Kenya Meteorological Department

REPUBLIC OF KENYA

STATE OF THE CLIMATE KENYA 2024

This state of the climate report Kenya 2024 like its predecessors, provides a snapshot of the state of the climate in Kenya during the year 2024. It examines key weather events during the year, puts them in the context of 1991-2020 climatology and highlights the impacts of the same on key socioeconomic sectors in Kenya.

This complete report can be found at www.meteo.go.ke

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The State of the Climate Report : A Guide to its Uses and Importance

Sectoral Users

- Health
- Energy Sector
- Tourism
- Transport
- Disaster Risk Reduction
- Agriculture
- Water Resources
- Researchers
- Academia

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Who is this document useful for?

Policymakers:

- Provides evidence for developing and implementing climate policies.
- Highlights extreme weather events and their socioeconomic impacts.
- Informs adaptation strategies for communities and the nation.

Youth and Advocates:

- Raises awareness about climate change and its consequences.
- Translates complex scientific data into accessible information.
- Motivates action to reduce carbon footprints.

Funders and Investors:

- Offers data to justify funding for climate mitigation and adaptation projects.
- Identifies priority areas for investment (e.g., renewable energy, resilient infrastructure).
- Directs aid to vulnerable populations and regions

Key Benefits of the Report

Policy Support:

- Evidence-based insights for local climate action.
- Highlights urgency for reducing greenhouse gas emissions.

Advocacy and Awareness:

- Simplifies scientific data for public understanding.
- Encourages community and youth engagement in climate action.

Resource Mobilization:

- Provides hard data to attract funding from governments, organizations, and investors.
- Demonstrates economic and social returns on climate investments.

Call to action

Download the Report:
Visit http://www.meteo.go.ke today!
Join the Conversation: Follow @meteokenya on social media.
Take Action: Advocate, invest, and implement policies for a sustainable future.

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We need your feedback

This year, the KMD team has launched a process to gather feedback on the State of the Climate reports. Once you have finished reading, we kindly ask that you give us your feedback by responding to this short survey. Your input is highly appreciated.

Key Messages

- Record Temperature: 2024 was the hottest year on record in Kenya.
- Rainfall Variability: In 2024, the western and central highlands experienced above-normal rainfall, while most other regions saw drier-than-average conditions.
- Tropical Cyclones: The 2023–24 South-West Indian Ocean cyclone season was an above-average season, including ten named storms, six tropical cyclones and two intense tropical cyclones. Despite its moderate activity, it was the least deadly and destructive season in three years.
- Flooding: The March to May 2024 season brought above-average rainfall, with some areas receiving 111-200% of their long-term mean. Widespread flooding affected over 100,000 households, causing more than KSh 400 million in damages across coastal regions. Crop losses, infrastructure destruction, and livestock deaths further worsened food insecurity and economic losses.
- Drought: The poor short rains led to a sharp increase in food insecurity, rising from 1 million people in July 2024 to 2.15 million by February 2025, with 265,900 in IPC Phase 4 (Emergency) and 1.88 million in IPC Phase 3 (Crisis).
- Food Security: The year began with improvements in food security due to above-average long rains but ended with a sharp deterioration following the poor performance of the short rains, leading to widespread food insecurity and humanitarian needs.
- Health: Overall, the rains led to significant humanitarian and public health challenges in Kenya. The displacement of populations, damage to infrastructure, and outbreak of diseases underscored the critical need for coordinated emergency response, disease surveillance, and preventive measures to mitigate future impacts.
- Renewable Energy: Hydropower generation rebounded in 2024, reducing reliance on costly thermal power. However, below-normal rainfall in late 2024 and a forecasted dry March to May 2025 season are expected to negatively impact output in 2025/26.
- Looking Ahead (March-May 2025): Warmer-than-average temperatures are expected across the entire country and below-average rainfall is expected over the northeastern regions and the north coast.
- Climate Services Provision: Effective climate services are essential for safety, economic growth, and environmental protection, supporting national and global goals like Kenya's Vision 2030, the SDGs, and the Sendai Framework. Kenya's National Framework for Climate Services (NFCS) enhances climate information delivery through regional and national outlook forums and participatory scenario planning, but data availability remains fundamental to improving these services.
- Enhancing Climate Data: KMD operates 41 synoptic observation stations, including airport and agrometeorological sites, but their sparse distribution falls below WMO standards, highlighting the need for increased investment in maintenance and expansion, with initiatives like SOFF offering potential support to enhance Kenya's observational network for improved early warning systems

Chapter One: Introduction

Global Climate Context 2024

The global annual mean near-surface temperature in 2024 was 1.55 °C [1.42 °C to 1.68 °C] above the 1850–1900 pre-industrial 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 (1850-2024) according to six datasets, beating the previous record of 1.45 °C [1.32 °C to 1.57 °C] set in 2023. The years 2015 to 2024 were the ten warmest years on record in all six datasets.

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 (CO2) at 420.0 ± 0.1 parts per million (ppm), methane (CH4) at 1 934 ± 2 parts per billion (ppb) and nitrous oxide (N2O) at 336.9 ± 0.1 ppb – respectively 151%, 265% and 125% of pre-industrial (before 1750) levels (Figure 1). Real-time data from specific locations, including Mauna Loa (Hawaii, United States of America) and Kennaook/Cape Grim (Tasmania, Australia) indicates that levels of CO2, CH4 and N2O continued to increase in 2024.

The ocean warming rate over the past two decades is higher than for the whole record (1960-present); 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 high in 2024. The ocean is a sink for CO2. Over the past decade, it absorbed around one quarter of the annual emissions of anthropogenic CO2 into the atmosphere. CO2 reacts with sea water and alters its carbonate chemistry, resulting in a decrease in pH, a process known as “ocean acidification”. Ocean acidification affects organisms and ecosystem services, including food security, by reducing biodiversity, degrading habitats, and endangering fisheries and aquaculture.

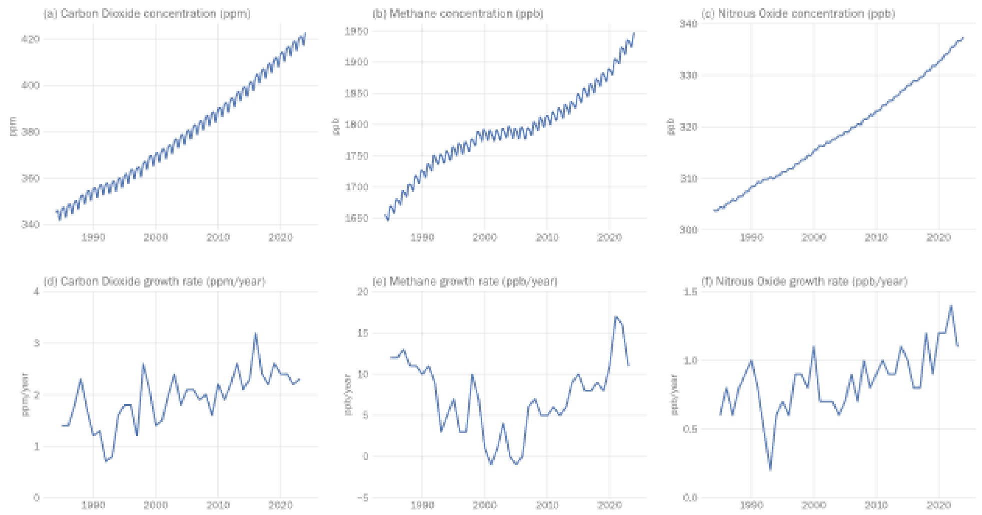


Figure 1: Top row: Monthly globally averaged mole fraction (measure of atmospheric concentration), from 1984 to 2023, of (a) CO_2 in parts per million, (b) CH_4 in parts per billion and (c) N_2O in parts per billion. Bottom row: Growth rates representing increases in successive annual means of mole fractions for (d) CO_2 in parts per million per year, (e) CH_4 in parts per billion per year and (f) N_2O in parts per billion per year.

Regional Impacts

Across Africa countries reported a variety of extreme events throughout the year (Figure 2). Floods were the most frequently reported extreme event with 46 events reported, some repeatedly in the same countries. Records indicate less than usual precipitation in many parts of Africa, while other regions had around normal or above normal precipitation. Drier than normal conditions were observed in the parts of southern Africa and the Southwest Indian Ocean Islands States including Madagascar. Furthermore, the Somali Peninsula, central Africa and some parts of the Sahel region received below normal rainfall.

In March 2024, tropical storm Filipo hit Mozambique, causing damage, and other severe storms produced heavy precipitation and strong winds inundating South Africa's coastline. There was severe flooding in the East Africa region during March to May rains leading to flooding in Kenya, Tanzania, Burundi, and other parts of the subregion impacting thousands of residents. The same situation obtained in parts of central Africa affecting Nigeria, Mali, Niger, and Chad. Southwest Indian Ocean Island states experienced notably tropical cyclones Chido, Belal, and Bheki and severe tropical storms resulting in heavy rainfall and flooding.

In 2024, Africa continued experiencing warming trends, consistent with the global increase in average temperatures which remained above the long-term averages, with significant anomalies noted in north, west and central Africa and parts of southern Africa. Area averaged temperature trend for the period 1991 – 2024 indicates significant increase for the Africa region. Twenty-two heatwave events were reported by a number of countries, further underscoring the fact that as global warming continues, more and more African tropical countries now experience heat waves previously not reported showing the increasing vulnerability of Africa to rising temperatures. Snow, snowstorms and cold waves were likewise reported by Libya and Botswana.

The extreme weather and climate events impacted many sectors across the continent including agriculture, food security, health, energy, transport, disaster risk reduction and programs under water resources management.

