 (Figure 12a).

The continued severe precipitation deficits in 2024 had adverse impacts on water resources and agriculture. Reservoir levels dropped to critical lows, including at Morocco's Al Massira Dam—the country's second-largest reservoir and a key irrigation source for farms near Casablanca—which fell to just 1-2% of its capacity in February 2024. In the Maghreb, wheat yields were well below average due to prolonged seasonal drought.

In Iraq, approximately half of households in Anbar, Kirkuk, Ninewa, and Salahaddin governorates reduced either the area under cultivation or their irrigation water use due to drought during the 2024 season.

Over the longer period 1991–2024, all subregions experienced one or more multi-year droughts, though with notable differences in intensity and duration (Figure 12b). The Arabian Peninsula experienced an extended dry spell from 1999 to 2013, with 2004 as a brief exception. The Near East recorded intermittent droughts of varying severity between 2007 and 2018. In East Africa, prolonged drought periods occurred from 2000 to 2006 and again from 2008 to 2012. North Africa faced a sustained dry period from 2000 to 2008, followed by a shorter episode from 2010 to 2013.

Despite these observed episodes, trend analysis does not indicate statistically significant changes in drought intensity across the subregions, suggesting that while drought remains a recurrent hazard, its long-term severity has remained relatively stable over the study period.



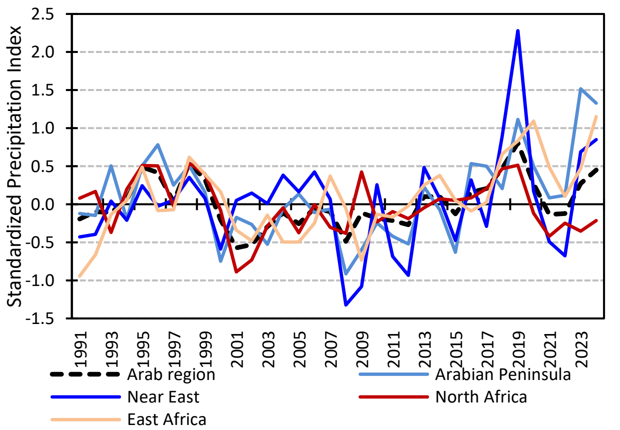


Figure 12 a) *The spatial distribution of the annual average Standardized Precipitation Index (SPI-12) for 2024 over the Arab region. This map is prepared using CHIRPS data. Areas in brown depict SPI values < 0, representing drier conditions. Areas in green represent SPI values > 0, representing wetter conditions.*

b) *Annual time series of areal average Standardized Precipitation Index over the entire Arab region from 1991 to 2024.*

Floods

In 2024, the Arab region experienced several significant flood events, including flash floods across all subregions. Many of these events occurred following prolonged drought, which likely exacerbated their impacts.

One of the most severe events occurred on 6 September 2024, affecting Morocco and Algeria, where catastrophic flash flooding caused extensive damage to residential areas and critical infrastructure (Figure 13a). A total of 25 fatalities were reported—20 in Morocco and 5 in Algeria. A prolonged event of heavy rain at the end of October also affected the eastern coastlines of Tunisia, with a 24-hour rain total of 147 mm in Lamta. The intense rainfall triggered flooding, particularly in low-lying areas, where civil protection services were deployed to evacuate water and restore traffic circulation.

Two flash flood events occurred in southern Libya on 11 August and 23 September, resulting in the death of one person and severe damage to infrastructure, including homes and hospitals. These events posed a significant threat to local livelihoods.

Over East Africa, extreme rainfall affected Sudan on 1 June 2024 (Figure 13b). At least 132 fatalities were reported and more than 300,000 people were affected. Riverine flooding impacted approximately 4 million hectares of cropland, leading to extensive damages to cereals, groundnuts, and sesame and affecting over 11,000 infrastructures, including villages and settlements[13]. In Somalia, extreme precipitation from April to June displaced 37,000 people, led to nine deaths, and resulted in significant infrastructure damage.

In the Near East, several major flood events occurred in early 2024, primarily affecting Iraq and Syria. On 17 January, nearly 10,000 people were affected by flooding in northwest Syria. In Iraq, flash floods on 18 February resulted in three deaths and affected approximately 18,000 people. In northern Lebanon, extreme precipitation in January led to widespread flooding, affecting over 10,000 people, submerging 3,000 houses, and destroying 8,000 hectares of agricultural land[14].

Across the Arabian Peninsula, major flood events occurred in the United Arab Emirates (UAE), Oman, Yemen, and parts of Saudi Arabia. The UAE experienced its most significant rainfall event in recent decades from 14 to 17 April 2024. The most substantial rainfall was recorded in the Khatam Al-Shakla region of Al Ain, with 259.5 mm recorded in 24 hours. On 16 April, many stations recorded over 100 mm of rainfall, including 142 mm in

Dubai—closed to the country's typical annual rainfall (140–200 mm). This event triggered widespread flash flooding, led to four deaths, and resulted in insured losses estimated at USD 2.9 to 3.4 billion[15].

Other notable extreme precipitation and flood events affected Oman, Yemen and in some parts of Saudi Arabia. In Oman, heavy rainfall on 11 February led to seven deaths, and on 14 April, flash flooding resulted in 20 fatalities and affected around 1,200 people. Yemen experienced substantial flooding in 2024, particularly later in the year. On 16 April, heavy rainfall affected nearly 40,000 people, while subsequent events on 28 July and 23 August resulted in more than 100 fatalities and impacted more than 170,000 people. In Saudi Arabia, heavy rainfall of 113.7 mm within 24 hours was recorded on 23 August in Jazan, triggering sudden flash floods in the southwestern coastal city.