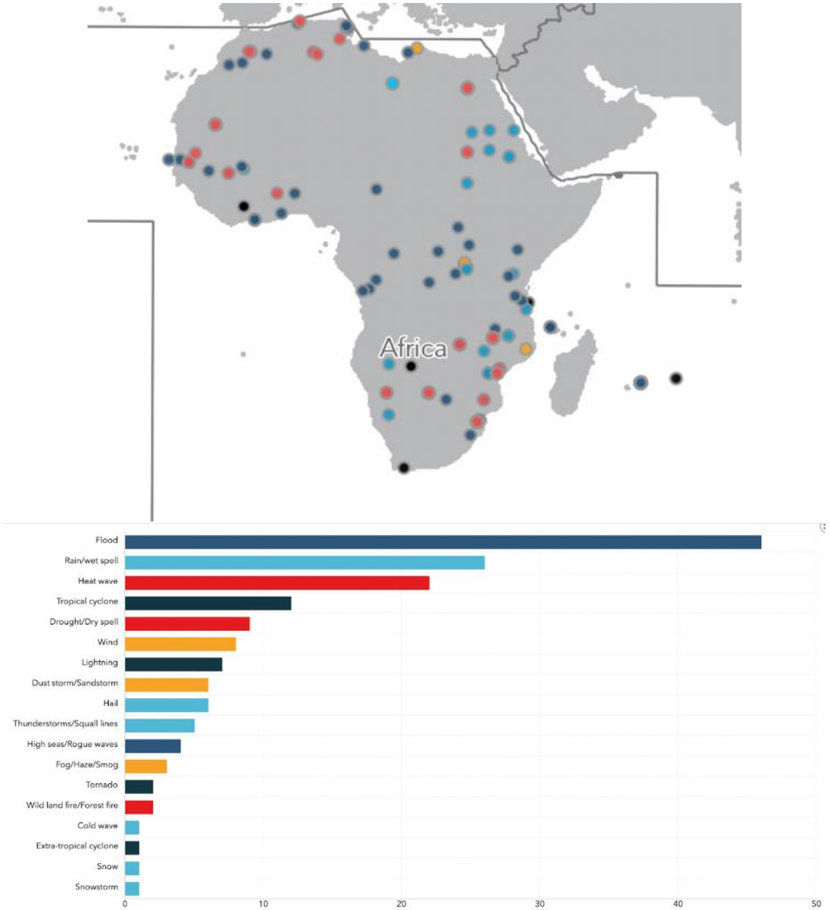


Figure 2: Extreme events reported in 2024 across Africa. Source: WMO Extreme Events dashboard

Chapter Two: Observed Climate in 2024

This section describes observed climatic changes in the year 2024 with respect to the climatological period 1991-2020. We present observed behaviour and changes in annual, monthly and seasonal rainfall and temperatures.

Temperature

2024 was the warmest year on record in Kenya, mirroring the global temperature rise (WMO, 2024). Figure 5 illustrates this ongoing warming trend. Figure 3 shows spatial distribution of temperature while figure 4 shows evolution of temperature across the country at different representative stations. Figure 3, analysis of the seasonal and annual temperatures, shows that above normal temperatures were experienced in most parts of the country in the year 2024.

In Lodwar, Mandera, Meru and Mombasa, 2024 recorded high temperatures for most months. Kitale, Kisii and Dagoretti, located in the western highlands, experienced relatively high but not exceptional conditions.

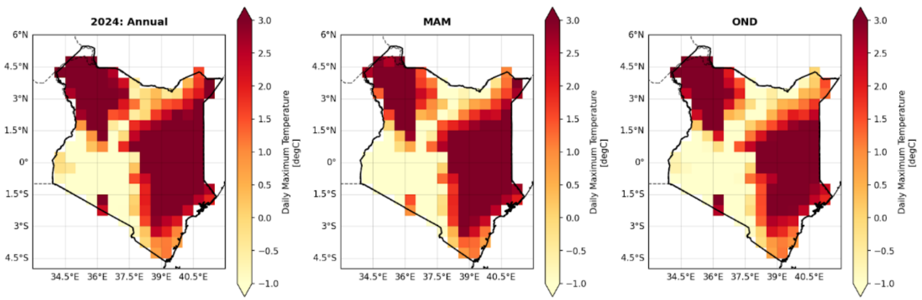


Figure 3: Annual and Seasonal temperature anomalies in 2024.

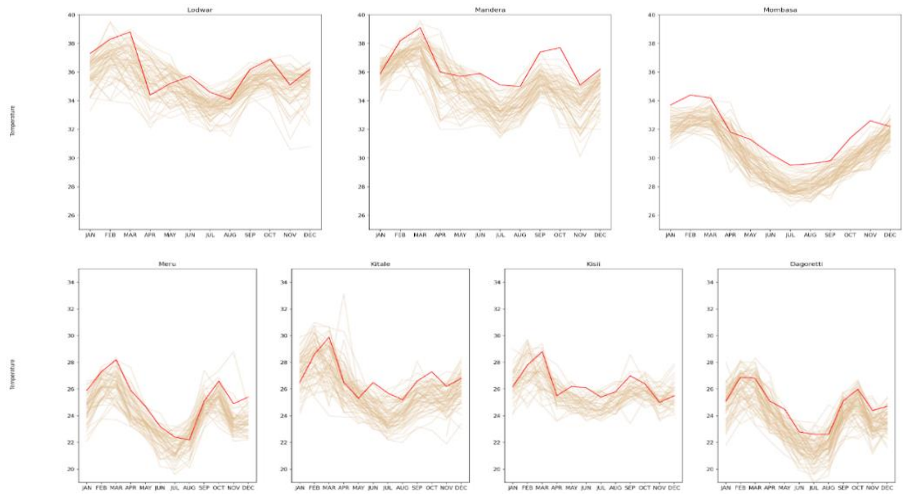


Figure 4: Evolution of maximum temperature across all years from 1991 to 2024 over Lodwar, Mandera, Mombasa (top), Meru, Kitale, Kisii and Dagoretti (bottom). The dark red line shows the maximum temperature in 2024.

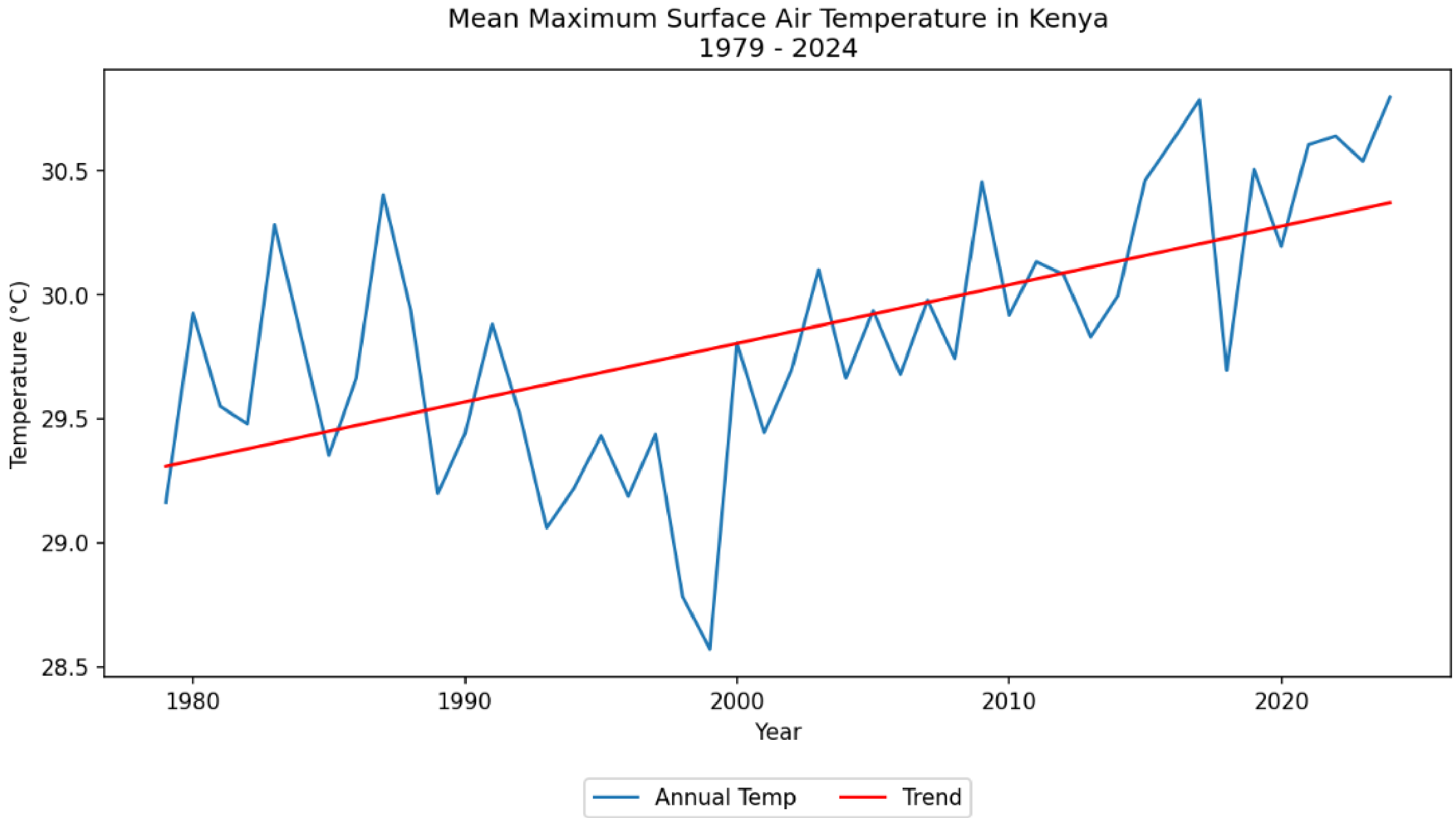


Figure 5: Annual and Seasonal temperature anomalies in 2024.

2024 was the warmest year on record in Kenya

Rainfall

Rainfall in 2024 exhibited significant spatial and temporal variability. April and November recorded the highest totals, with widespread and localized flash flooding April in the central highlands, including the Nairobi area (WWA, 2024). The western and central highlands experienced above-normal rainfall, while most other regions saw drier-than-average conditions.

The analysis of extreme rainfall indices—cumulative 5-day rainfall (Rx5day) in particular—provides insight into short-duration and multi-day extreme rainfall events (Figure 7). The dark red line illustrates the temporal evolution of this index in 2024, while the orange lines represent trends from 1991 to 2024. Notably, intense rainfall was observed from the last week of April into the first week of May (Figure 8), coinciding with widespread flash flood events reported across the country. Additionally, late November exhibited a brief spike in rainfall. However, the overall season remained dry, as reflected in the 30-day accumulation (Figure 8) and the spatial distribution of OND rainfall (Figure 9).

March-April-May (MAM)

The MAM season was characterized by above-average rainfall across most parts of the country, with some areas receiving 111–200% of the long-term mean (LTM). Central Kenya and the Rift Valley recorded rainfall exceeding 200% of the average. However, the Coastal region, Lake Victoria Basin, and parts of western Kenya experienced near to below-average rainfall, with the Coastal region recording less than 90% of normal levels. The highest seasonal rainfall total was recorded at Ndaka-ini station in Murang'a County (1,355.5mm), followed by Gatare Forest station, also in Murang'a, with 1,261.5mm. Other stations, including Dagoretti, Chuka Forest, Kimakia, Kangema, Kagwe Tea Factory, Wilson, Kabete, Moi Air Base, and Ngong, recorded over 1,000mm of rainfall. Notably, several stations, such as Nyahururu, Moi Air Base, Dagoretti Corner, Wilson Airport, JKIA, Kabete, Thika, and Machakos, experienced their wettest MAM season on record.

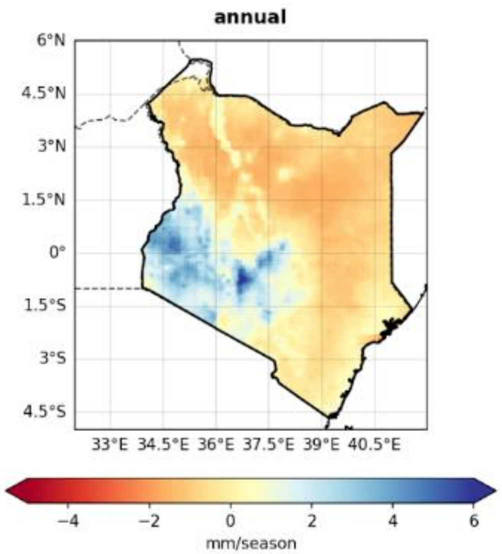


Figure 6: Standardised anomaly for precipitation in 2024

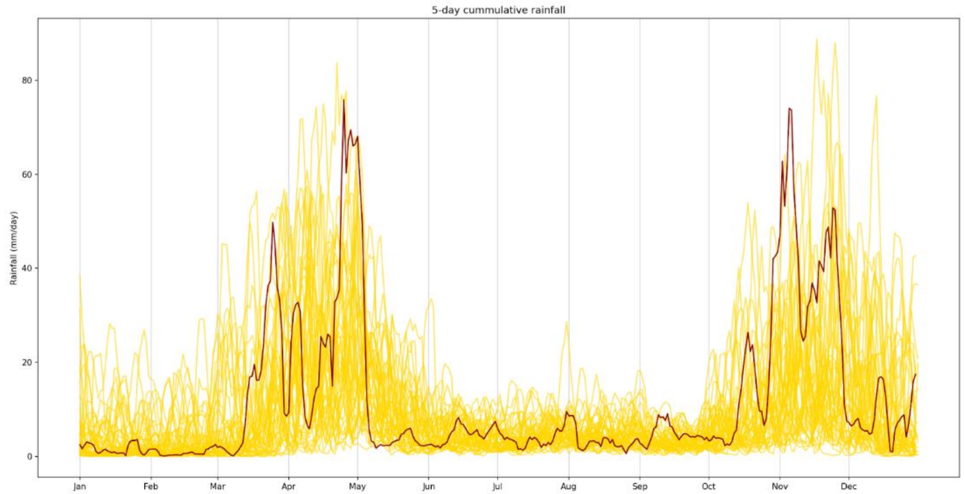


Figure 7. Temporal evolution of cumulative 5-day rainfall in all years from 1991-2024. The dark red line shows Rx5day in 2024.

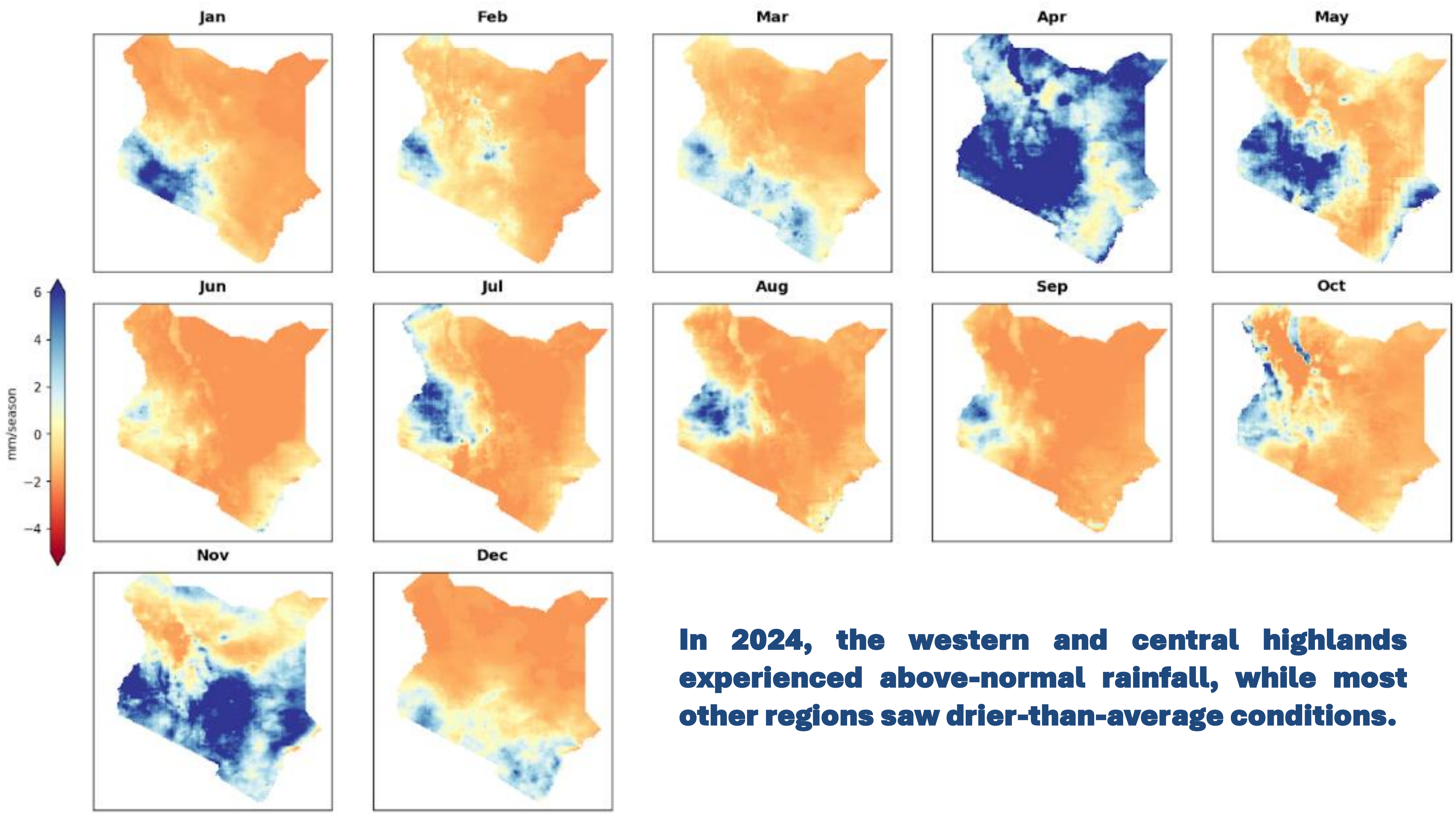


Figure 8. Monthly rainfall anomalies in 2024

In 2024, the western and central highlands experienced above-normal rainfall, while most other regions saw drier-than-average conditions.

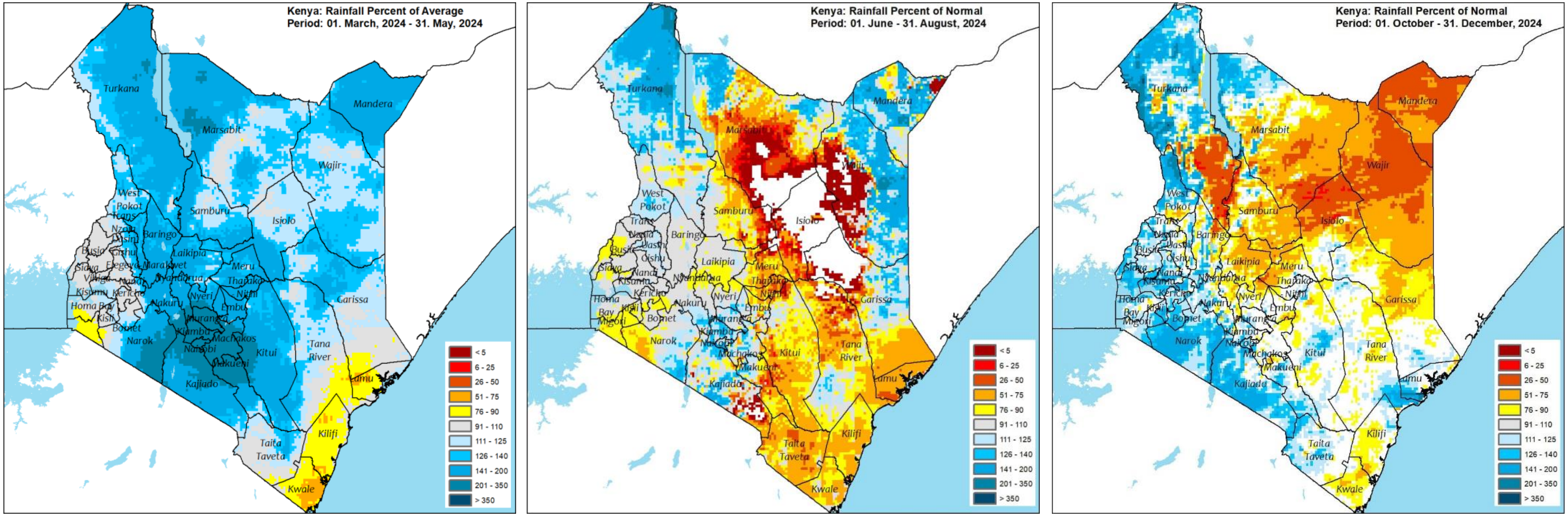


Figure 9: Rainfall performance as a percentage of normal in March-April- May (Left), June-August (Center) and October-December (Right)l

June-July-August (JJA)

During the June-July-August (JJA) 2024 period, the western sector of the country, and parts of the Highlands East of the Rift Valley, including Nairobi County, experienced significant rainfall. The highest seasonal rainfall total (649.7mm) was recorded at the Annex B Wareng rainfall station in Uasin Gishu County, followed closely by the Moi University rainfall station in the same county, which recorded 627.6mm. In contrast, The coastal region, despite being a typically high-rainfall area, recorded near to below-average rainfall, indicating a deviation from the LTM. Most stations in the northeastern and southeastern lowlands recorded less than 10mm of rainfall. The data underscores the variability in rainfall performance against the LTM, with some regions experiencing above-average rainfall while others remained dry.