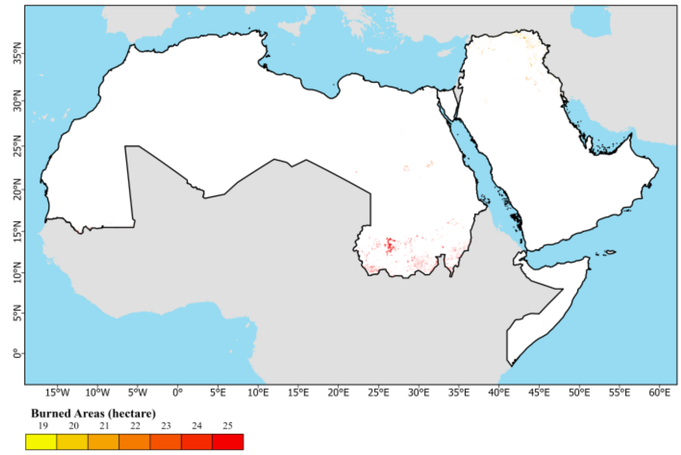
Figure 13 a) *Photo*[16] *Douar Oukarda à Smouguen, Tata, after the 6/9/2024 flash flood with the inset photo showing the situation before the flood,* ***b)*** *Flooding in Sudan in 2024. Photo: IOM / Lisa George*[17].

Wildfires

Satellite imaging technology enables comprehensive wildfire monitoring by detecting atmospheric smoke signatures and post-fire landscape alterations. However, in conflict-prone regions, these satellite-derived fire datasets may capture both natural wildfires and fires stemming from human activities, including conflict. This overlap limits the ability to definitively attribute fire activity to climatic or ecological factors. Therefore, the results presented here should be interpreted with caution.

Wildfire activity across the Arab region was relatively low in 2024. Burned areas were mainly concentrated in southern Sudan and eastern Iraq, followed by northern Syria and southern Egypt (Figure 14a). Lebanon experienced an unusually prolonged wildfire season in 2024. A combination of dry vegetation, high winds, and below-average precipitation contributed to at least nine wildfires across the country in October. Other areas experienced minimal or negligible wildfire activity during the year.

Long-term data for the period 2001–2024 indicate that East Africa recorded the highest annual average burned area, at 6.39×10^6 hectares, followed by North Africa (0.40×10^6 hectares) and the Near East (0.33×10^6 hectares). The Arabian Peninsula recorded the lowest average, at just 0.03×10^6 hectares (Figure 14b). A decreasing trend in burned area is observed in East Africa (-1.4×10^6 ha per decade) and to a lesser extent in North Africa (-0.1×10^6 ha per decade). The Near East shows a slight increasing trend, at $+0.3 \times 10^6$ ha per decade. These spatial patterns and long-term trends underscore the importance of targeted fire management strategies in high-risk areas.



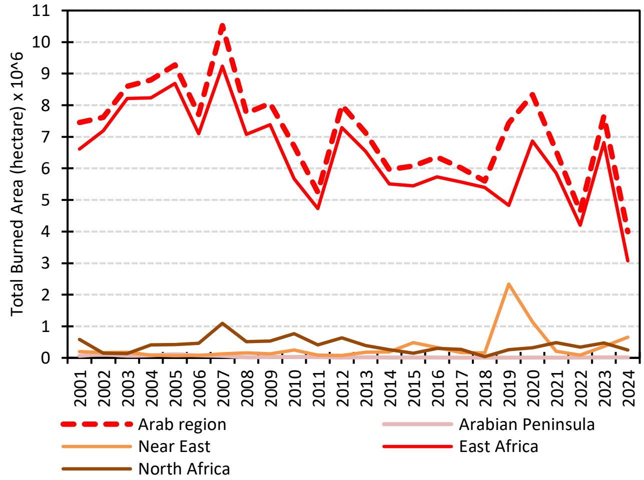


***Figure 14a)** Spatial distribution of burned area (hectare) for 2024 (Jan-Sept) derived from MODIS monthly burned area product.*

***b)** Time series of annual total burned area (hectare) of the entire Arab region using MODIS MCD64A1.061 monthly burned area product for the period 2001 to 2024.*

Sandstorms

A global view of sand and dust storms (SDS) is monitored using aerosol optical depth (AOD), a measure of suspended aerosol particles, including dust, in the atmosphere. In 2024, most of the northern Arabian Peninsula experienced near-average dust activity. However, Qatar and the Sultanate of Oman recorded elevated AOD values, while Libya, Tunisia, and Morocco exceeded the 2001–2023 average, indicating above-normal dust storm activity.

SDS events are frequent across the Arab region, with several intense events recorded in 2024. On 24 August, a plume of Saharan dust—Earth's largest source of airborne dust—was detected over the Atlantic Ocean as strong winds lofted dust offshore from southern Morocco, forming dense bands across the region (Figure 15a). Another major SDS event occurred between 14 and 17 December, affecting the Tigris–Euphrates River basin. The storm originated in eastern Syria and northern Iraq and transported dust hundreds of kilometers toward the Arabian Gulf. This event significantly reduced visibility and led to hazardous air quality in multiple urban centers across the Middle East. Visibility dropped to just a few meters, posing serious public health risks. The most severe impacts were recorded in Iraq, particularly in the Saladin and Baghdad governorates, where intense winds generated a severe dust storm. At least 65 people were reported injured, with the Balad district in Saladin, just north of Baghdad, among the most affected areas (Figure 15b)[18].

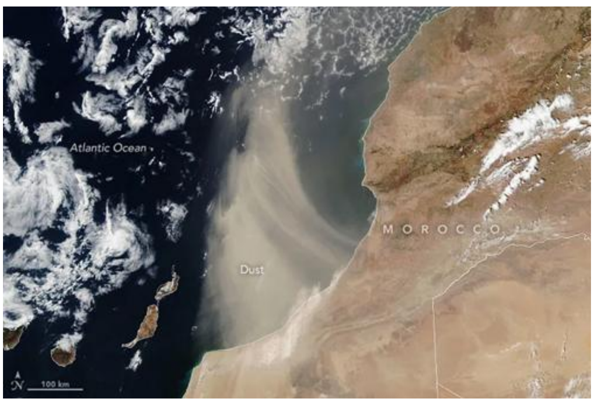
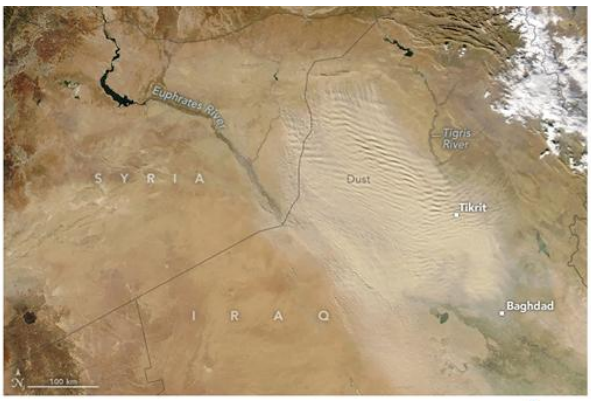


Figure 15 a) Satellite image showing a plume of Saharan dust streamed offshore from southern Morocco on August 24, 2024. Source: https://earthobservatory.nasa.gov/images/153246/dust-pours-off-the-moroccan-coast.



b) Satellite image showing a cloud of dust originating in the Tigris–Euphrates basin in December 2024.
Source:
https://earthobservatory.nasa.gov/images/153716/winter-blast-of-dust-in-the-middle-eas.

Climate-related risks and socioeconomic impacts

The frequency and severity of extreme weather and climate events have increased significantly, with an 83% rise in recorded disasters between 1980–1999 and 2000–2019[19]. These events disproportionately impact vulnerable regions and socio-economic groups, compounding existing challenges for disadvantaged populations[20]. In the Arab region, where socioeconomic and environmental vulnerabilities are pronounced, the implications of these events are far-reaching, requiring focused analysis and action. The year 2024 witnessed numerous extreme weather events with profound socio-economic impacts across the region, highlighting the urgent need for strategic interventions.

Global loss and damage estimates are often based on insured losses, which tend to reflect impacts in wealthier countries. In contrast, the Arab region frequently experiences disproportionate non-economic losses, including fatalities, displacement, loss of agricultural land, and damage to critical infrastructure, which are less likely to be fully captured by insured loss statistics. In 2024, approximately 1% of the Arab population—around 3.77 million people[21]—were reported to be affected by extreme climate events, although the actual number is likely much higher due to underreporting and limited data availability in some areas. These losses include both immediate impacts and slower-onset effects, such as prolonged drought or degradation of essential services.

Physical infrastructure and economic losses

Extreme weather events in 2024 caused significant damage to private dwellings, commercial properties, and critical infrastructure across the Arab region. In northern Lebanon, flooding in January affected more than 10,000 people, submerged 3,000 homes, and destroyed 8,000 hectares of agricultural land[22]. Similarly, flooding in Dubai disrupted transportation networks, blocked streets, and damaged key infrastructure[23]. In Sudan, riverine flooding affected approximately 4 million hectares of cropland, resulting in severe damage to cereal, groundnut, and sesame production, and impacting over 11,000 infrastructure units, including villages and settlements[24].

In several countries, extreme heatwaves strained energy grids, with temperatures exceeding 50°C in Bahrain, Iraq, Kuwait, Saudi Arabia, and the United Arab Emirates. These events highlighted the vulnerability of existing infrastructure and the need for climate-resilient planning and investment.

Human health and displacement

The health impacts of extreme weather events in 2024 included heat-related illnesses, waterborne diseases, and mental health challenges. While extreme heat continued to impact the region, cold waves in Lebanon and Iraq affected millions[25], disrupting daily life. Additionally, floods in Syria displaced over 9,700 people and damaged hundreds of tents in refugee camps[26].

Displacement due to extreme weather and climate events continued to rise. The Internal Displacement Monitoring Centre reported that weather-related events accounted for a significant proportion of disaster displacement. For example, flooding in Yemen from April to August 2024 impacted a reported 211,498 people[27], while Sudan's floods displaced entire communities and livestock, intensifying vulnerabilities[24].

Agriculture and food security

The agricultural sector was severely affected by extreme events in 2024. Floods devastated 41% of cropland] in Sudan[24]. Droughts and heatwaves across the region reduced yields in staple crops such as maize and soybeans and degraded grasslands critical for livestock. In Lebanon, floods destroyed agricultural infrastructure and equipment, impacting employment and income for vulnerable households[28].