October-November-December (OND)

The OND "short rains" were generally below average, with a delayed onset and prolonged dry spells. Rainfall amounts varied significantly across the country, with North Eastern Kenya and parts of Turkana receiving only 26-75% of normal rainfall, while the Coastal and Southeastern regions recorded 76-125% of normal levels. Western Kenya and the Rift Valley had above-normal rainfall, with Miyare Rainfall Station (Migori) recording 805.3 mm, the highest for the season. November was the wettest month, while October and December remained mostly dry. Overall, 54% of stations recorded near-average rainfall, 20% above average, and 26% below average, reflecting the variability and uneven distribution of rainfall across the country in 2024.

Marine Weather

Wind Patterns

The monsoon winds over the Indian Ocean for the year 2024 is illustrated in Figure 15. The figure illustrates the 10m winds direction (vectors) and 10m wind speed (shading) over the WIO adjacent to Equatorial East Africa (EEA). Wind speeds and direction are characterized by monsoon flows which are seasonally dependent in reference to the overhead solar insolation. During the NE monsoon occurring during DJF as shown in figure 15 (d), the wind speeds over the EEA coast are low as compared to the SE monsoon occurring during JJA as shown in figure 15 (b). The reduction in wind speeds is characterized by the transition period during SON season when the sun is overhead over EEA. From Figure 15 it is evident that during the NE monsoon, high wind speeds are observed along the Somali coast, while during SE monsoon the entire WIO basin is dominated by high wind speeds. The NE monsoon winds are lighter and predominantly northerly, while the SE monsoon winds are strong and mainly southerly. The SE monsoon season is characterized by rough seas caused by strong winds of more than 20 knots and high waves of more than 2.4 meters.

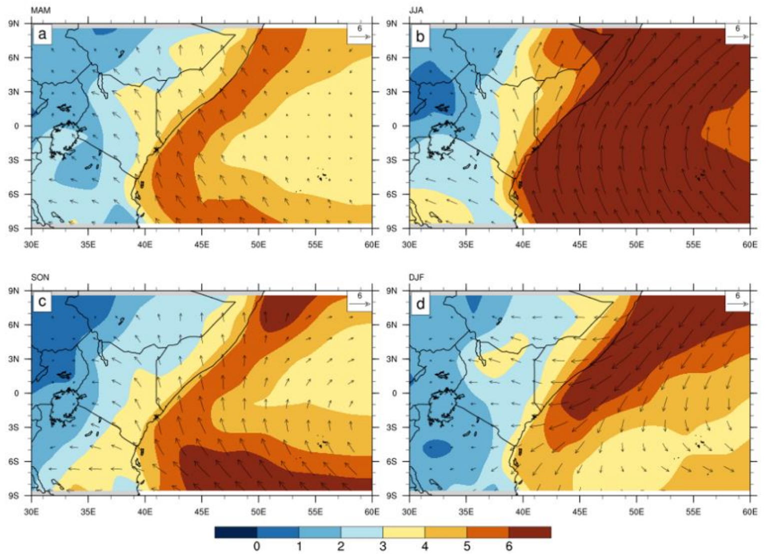


Figure 10: Seasonal distribution of the 10m winds directions (vector) and 10m wind speed (m/s)-shading (a) MAM, (b) JJA, (c) SON, and (d) DJF in 2024.

Tropical Cyclones

The 2023–24 South-West Indian Ocean cyclone season was an above-average season, including ten named storms (including an unnamed tropical storm), six tropical cyclones and two intense tropical cyclones. Despite its moderate activity, it was the least deadly and destructive season in three years.

It is the current event of the annual cycle of tropical and subtropical cyclogenesis. It began on 15 November 2023, and ended on 30 April 2024, except for Mauritius and the Seychelles, where it ended on 15 May 2024. On May 4th TC Hidaya made landfall in Tanzania, the closest TC to hit near the equator. Wind speeds from Hidaya measured around the same as a Category 1 hurricane, at 150 km/h on 3rd May just before landfall. No major impacts associated with tropical cyclones were recorded along the Kenyan coast.

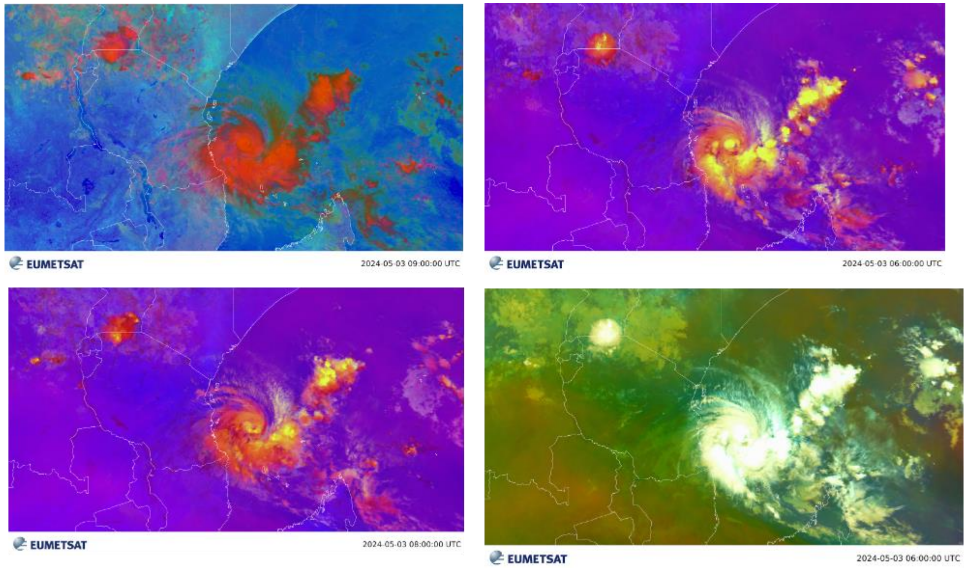


Figure 11: TC Hidaya just before landfall on 4th May 2024 as seen on Severe Convection RGB, Airmass RGB and Day Microphysics RGB Source: EUMETSAT

High Tides

Figure 18 illustrates 2024 observed water levels compared to the long-term mean records and climatology at the Kilindini port tide gauge station with respect to the Mean High High Water (MHHW) level. Updates are typically available by the 15th day of each month using the Fast Delivery of tide gauge data for Mombasa Kenya. The highest tidal waves were observed in the months of March, May, November and December 2024.

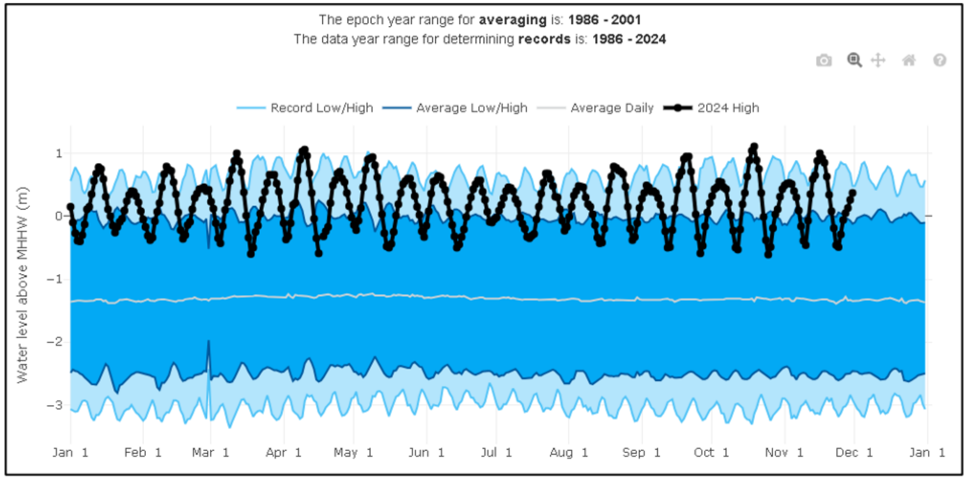


Figure 12: Monthly Means of the observed tidal heights in 2024 for Kilindini area of Mombasa

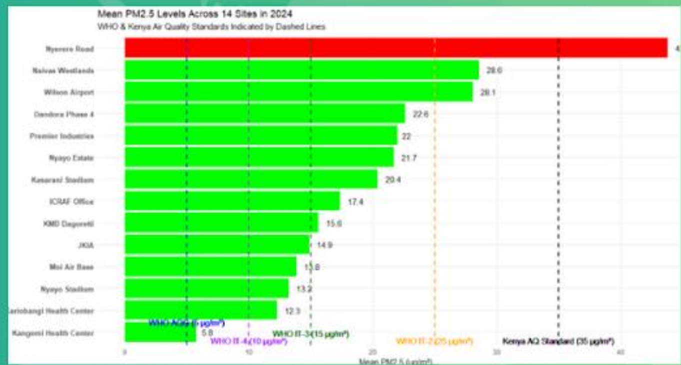
STATUS OF AIR QUALITY IN KENYA: THE CASE OF NAIROBI CITY

Air quality and climate are interconnected because the chemical species that lead to a degradation in air quality are normally co-emitted with greenhouse gases. Thus, changes in one inevitably cause changes in the other (WMO, 2022). Climate change and air pollution are both environmental problems affecting development in Kenya, and are potentially dangerous for human, animal and ecosystem health. Air pollution can be detrimental in urban areas, where large numbers of people and emissions are concentrated. In Nairobi, air pollution is a significant environmental and public health concern, with rapid urbanization, increasing vehicular emissions, industrial activities, and waste burning contributing to deteriorating air quality WMO (2022).