Economic and fiscal challenges

The economic repercussions of extreme weather and climate events in 2024 were wide-ranging across the Arab region. In Algeria, flooding led to significant infrastructure damage, disrupting transportation networks and daily life[29]. In Sudan, the combined impacts of flooding on agriculture and infrastructure placed additional pressure on public finances, underscoring the need for robust macroeconomic planning and climate risk-informed budgeting to address growing economic vulnerabilities. Additionally, climate-related risks contributed to reduced foreign direct investment (FDI) in vulnerable areas and prompted increased fiscal expenditure on emergency response and disaster recovery[30].

Broader socioeconomic implications

1. **Supply Chain Disruptions:** Flooding in Iraq and Somalia disrupted transportation networks, causing delays in trade and logistics[31]. In Dubai, severe rainfall in April 2024 interrupted operations at one of the world's busiest airports, affecting thousands of passengers and businesses.

2. **Investment Deterrence:** Regions facing recurrent extreme weather and climate events such as Sudan and Yemen struggled to attract long-term investment, compounding existing economic challenges and limiting development opportunities.

3. **Social Inequality:** Vulnerable populations, particularly in rural, agriculture-dependent communities, were disproportionately affected by extreme events. Loss of livelihoods, displacement, and limited access to services exacerbated existing social and economic disparities.

The Arab region's exposure to climate extremes highlights the importance of strategically focusing on key socioeconomic sectors to build resilience. Quantifiable indicators like infrastructure damage, health outcomes, agricultural productivity, and fiscal pressures are essential for informed policy development. An indicator-based approach will strengthen national and regional capacity to monitor, plan, and respond to the evolving socioeconomic impacts of climate variability and extremes.

Strategic Perspectives

The Arab region faces a complex array of socioeconomic and environmental challenges, many of which are being intensified by the adverse impacts of climate change. Critical sectors such as water resources, agriculture, infrastructure, public health, and tourism are already experiencing mounting stress. These compounding risks are increasing the region's vulnerability to climate-related hazards and heightening disaster risk. Home to over 436 million people—60 per cent of whom are under the age of 30—the Arab region is one of the world's most arid, with more than 90 per cent of its land classified as arid or hyper-arid. Of the 22 Arab States, 19 are considered water-scarce, and 13 fall below the absolute freshwater scarcity threshold of 500 m³ per capita per year.

This section examines how countries across the Arab region are responding to the growing climate threat through a combination of policy frameworks, practical adaptation efforts, and innovative solutions to build long-term resilience. With the escalating water scarcity issue, the region has seen a growing number of projects and initiatives to ensure water security, one of the main social and economic priorities in the region.

Climate Scenarios

Projections, under RCP8.5, for the near term (2021–2040) indicate that the number of days with maximum temperatures exceeding 35 °C will increase over all the region and could increase by up to 38 days per year in Djibouti, 36 in Yemen, and 30 in Somalia (ESCWA, 2017) [32] (Figure 16).

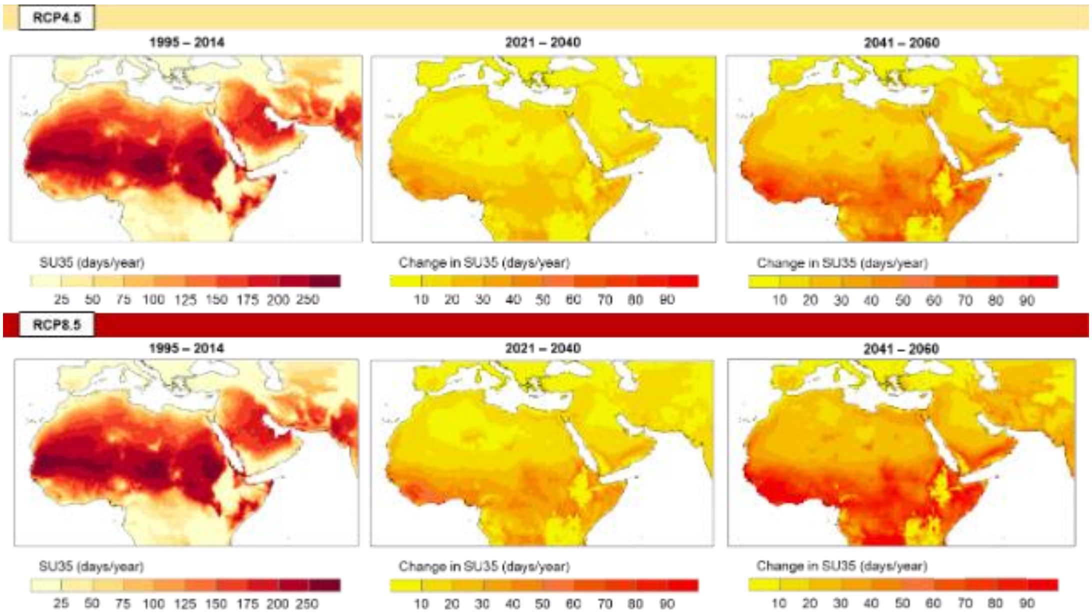


***Figure 16**. Change in number of days annually which daily maximum temperature > 35 °C (SU35) for near-term (2021-2040) and mid-term (2041-2060) compared to the reference period (1995-2014) over the Arab Domain (bias-adjusted; adapted from ESCWA, 2017).*

Across the Arabian Peninsula, the frequency and intensity of extreme precipitation are also expected to rise, exacerbating both drought and flood risks. By 2021–2040, the number of days with rainfall ≥10 mm could increase on average by 33% in Kuwait, 31% in Yemen and 26% in Oman under SSP5-8.5 (RICCAR, 2022) (Figure 17) [33]. These projected physical changes—particularly rising temperatures and erratic rainfall—have direct implications for water availability, the region's most urgent climate vulnerability.

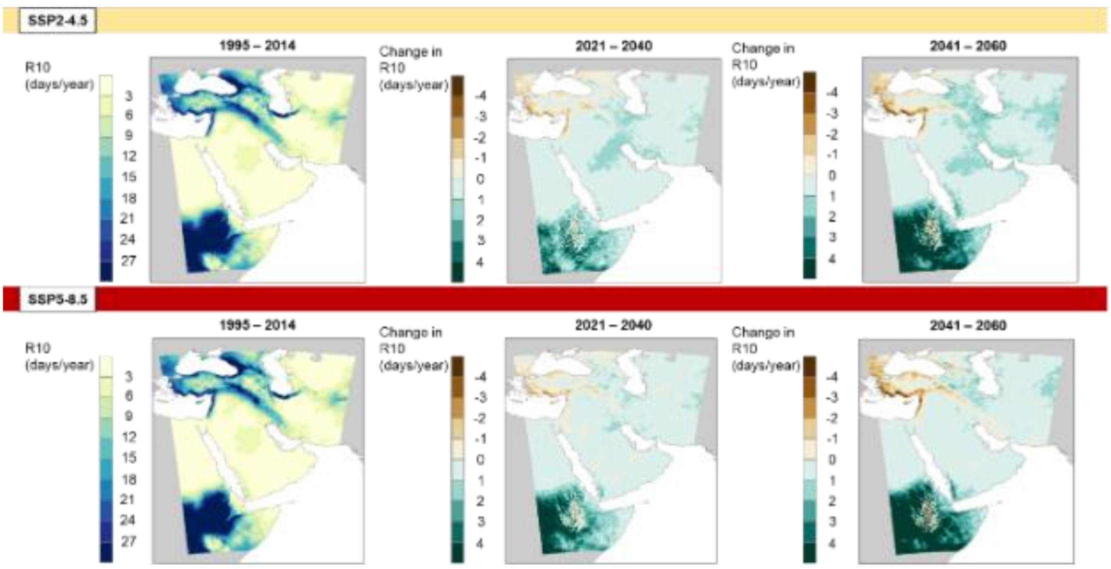


***Figure 17**. Change in number of days annually which daily precipitation ≥ 10 mm for near-term (2021-2040) and mid-term (2041-2060) compared to the reference period (1995-2014) over the Mashreq Domain (bias-adjusted; adapted from RICCAR, 2022).*

Water Resources: key challenges and strategies

With water scarcity already severe and set to worsen under future climate scenarios, the Arab region faces an escalating challenge in securing sustainable water resources.

The region contains 15 of the world's 20 most water-scarce countries. Although it is home to about 5% of the world's population, it receives less than 2% of the planet's renewable freshwater. Climate change, population growth, unsustainable water practices, and conflict are compounding these challenges (Al-Otaibi, 2015)[34].

Approximately 80% of surface water and 66% of total water resources in the region are transboundary, increasing the risk of interstate water disputes (UNDP, 2013)[35]. By 2050, two-thirds of Arab countries may have less than 200 m³ of renewable freshwater per capita annually.

Roughly 82% of wastewater in the region remains untreated or unused—presenting a major opportunity to bridge the water supply gap. Most countries have shifted from supply-side to demand-side water management, which focuses on providing water and related services, through regulatory, economic, and technological tools (Mateo-Sagasta et al., 2022)[36]. This includes promoting modern irrigation techniques (e.g., drip, sprinklers) to improve efficiency in the agriculture sector, which is the region's largest water consumer.

To close the gap, non-conventional water sources are becoming a strategic priority[37], including:

1. Seawater desalination
2. Reuse of agricultural drainage
3. Reuse of treated wastewater
4. Sustainable use of brackish groundwater
5. Rainwater harvesting
6. Cloud seeding initiatives

Water in the Arab region at a glance:

15/20
of the world's most water-scarce countries

66%
of total water resources are transboundary

<200 m³
of renewable freshwater per capita annually in 2/3 of countries by 2050

82%
of wastewater remains untreated or unused

Regional initiatives—such as the Arab Water Security Strategy (2010–2030)[38], the FAO Water Scarcity Initiative, and the Arab Non-Conventional Water Resources Initiative—are supporting these efforts. Governments are also integrating water strategies into broader climate adaptation plans. As water insecurity intensifies, Arab governments are increasingly integrating water management into broader climate policy frameworks—both nationally and internationally.

Showcases of national strategies for improving water resource management

Several countries across the Arab region are implementing large-scale strategies and projects to enhance water security in response to rising climate pressures (Figure 18).

Algeria, Morocco, and Tunisia have developed ambitious strategies to address growing water security challenges driven by frequent and prolonged drought. In Algeria and Morocco, large-scale initiatives are underway, including seawater desalination, expansion of dam infrastructure, and wastewater treatment for agricultural reuse. Public awareness campaigns are also being implemented to promote rational water consumption. In Tunisia, a comprehensive national strategy "Water 2050 in Tunisia" was adopted with an estimated implementation cost of €23 billion. The strategy aims to enhance the efficiency of drinking water distribution and irrigation networks, targeting the recovery of 300 million m³ of water per year. Key components include the reuse of treated wastewater and the construction of 32 hill dams by 2050.

In Jordan, four major water projects are underway, including wastewater treatment facilities in Al-Ghabawi and As-Samra, with treatment capacities of 8.2 million m³ and 300 million m³ per year, respectively. A third flagship initiative—the National Water Carrier Project—will transfer up to 300 million m³ per year from Aqaba to central and northern Jordan. Most of these projects incorporate renewable energy sources. Over €800 million has been allocated, with funding from the Government of Jordan, the European Union, the United States, and Germany, alongside multilateral financial institutions.