Monitoring Air Quality in Nairobi City

Air quality monitoring focusing on PM2.5. was conducted across 14 sites in Nairobi city. ***(see image below)***

PM2.5 poses the most severe health risks due to its ability to deeply penetrate human respiratory and circulatory systems. Numerous studies have linked long-term PM2.5 exposure to lung cancer, stroke, heart disease, and cognitive impairments



Implications for decision making

1 Nairobi a rapidly urbanizing city, faces increased levels of air pollution primarily from traffic emissions, industrial activities, waste burning, and domestic fuel use. Exposure to fine particulate matter can be associated with increased incidences of respiratory illnesses. The findings from this monitoring have identified pollution hotspots in the city, highlighting the urgent need for air quality interventions, targeting transport corridors, industrial zones, and residential estates that recorded high levels of PM2.5 pollution.

2 A combination of air pollution mitigation measures and interventions, including increased public awareness, and enforcement of existing regulations, and better urban planning are needed.

3 The monitoring also highlights the need for an expanded monitoring network to fill in existing data gaps. The integration of meteorological parameters with air quality data in future can enable more accurate forecasting thereby enhancing possibility for predictive models to generate evidence for improved decisions and interventions for air quality management in Kenya.

Extreme Events in 2024

Recurring droughts and floods in Kenya in 2024 highlighted the need for stronger resilience measures, including flood mitigation, climate-smart agriculture, and early warning systems. Addressing these challenges requires both immediate aid and long-term strategies, with coordinated efforts from national and local stakeholders, supported by climate data from the Kenya Meteorological Department (KMD).

Drought

The drought situation in Kenya's Arid and Semi-Arid Lands (ASAL) counties in 2024 was marked by significant fluctuations, driven by the performance of the March to May 2024 (MAM 2024) long rains and the October to December 2024 (OND 2024) short rains. The year began with improvements in food security due to above-average long rains but ended with a sharp deterioration following the poor performance of the short rains, leading to widespread food insecurity and humanitarian needs.

The long rains (MAM 2024) were above average in most parts of the country, with some areas in central Kenya and the Rift Valley receiving over 200% of the average rainfall. However, the Coastal region and parts of western Kenya experienced near to below-average rainfall. Although the above-average rainfall led to significant improvements in food security across Arid and Semi-Arid Lands (ASAL) counties, there was a sharp deterioration in food security following the poor short rains season, underscoring the urgent need for humanitarian assistance in affected regions, particularly in pastoral and agro-pastoral zones. The situation calls for enhanced climate resilience strategies, including improved water management, drought-resistant crops, and early warning systems to mitigate the impact of erratic rainfall patterns (see impacts to Agriculture and Food Security section for more information). Child protection remains a critical concern, with children in ASAL counties facing multiple risks, including recruitment into armed groups, early marriages, and limited access to education and healthcare. The drought situation in Kenya's ASAL counties in 2024 underscores the complex interplay between climate variability, food security, and humanitarian needs.

Extreme rainfall and flooding

The March to May 2024 Long Rains season in Kenya was marked by heavier than usual rainfall that led to severe flooding across many places in the country. In Nairobi in April, heavy rainfall led to displacement of residents of the informal settlements in the city with Mathare, Kibera and Mukuru being the hardest hit. Residents had to take temporary shelter in primary schools within the area.

In the northeastern part of the country, including Mandera, Wajir, Isiolo, Garissa, and Tana River counties, heavy rains and river overflow led to widespread flooding. Approximately 30,000 hectares of crops were destroyed, significantly affecting food production, while around 15,000 livestock were lost. Critical infrastructure, including roads and bridges, was severely damaged, with repair costs exceeding KSh 500 million. Over 20,000 people were displaced, increasing health risks and straining food resources. In the northwestern regions, Turkana and Marsabit counties experienced substantial flooding, resulting in significant agricultural damage and livestock losses

The coastal regions, including Kilifi, Taita Taveta, Kwale, and Lamu, also experienced severe flooding. The total estimated damage across the coastal regions exceeded KSh 400 million, with increased food prices and reduced availability exacerbating food insecurity. In Kilifi, the overflowing Sabaki River displaced farmers and disrupted education, affecting schools such as Mmangani, Kakuyuni Special, and Kakokeni Girls Secondary Schools. In Lamu, flash floods reduced crop acreage, damaged health services, and restricted healthcare access in areas like Chalaluma and Pandanguo.

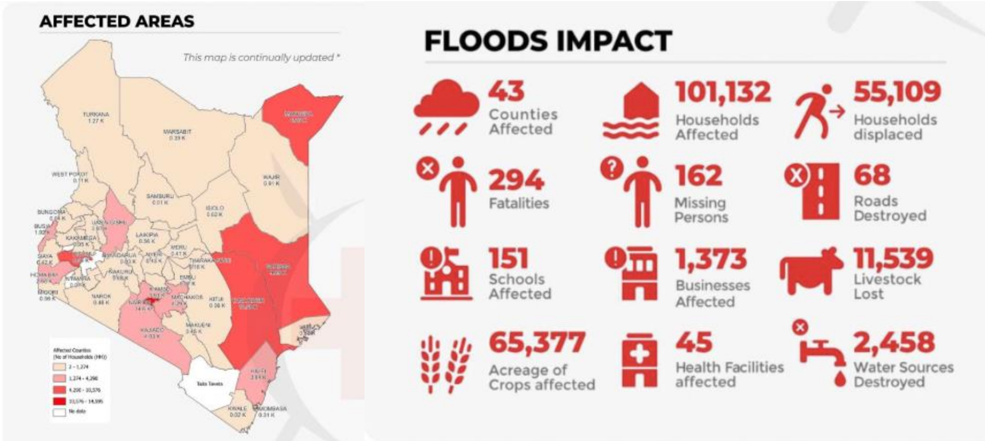


Figure 13: Flood impacted counties and the associated impacts. Source: Kenya Red Cross

What is Attribution???

“the process of evaluating the relative contributions of multiple causal factors to a change in climate or the likelihood-magnitude of a specific event, with an assignment of statistical confidence” (IPCC, 2013).

Attribution of climate change involves both statistical analysis and careful assessment of multiple lines of evidence to demonstrate, within a specified margin of error, that the observed changes are unlikely to be entirely due to internal variability and are consistent with the estimated responses to a given combination of anthropogenic and natural forcings. Consistency of an estimated response to a hypothesised forcing with an observed change is often determined by estimating the amplitude of the hypothesised pattern of change from observations and then assessing whether this estimate is statistically consistent with the expected amplitude of the pattern (IPCC, 2007). It is establishing a cause-effect relationship by separating internal and external drivers/forcings of the climate system responsible for the observed changes.

Extreme Event Attribution

Apart from the detection and attribution of long-term trends in extremes, new methodologies/ approaches have been developed to answer the question of whether and to what extent external drivers on the climate system, specifically greenhouse gases, have altered the intensity and probability of occurrence of individual extreme weather and climate events (NAS, 2016).

“...quantifying whether and how much past emissions have contributed to the probability of an extreme event occurring: how have we loaded the weather dice?”

Recent extreme event attribution studies in Kenya/East Africa

- Human-induced climate change increased 2021–2022 drought severity in horn of Africa
- Attribution of the human influence on heavy rainfall associated with flooding events during the 2012, 2016, and 2018 March-April-May seasons in Kenya
- Urban planning at the heart of increasingly severe East African flood impacts in a warming world
- Compounding natural hazards and high vulnerability led to severe impacts from Horn of Africa flooding exacerbated by climate change and Indian Ocean Dipole
- OND 2023 Extreme rainfall

Chapter Three: Observed Climate Drivers

The Intertropical Convergence Zone (ITCZ)

The Intertropical Convergence Zone (ITCZ) is a belt of low pressure near the equator where trade winds from the Northern and Southern Hemispheres converge, resulting in frequent thunderstorms and heavy rainfall. Its position shifts seasonally, moving northward during the Northern Hemisphere's summer (around July) and southward during the Southern Hemisphere's summer (around January). This movement is driven by the tilt of the Earth's axis and the distribution of solar heating. In 2024, the ITCZ's position and shifts played a critical role in determining rainfall patterns across Kenya and East Africa. Over Kenya, the ITCZ's northward movement around March to May brought the long rainy season, characterized by substantial rainfall, particularly in the highlands, western regions, and the Lake Victoria basin. As the ITCZ shifted further north from June to September, Kenya typically experienced drier conditions, except for localized rainfall in western and coastal areas. The ITCZ's southward return around October to December triggered the short rainy season.

Oceanic Teleconnections

El Niño–Southern Oscillation (ENSO)

The El Niño-Southern Oscillation (ENSO) a recurring climate phenomenon that significantly influences global weather patterns, has three main phases: El Niño, La Niña, and ENSO-neutral.

- El Niño occurs when sea surface temperatures in the central and eastern Pacific Ocean rise above normal, leading to disruptions in global weather patterns, such as increased rainfall in some regions and droughts in others.
- La Niña, the opposite phase, is marked by cooler-than-normal sea surface temperatures, often causing opposite effects to El Niño, including drier conditions in areas that are usually wet during El Niño.
- ENSO-neutral refers to periods when neither El Niño nor La Niña conditions are present, with sea surface temperatures remaining close to average.

In regions like Kenya, El Niño is historically linked to enhanced rainfall, while La Niña is associated with reduced rainfall, often leading to drought conditions.

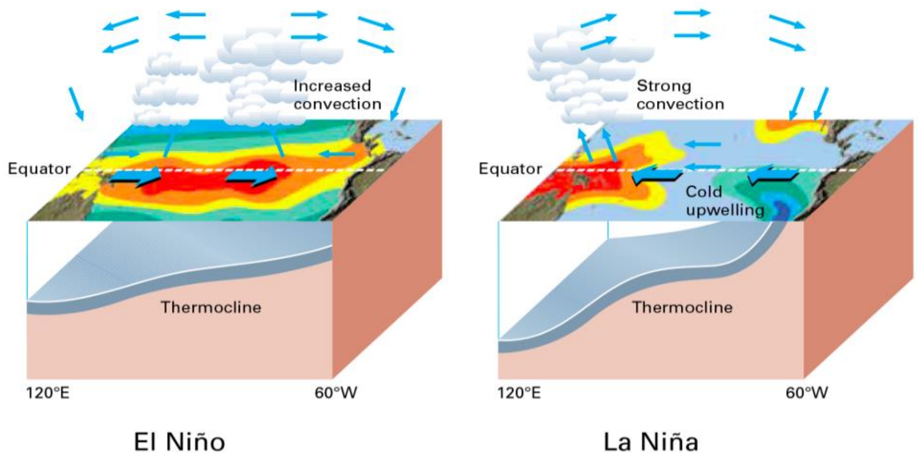


Figure 14: El Nino and La Nina phases.

El Niño/La Niña Summary for 2024

Identifying El Niño and La Niña Periods

El Niño conditions are identified when the Oceanic Niño Index (ONI) is ≥ +0.5°C for at least five consecutive overlapping 3-month seasons. La Niña conditions are defined when the ONI ≤ -0.5°C for at least five consecutive overlapping 3-month seasons. The ONI values for 2024 are provided below, showing the temperature anomalies for each three-month period from recent years through February 2025:

Table 1: ONI values for 2024

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2020	0.5	0.5	0.4	0.2	-0.1	-0.3	-0.4	-0.6	-0.9	-1.2	-1.3	-1.2
2021	-1.0	-0.9	-0.8	-0.7	-0.5	-0.4	-0.4	-0.5	-0.7	-0.8	-1.0	-1.0
2022	-1.0	-0.9	-1.0	-1.1	-1.0	-0.9	-0.8	-0.9	-1.0	-1.0	-0.9	-0.8
2023	-0.7	-0.4	-0.1	0.2	0.5	0.8	1.1	1.3	1.6	1.8	1.9	2.0
2024	1.8	1.5	1.1	0.7	0.4	0.2	0.0	-0.1	-0.2	-0.3	-0.4	-0.5
2025	-0.6											

Analysis of the 2024 ENSO Phases

- El Niño Conditions: From December 2023 to May 2024, the ONI values were consistently above 0.5°C, indicating the presence of a strong El Niño event. The DJF (Dec 2023 – Feb 2024) value of 1.8°C marked the peak of this El Niño, with subsequent values steadily declining but still remaining above the neutral threshold of 0.0°C.
- Transition to Neutral Conditions: Starting in June 2024, the ONI values began to approach 0.0°C, signaling a transition toward neutral conditions. By June and July 2024, the ONI was near 0.0°C, indicating the weakening of El Niño conditions.
- Weak La Niña Conditions: From August 2024 onward, the ONI values shifted into the negative range. By September 2024, the ONI was at -0.3°C and continued to decline through October and November 2024, indicating the development of weak La Niña conditions. These values suggested that La Niña was not fully established, but the cooling trend was notable, especially in the eastern equatorial Pacific.

Indian Ocean Dipole

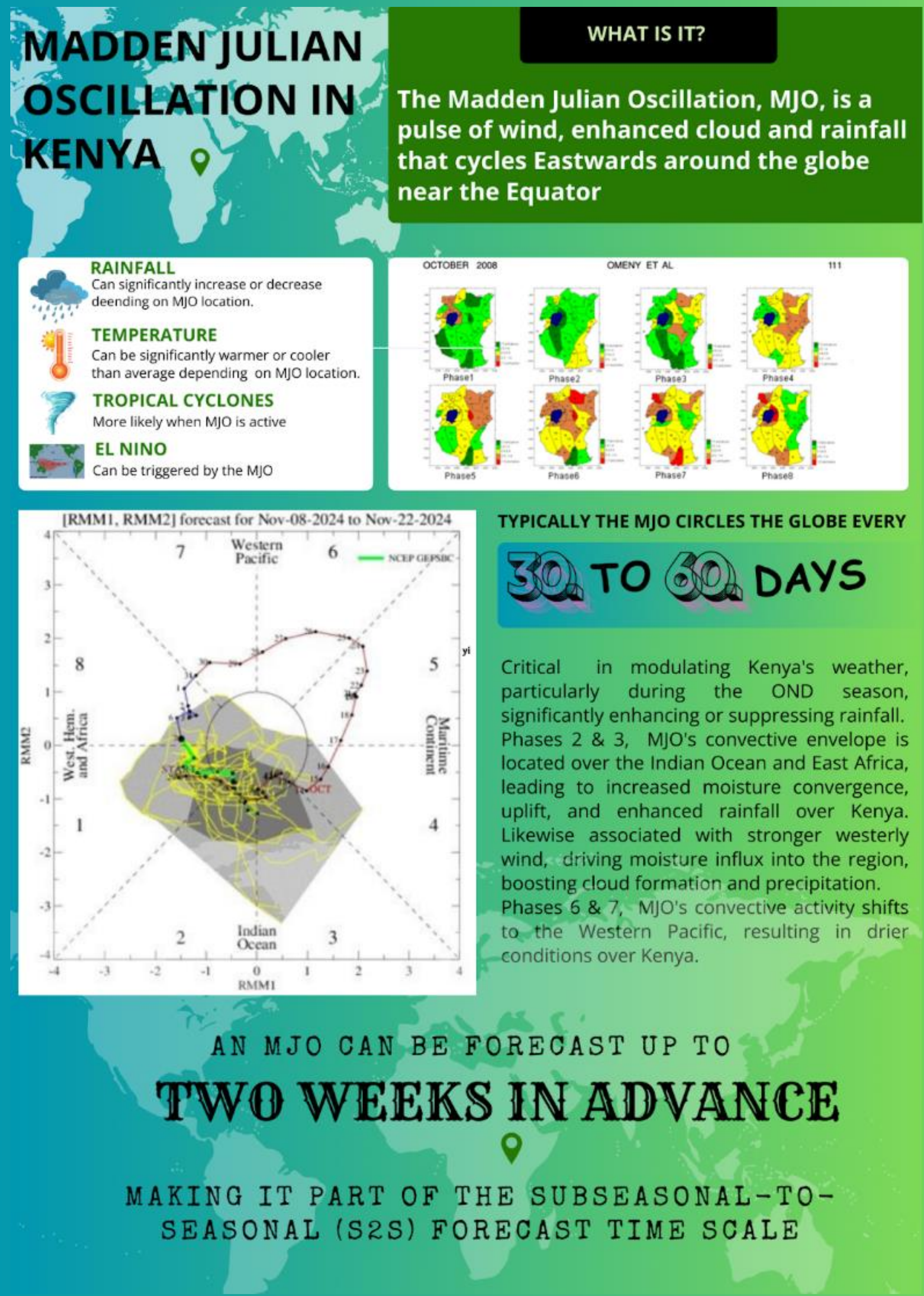
The Indian Ocean Dipole (IOD) is defined by the difference in sea surface temperatures between the eastern and western tropical Indian Ocean. The influence of the IOD is often linked with other climate phenomena such as the El Niño-Southern Oscillation (ENSO), which can amplify or dampen its effects.

- Negative IOD: During a negative IOD event, sea surface temperatures are typically warmer than average in the eastern parts of the tropical Indian Ocean and cooler than average in the west. This pattern can lead to below-average rainfall in regions like Kenya.
- Positive IOD: In contrast, a positive IOD event is characterized by cooler-than-average waters in the eastern tropical Indian Ocean and warmer-than-average waters in the west. This phase tends to bring enhanced rainfall, which can have significant impacts on regions dependent on seasonal rains, such as Kenya.
- Neutral IOD: When the sea surface temperatures in the Indian Ocean are balanced, the IOD is considered neutral, with no significant impact on regional weather patterns.

The development of IOD events is monitored through specific regions in both the eastern and western Indian Ocean, as these temperature differences are crucial in forecasting the potential impacts of the IOD on regional weather patterns. In Kenya, a positive IOD event is often associated with increased rainfall, while a negative IOD event typically leads to drier conditions.

Indian Ocean Dipole (IOD) Summary for 2024

- In January 2024, the positive IOD event began to weaken, which is typical as the monsoon trough shifted south into the Southern Hemisphere. This breakdown occurred later than usual, with forecasts indicating that the IOD index would fall below +0.4°C by the end of the month.
- By February 2024, the IOD had returned to neutral, with the index staying below the positive threshold for two consecutive weeks. This neutral phase was expected to persist until at least April 2024.
- In March 2024, the IOD index was above the positive threshold at +0.86°C, but the IOD remained neutral, as the eastern Indian Ocean cooled due to increased monsoonal activity.
- By April 2024, the IOD index continued to hover above the positive threshold (+0.68°C), signaling the potential development of a positive IOD event, though earlier than typically expected. However, it had not yet been confirmed as a sustained positive event.
- From May to June 2024, the IOD remained neutral, with the index staying below the positive threshold. Predictability was low, but forecasts suggested that the IOD would likely remain neutral at least until early spring.
- By July 2024, the outlook indicated that the IOD would stay neutral through the winter, though some models projected a possible negative IOD later in the year.
- In August and September 2024, the IOD remained neutral, with the index slightly negative in September at -0.07°C. Most models indicated that the IOD would continue in a neutral or weakly negative state, and an IOD event was deemed unlikely.
- By October 2024, the IOD index briefly dipped below the negative threshold to -0.58°C, but it was expected to stay neutral for the rest of the year, despite occasional fluctuations.
- November 2024 saw the IOD index remain below the negative threshold for an extended period, raising the possibility of a negative IOD event. However, models suggested that it would return to neutral by December 2024.
- By December 2024, the IOD had returned to neutral after a brief negative phase, in line with typical IOD behavior at this time of year. Forecasts indicated that the IOD would remain neutral through to April 2025.