In Saudi Arabia, the National Water Strategy 2030 led to the establishment of the Water Authority, tasked with planning, regulation, and oversight of national water projects. The strategy aims to protect water sources and surrounding ecosystems from degradation and ensure the sustainability of water use for future generations. A new legal framework, including a comprehensive water system law, ensures legal protection for water reserves and specifies provisions.

In Egypt, measures are being implemented to protect the Nile Delta from sea level rise and associated climate impacts. These include efforts to safeguard the livelihoods of millions of residents by improving agricultural productivity in rural areas.

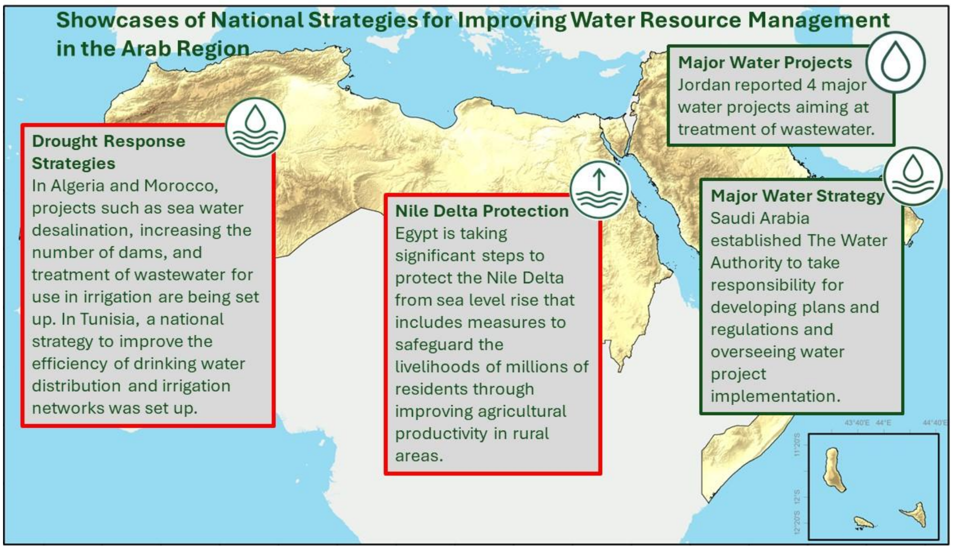


Figure 18. Improving water Resources Management in the Arab Region: Showcases of national strategies.

Arab Engagement in the Multilateral Climate Process

Against this backdrop of mounting climate risks—particularly water stress—Arab countries have taken an active role in shaping the global climate agenda. Arab States have hosted several sessions of the UNFCCC Conference of the Parties (COP), including Morocco (COP7 in 2001 and COP22 in 2016), Qatar (COP18 in 2012), Egypt (COP27 in 2022), and the United Arab Emirates (COP28 in 2023) (Figure 19). Arab countries participate individually and as part of the Arab Group on Climate Change.

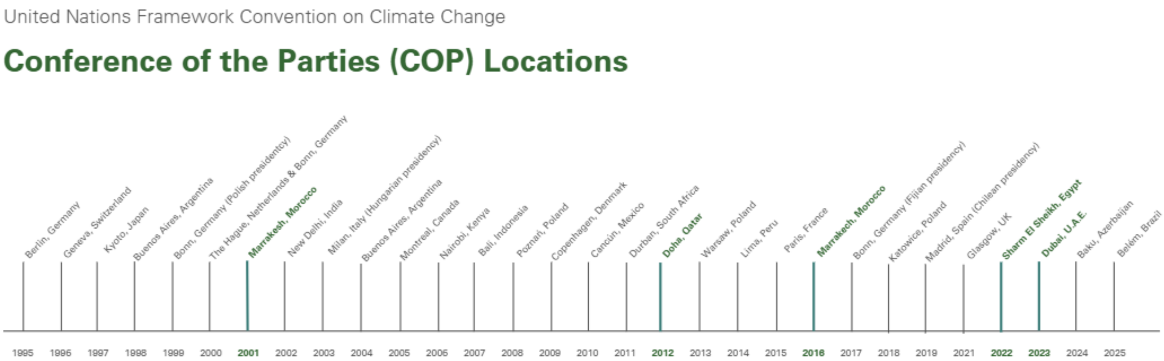


Figure 19. *UNFCCC Conference of the Parties locations. Conferences hosted in the region are highlighted in green.*

Many States have updated their Nationally Determined Contributions (NDCs) to include emissions reduction and mitigation targets. However, progress on National Adaptation Plans (NAPs) remains limited, despite adaptation being a regional priority under the Paris Agreement. The Arab Framework Action Plan on Climate Change (2010–2020), coordinated by the League of Arab States through CAMRE, has provided a foundation for regional cooperation. Climate services—especially in forecasting, monitoring, and sector-specific applications—are increasingly recognized in national strategies. Of 37 NDCs reviewed in the region, 29 referenced climate services, most frequently in relation to forecasting (24%), data management (22%), and observation networks (22%).

While high-level engagement on climate resilience has progressed, effective on-the-ground implementation remains essential—particularly in areas such as early warning systems that translate global objectives into local action. As of March 2024, 59% of Arab countries reported having Multi-Hazard Early Warning Systems (MHEWS) in place, slightly exceeding the global average of 55%. This represents encouraging progress, but significant disparities in system coverage and implementation remain. Strengthening technical capabilities, securing sustainable financing, and enhancing regional coordination will be critical to closing these gaps and ensuring timely, actionable information reaches vulnerable communities.

Mitigation Strategies

Alongside strengthening resilience through early warning, many Arab States are also investing in long-term mitigation strategies to address the root causes of climate change (Figure 20). Mitigation efforts across the Arab region are gaining momentum, particularly through a shift toward clean energy and sustainable urban development. Several countries have committed to increasing the share of renewable energy in their national energy mixes, with targets of up to 40% by 2030. Examples are highlighted in the map below, including large-scale wind and solar infrastructure in Morocco, low-cost traffic management systems in Egypt, national greening initiatives in Kuwait and Bahrain, and the Saudi and Middle East Green Initiatives to scale up clean energy and reduce emissions. These mitigation strategies, alongside adaptation and water security efforts, form the backbone of a more climate-resilient and sustainable Arab region.

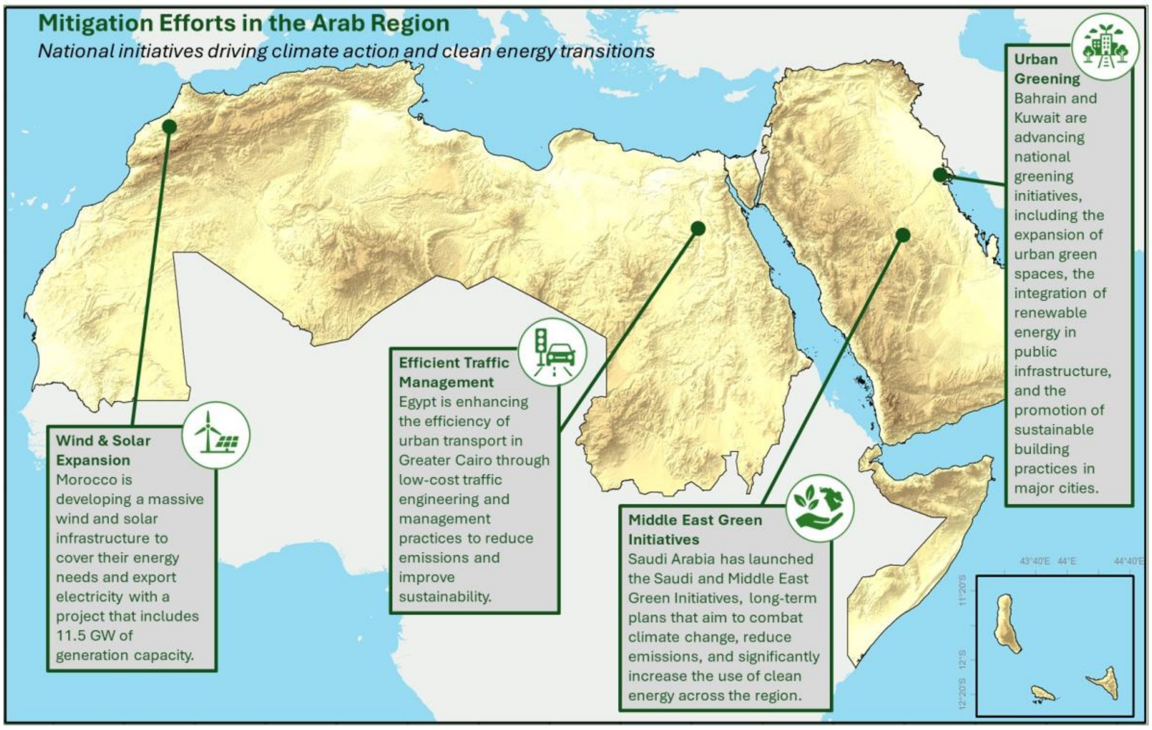


Figure 20. *Selected mitigation efforts across the region.*

Data sets and methods

All data sets and their use are subject to license or permission, even if they are from an open source. Please consult the data download pages for appropriate support.

TEMPERATURE

WMO Climate Data Dashboard

HadCRUT.5.0.2.0: Morice, C. P.; Kennedy, J. J.; Rayner, N. A. et al. An Updated Assessment of Near-Surface Temperature Change From 1850: The HadCRUT5 Data Set. Journal of Geophysical Research: Atmospheres 2021, 126, e2019JD032361. https://doi.org/10.1029/2019JD032361. HadCRUT.5.0.2.0 data were obtained from http://www. metoffice.gov.uk/hadobs/hadcrut5 on 19 January 2025 and are © British Crown Copyright, Met Office 2025, provided under an Open Government Licence, http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/.
NOAAGlobalTemp v6: Huang, B., X. Yin, M. J. Menne, R. Vose, and H. Zhang, NOAA Global Surface Temperature Dataset (NOAAGlobalTemp), Version 6.0.0. NOAA National Centers for Environmental Information. https://doi.org/10.25921/rzxg-p717
GISTEMP v4: GISTEMP Team, 2022: GISS Surface Temperature Analysis (GISTEMP), version 4. NASA Goddard Institute for Space Studies, https://data.giss.nasa.gov/gistemp/. Lenssen, N.; Schmidt, G.; Hansen, J. et al. Improvements in the GISTEMP Uncertainty Model. Journal of Geophysical Research: Atmospheres 2019, 124, 6307–6326. https://doi.org/10.1029/2018JD029522.
Berkeley Earth: Rohde, R. A.; Hausfather, Z. The Berkeley Earth Land/Ocean Temperature Record. Earth System Science Data 2020, 12, 3469–3479. https://doi.org/10.5194/essd-12-3469-2020.
And two reanalyses:
JRA-3Q: Kosaka, Y.; Kobayashi, S.; Harada, Y.; Kobayashi, C.; Naoe, H.; Yoshimoto, K.; Harada, M.; Goto, N.; Chiba, J.; Miyaoka, K.; Sekiguchi, R.; Deushi, M.; Kamahori, H.; Nakaegawa, T.; Tanaka, T. Y.; Tokuhiro, T.; Sato, Y.; Matsushita, Y.; Onogi, K. The JRA-3Q Reanalysis. J. Meteorol. Soc. Jpn. Ser II 2024, 102 (1), 49–109. https://doi.org/10.2151/jmsj.2024-004.
ERA5: Hersbach, H.; Bell, B.; Berrisford, P. et al. ERA5 Monthly Averaged Data on Single Levels from 1940 to Present; Copernicus Climate Change Service (C3S) Climate Data Store (CDS), 2023. https://doi.org/10.24381/cds.f17050d7 .