Chapter Four: Socio-economic Impacts

Early Warning/Disaster Risk Reduction

During the year KMD issued 9 extreme weather advisories mainly on heavy rainfall, strong winds and high waves. By May 2024, reports estimate that about 267 people had been killed, 188 injured, 75 were missing, while 281,835 people (56,367 families) were displaced and almost 380,573(76,114 families) affected by persistent heavy rains and flooding. At least 9,973 livestock had been lost, 41,562 acres of cropland and 61 roads damaged, 886 businesses, 1,967 schools, 1,465 water sources and 62 health facilities damaged in 11 out of 42 counties affected by floods. On 29th April a dam broke in Mai Mahiu in Nakuru County following heavy rain and flooding--50 people were killed.

Image: Scenes from the Maai Mahiu dam break which led to about 50 deaths. Source: Standard Media Kenya

Agriculture and Food Security

Agriculture lies at the heart of Kenya's economy, with over 40% of the total population and more than 70% of the rural populace employed in the sector (CBK, 2024). The sector is highly weather-dependent and thus susceptible to climate variability.

During the 2024 MAM long rains, the country experienced widespread above-average rainfall, leading to improvements in forage, water availability, and crop production in high- and medium-production areas. This contributed to a temporary improvement in food security, reducing the number of food-insecure people to 1 million by August 2024. However, severe flooding affected at least 43 counties and 101,132 households, displacing over 55,000 households and causing destruction to crops, infrastructure, property, and essential facilities. While the floods allowed for some positive agricultural outcomes, such as seasonal planting along the Tana River, the destruction of cropland and livestock losses significantly affected food production in several regions. The Lake Basin counties faced severe flooding due to high rainfall amounts during the MAM 2024 season, which exacerbated food insecurity, increased health risks, and worsened nutrition conditions. Food prices surged throughout the year, further limiting access for vulnerable populations in these counties (Red Cross, 2024).

Impact of Drought and Short Rains on Food Security

Despite the temporary improvements in food security following the long rains, the October to December 2024 (OND) short rains performed poorly, leading to a significant deterioration in food security. The 2024 Short Rains Assessment (SRA 2024) conducted in February 2025 revealed that the number of people facing acute food insecurity had risen to 2.15 million, with 265,900 people classified in IPC Phase 4 (Emergency) and 1.88 million in IPC Phase 3 (Crisis). This marked a sharp increase from 1 million food-insecure individuals in July 2024 and exceeded earlier projections of 1.8 million by January 2025.The deterioration was particularly severe in pastoral and agro-pastoral areas, where below-average rainfall reduced livestock productivity, increased grazing distances, and led to declining milk production. Counties such as Turkana, Marsabit, Mandera, Wajir, and Garissa were classified in IPC Phase 3, with other counties experiencing similar food insecurity challenges.

Flooding and Food Security Impacts

According to the National Drought Management Authority (NDMA), counties in northeastern Kenya, including Mandera, Wajir, Isiolo, Garissa, and Tana River—primarily pastoral regions—experienced severe flooding due to heavy rains and river overflow. The floods destroyed approximately 30,000 hectares of crops, significantly affecting food production, and resulted in the loss of around 15,000 livestock. Similarly, Turkana and Marsabit counties suffered heavy flooding, impacting 25,000 and 20,000 hectares of cropland, respectively, with estimated livestock losses of 10,000 animals in both counties. The floods also caused severe erosion, reducing soil fertility and further limiting agricultural productivity. The combined impact of these losses heightened food insecurity, with local markets struggling to meet demand and food prices increasing by up to 40% (NDMA, 2024).In southeastern Kenya, counties such as Kitui and Makueni were similarly affected, with floods destroying 20,000 hectares of maize and beans and damaging infrastructure, making food access more challenging (NDMA, 2024).

Additional Food Security Challenges

In addition to flooding and drought impacts, food security in Kenya was further threatened by pest infestations. Fall Armyworm (FAW) outbreaks were reported in several counties, including Baringo, Isiolo, Kajiado, Kilifi, Kwale, Meru North, Taita Taveta, and Tana River. The most severe impacts were observed in Baringo, Kajiado, and West Pokot, where FAW infestation led to significant crop losses, exacerbating food shortages and further driving up food prices.

Kenya's food security situation in 2024 fluctuated sharply due to climate variability, with improvements following the long rains but a rapid deterioration after the poor short rains. While economic recovery and back-to-back rainy seasons initially improved food availability and access, severe flooding and prolonged dry conditions later in the year reversed these gains. The worsening food security situation highlights the need for climate resilience strategies, improved water management, drought-resistant crops, and early warning systems to mitigate the impact of erratic weather patterns on agriculture.

Health

Rainfall extremes, whether excessive or insufficient, significantly impact the spread and intensity of diseases. Heavy rainfall, flooding and stagnant water can create breeding grounds for waterborne diseases like cholera and vector-borne illnesses such as malaria. Conversely, prolonged rainfall shortages, such as during droughts, reduce water availability and sanitation. Both extremes can weaken public health systems, highlighting the critical need for preparedness and resilience in addressing these health risks.

During the March, April, and May (MAM) 2024 long rains season, Kenya experienced significant rainfall, which caused widespread loss of lives, displacement of populations, and destruction of property. By 19th May 2024, 41 counties had been affected.

Key statistics:

- Total number of people affected: 412,763
- Households displaced by floods: 55,676 (equivalent to 278,380 people)
- Number of people injured: 188
- Number of people missing: 78
- Total deaths reported: 295
- Critical infrastructure affected: 64 health facilities across 12 counties (Tana River, Kisumu, Kajiado, Busia, Kiambu, Nakuru, Murang'a, Kilifi, Garissa, Homa Bay, Migori, and Nairobi)

Disease Outbreaks and Health Impacts

Cases of respiratory illnesses were reported in Mombasa County health facilities and were distributed across three counties: Kilifi: 12 cases, Mombasa: 1,416 cases, Kwale: 4 cases. A total of 1,432 cases, including 18 deaths (case fatality rate [CFR] of 1.3%), had been reported as of 19th April 2024. By 2nd May 2024, 88 cases of Dengue fever had been reported from Dagahaley camp in Dadaab Sub-county, Garissa County.

By 11th August 2024, 300 cases of cholera, including 3 deaths (CFR of 1.0%), had been reported in the following counties: Nairobi, Isiolo, Siaya, Tana River, and Lamu.

Visceral Leishmaniasis cases were reported in Kitui and Mandera Counties. A total of 70 cases were recorded cumulatively, distributed as follows:

- Mandera County: 60 cases reported
  - Kotulo: 3,
  - Mandera South: 2,
  - Mandera East: 55
- Kitui County: 10 cases reported
  - Mwingi North: 6,
  - Mwingi Central: 4.

Four deaths were documented, resulting in a Case Fatality Rate (CFR) of 7.4%. Males accounted for 84% of all positive cases as of November 24, 2024 (MOH Kenya, Disease Surveillance and Response Unit).

Human and livestock diseases also remained a significant concern across the country during the year as reported by NDMA. Measles outbreaks were reported in several counties with active cases in Kwale (19), Turkana (10), Mandera (7) and Garissa (4), resulting in one death in Lagdera and twelve in Turkana West sub county. Additionally, there were cholera outbreaks in Tana River, Lamu and Isiolo county. Cases of endemic livestock diseases reported include Contagious Caprine Pneumococcal (CCPP), Pestes des Petits Ruminants (PPR), Foot and Mouth disease (FMD), Sheep and Goat Pox (SGP) and few cases of Contagious Bovine Pneumococcal (CBPP) and East Coast Fever (ECF). Acute Camel Death Syndrome and Hemorrhagic septicemia in camels were reported mainly in Moyale, North Horr and Laisamis sub-counties of Marsabit County.

Overall, the rains led to significant humanitarian and public health challenges in Kenya. The displacement of populations, damage to infrastructure, and outbreak of diseases underscored the critical need for coordinated emergency response, disease surveillance, and preventive measures to mitigate future impacts.

Education

The widespread flooding recorded throughout the year had negative impacts on the education sector in Kenya. At least 62 primary schools across the country were submerged or destroyed and the government projected that an estimated 15,000 children were at risk from waterborne diseases. Part of the school infrastructure destroyed included toilets which then posed serious health risks to over 1.5 million school children across the country.

A report by the Elimu Bora Working Group (EBWG) found that return rates to school across many schools in the country after the March to May season were really low due to the flooding. Since schools were damaged, school feeding programs could no longer continue efficiently further disadvantaging those in marginalised areas. Additionally noted was the need for psychosocial and mental health support to learners and teachers. Ahead of schools reopening on 13 May, the Kenya Government announced one billion Kenyan shillings package (US$7.5 million) to rehabilitate schools affected by the floods.

Image: Aerial picture of Lower Nyando (bottom) and Yala River at Yala town (top) in late November 2024

Water Resources

The El-Nino phenomenon experienced in Kenya during the 2023 OND period caused substantial rainfall amounts across the country. Most river flows therefore remained above the flood alarm levels. The rains continued in most parts of the country during the months of January and February 2024 and therefore the river flows did not recede significantly. The Nyando river mouth and areas adjacent to Lake Victoria remained inundated due to sustained high lake levels during this period.

The country suffered devastating impact of floods during the 2024 MAM period, affecting livelihoods, infrastructure and social facilities with more than two hundred fatalities reported. Water levels in all the major rivers across the country remained above the Flood Alarm threshold during this period. Most dams in the country were full by the end of April 2024 posing imminent danger to the downstream populations. The Seven-folks Dam comprising Masinga, Kamburu, Kiambere, Gitaru and Kindaruma started to overflow on 29th April 2024, further exacerbating the flood menace in lower Tana.

The JJAS period witnessed decreased flows across all basins in the Country. However, the effects of the MAM floods were still experienced in many low-lying areas. Parts of the Lake Victoria shoreline areas including the river mouths of Nzoia, Nyando, Sondu and Kuja-Migori remained inundated due to sustained high lake levels. Some areas in the lower Tana basin in Garissa and Tana River Counties have also remained waterlogged despite lower flows observed in the Tana River.