RAINFALL

The Rainfall Estimates from Rain Gauge and Satellite **(**CHIRPS**)** dataset, with a spatial resolution of 0.05° covering the period from 1991 to 2024, was utilized to estimate rainfall anomalies. This dataset was used to calculate the regional average of annual mean rainfall anomalies over the Arab region relative to the reference period 1991–2020. The rainfall anomalies for 2024 were derived relative to the 1991–2020 average.

Citation: Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., Shukla, S., ... & Michaelsen, J. (2015). The climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes. Scientific Data, 2(1), 150066. DOI: 10.1038/sdata.2015.66.

HEATWAVE

The Heatwave Index (HWI) analysis over the Arab World region was prepared using the ERA5-Land data. The data was obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF), which provides high-resolution gridded meteorological data with a horizontal resolution of 0.1^0 x 0.1^0. In this analysis, heat waves are defined as days where daily maximum temperatures exceed the climatological normal by at least 5°C for a minimum of four consecutive days in summer. The climatological normal is calculated based on the historical baseline period 1991-2020, ensuring consistency in identifying anomalous temperature events. This threshold-based approach allows for the precise detection and quantification of heatwave occurrences, their intensity, and spatial extent.

Citation : G. Ouzeau, J.-M. Soubeyroux, M. Schneider, R. Vautard, S. Planton 2016. Heat waves analysis over

France in present and future climate: Application of a new method on the EURO-CORDEX ensemble. Climate Services 4: 1-12, ISSN 2405-8807. https://doi.org/10.1016/j.cliser.2016.09.002.

DROUGHT

The 12-month Standardized Precipitation Index (SPI) analysis over the Arab World region was prepared using the CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data). This index monitors meteorological drought based on precipitation anomalies over 12-month accumulation periods. It is acquired from the Drought Observatories of the Copernicus Emergency Management Service at a horizontal resolution of 0.05° x 0.05°.
The source of data is https://data.jrc.ec.europa.eu/dataset/922a1f71-e1a4-480b-bbd2-a5ee75bb30c9.

SEA LEVEL RISE

GMSL from CNES/Aviso+ https://www.aviso.altimetry.fr/en/data/products/ocean-indicators-products/mean-sea-level/data-acces.html#c12195

Sandstorms

The Terra and Aqua combined MCD19A2 Version 6.1 Land Aerosol Optical Depth (AOD) gridded Level 2 product produced daily at 1 km resolution, from January 1, 2001, to December 31, 2024, was utilized to for AOD monthly averages using Google Earth Engine platform. Citation: https://doi.org/10.5067/MODIS/MCD19A2.061

HUMIDITY

ERA5-Land: Muñoz Sabater, J. (2019): ERA5-Land monthly averaged data from 1950 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). 2023. https://doi.org/10.24381/cds.f17050d7.

WILDFIRE

The Terra and Aqua combined MCD64A1 Version 6.1 Burned Area data product, with a spatial resolution of 500 meters, from November 1, 2000, to October 1, 2024, was utilized to show the burned area (in hectares).

Citation: Giglio, L., Justice, C., Boschetti, L., Roy, D. (2021). MODIS/Terra+Aqua Burned Area Monthly L3 Global 500m SIN Grid V061 [Data set]. NASA EOSDIS Land Processes Distributed Active Archive Center. Accessed 2024-12-19 from https://doi.org/10.5067/MODIS/MCD64A1.061.

EXTREME EVENTS AND IMPACT ASSESSMENT

WMO Supplement on Extremes

EM-DAT data were used to map extreme events and calculate historical climate impact. This database on natural and technological disasters contains essential core data on the occurrence and effects of more than 21,000 disasters worldwide from 1900 to the present. EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université catholique de Louvain, located in Brussels, Belgium. The indicators used for mortality, number of people affected, and economic damage are total deaths, the number affected, and total damages (thousand US$), respectively. However, EM-DAT is subject to limitations stemming from restricted data sources and variability in global disaster reporting, which may introduce biases beyond CRED's control. These warrants cautious interpretation, especially in regions with inconsistent reporting.

Citation: Guha-Sapir, D., Below, R., & Hoyois, P. (2022). EM-DAT: The Emergency Events Database – Université Catholique de Louvain (UCLouvain), Brussels, Belgium. Retrieved from https://www.emdat.be.

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[4] Only 5 temperature datasets used: Berkeley Earth, GISTEMP v4, HadCRUT.5.0.2.0, JRA-3Q, and NOAAGlobalTemp v6.

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