Generally, the levels in the Rift Valley lakes as well as Lake Victoria remained very high during the JJAS period. The observed levels indicate that from May 2024, lakes Nakuru, Naivasha and Turkana within the Rift valley, the levels have surpassed the highest recorded in the year 2020. Lake Victoria also sustained high levels throughout the June to August period. It is notable that the levels recorded from May 2024 were much higher than what was observed in the years 1965 and 2020.

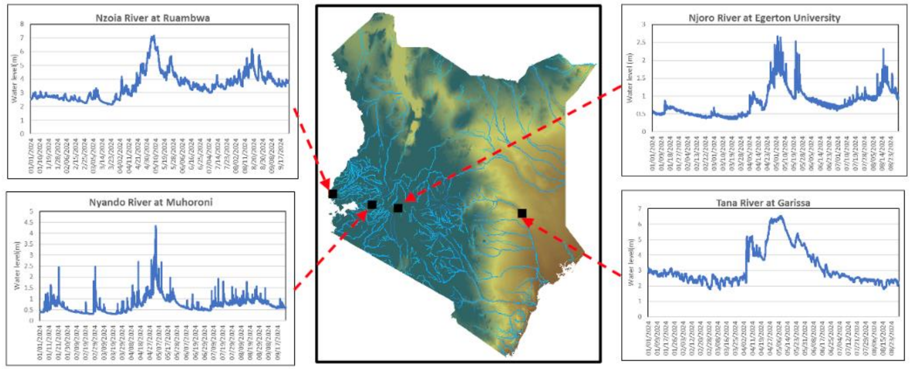


Figure 15: Review of the River Flows in June-July-August -September 2024

Increased flows were observed in the months of November and December in Rivers Nzoia, Yala, Nyando, Sondu and Gucha-Migori causing flooding in the Lower Nyando, Lower Kuja-Migori and Lower Sondu Rivers. Parts of Lake Victoria Shoreline areas (northern shoreline) remained inundated due to sustained high lake levels. All the other river basins, i.e Rift valley, Athi, Tana and Ewaso Ng'iro north recorded receding river flows during the OND 2024 period.

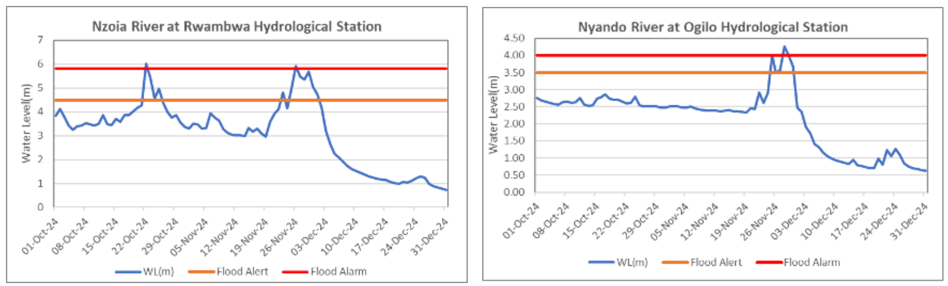


Figure 16: Hydrographs of the Nyando and Nzoia River levels in October to December 2024

Energy & Electricity Generation

The performance of hydropower generation has remained low for the last five financial years due to relatively depressed rainfall seasons. The worst performance was recorded in the 2022/2023 financial year when hydropower generation reduced to just 2,569 GWh from a high of 4,141GWh recorded in 2020/2021 financial year (Table 2). This reflected a drop in hydropower contribution in the generation mix from 34.22% in 2020/2021 financial year to 19.33% in 2022/2023 financial year (Table 3). The hydropower generation improved to 3,396 GWh in 2023/24 financial year accounting for 24.81%.

Hydropower, as the only renewable energy source capable of adjusting output to meet peak demand and fluctuating loads, saw increased generation in the 2023/24 financial year. At the same time, the expansion of wind, solar, and geothermal energy helped manage rising costs, despite their limitations in providing flexible power adjustments.

With near to below-average rainfall during October to December 2024, water inflows into hydropower reservoirs improved slightly, allowing for increased hydropower generation and reducing reliance on costly thermal power plants. However, hydropower is expected to perform poorly in the 2025/2026 financial year due to below normal rainfall experienced during the short rainfall season of October to December 2024 and the forecasted depressed rainfall during the long rainfall season of March to May 2025.

Table 2: Energy Generated (GWh)

	2019/20	2020/21	2021/22	2022/23	2023/24
Hydro	3,693	4,141	3,349	2,569	3,396
Geothermal	5,352	5,034	4,953	6,035	5,708
Thermal	882	940	1,648	1,396	1,127
Cogeneration	0.29	0.33	0.38	0.21	0.11
Solar	91	88	313	444	474
Wind	1,284	1,700	2,052	2,202	1,781
Imports	161	197	338	644	1,199
Total	**11,462**	**12,101**	**12,653**	**13,290**	**13,685**

Table 3: Energy Generated in percentage.

	2019/20	2020/21	2021/22	2022/23	2023/24
Hydro	32.22%	34.22%	26.47%	19.33%	24.81%
Geothermal	46.69%	41.60%	39.15%	45.41%	41.71%
Thermal	7.69%	7.77%	13.02%	10.50%	8.24%
Cogeneration	0.00%	0.00%	0.00%	0.00%	0.00%
Solar	0.79%	0.73%	2.47%	3.34%	3.46%
Wind	11.21%	14.05%	16.22%	16.57%	13.01%
Imports	1.40%	1.63%	2.67%	4.85%	8.76%

Transportation

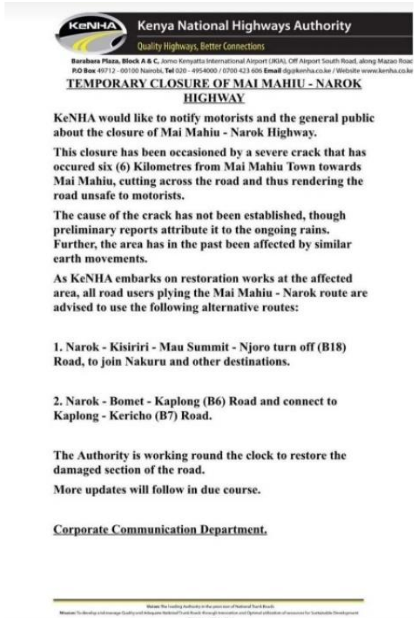
Aviation

The aviation sector is a key part of the Kenyan economy. During the year 2024, heavy rainfall during the March to May season had impacts on the sector. On April 27, 2024 Nairobi experienced heavy showers of rain and thunderstorms led to significant flooding in Nairobi and its environs including flooding in the Jomo Kenyatta International Airport. The met station at the airport reported 109.6mm for 27th April. Following the heavy downpour and poor visibility in Nairobi, Kenya Airways was forced to divert a number of its flights, which resulted in delays for some of the departures from Nairobi. A heavy rainfall advisory was issued for the period 25th to 28th April 2024.

Image: Jomo Kenyatta International Airport during the flooding. Source

Road

Roads were carried away and closures put in place following heavy rainfall and flooding during the long rains season.



KeNHA Kenya National Highways Authority

Quality Highways, Better Connections

Barabara Plaza, Block A & C, Jomo Kenyatta International Airport (JKIA), Off Airport South Road, along Mazao Road
P.O Box 49712 - 00100 Nairobi, Tel 020 - 4954000 / 0700 423 606 Email dg@kenha.co.ke / Website www.kenha.co.ke

TEMPORARY CLOSURE OF MAI MAHIU - NAROK HIGHWAY

KeNHA would like to notify motorists and the general public about the closure of Mai Mahiu - Narok Highway.

This closure has been occasioned by a severe crack that has occured six (6) Kilometres from Mai Mahiu Town towards Mai Mahiu, cutting across the road and thus rendering the road unsafe to motorists.

The cause of the crack has not been established, though preliminary reports attribute it to the ongoing rains. Further, the area has in the past been affected by similar earth movements.

As KeNHA embarks on restoration works at the affected area, all road users plying the Mai Mahiu - Narok route are advised to use the following alternative routes:

1. Narok - Kisiriri - Mau Summit - Njoro turn off (B18) Road, to join Nakuru and other destinations.

2. Narok - Bomet - Kaplong (B6) Road and connect to Kaplong - Kericho (B7) Road.

The Authority is working round the clock to restore the damaged section of the road.

More updates will follow in due course.

Corporate Communication Department.

Image: Road closure advisory and road destruction during MAM 2024

Chapter Five: Projected Climate Patterns in 2025

El Nino Southern Oscillation (ENSO)

El Niño and La Niña (collectively referred to as the El Niño–Southern Oscillation or ENSO) are characterized by changes in sea surface temperatures (SSTs) in the equatorial Pacific Ocean. During El Niño, SSTs in the central and eastern Pacific Ocean become warmer than average, while during La Niña, these SSTs become cooler than average.

La Niña is generally associated with suppressed rainfall over Kenya and East Africa, while El Niño tends to enhance rainfall, leading to above-average precipitation.

As of mid-February 2025, weak La Niña conditions persist in the equatorial Pacific, characterized by cooler-than-average sea surface temperatures in the Niño 3.4 region, which remain slightly below the -0.5°C threshold—an essential indicator of La Niña. These conditions have been present since December 2024, following the initial transition into La Niña territory.

The IRI ENSO forecast indicates equal chances (50%) of La Niña and ENSO-neutral conditions for the February-April 2025 period. From March-May 2025 onward through June-August, ENSO-neutral conditions are favored. For the following two seasons, July-September and August-October 2025, there is no strong preference between La Niña and ENSO-neutral, though ENSO-neutral is slightly favored in the earlier period and La Niña in the later one.

By September-November (54%) and October-December (55%) 2025, La Niña conditions are slightly more likely than ENSO-neutral conditions. However, the ENSO spring predictability barrier refers to the reduced reliability of ENSO forecasts during March–May, as ENSO is in a transitional phase. Predicting the October–December (OND) season before this period ends is not advisable due to high uncertainty. However, forecasts made after March–May are generally more reliable.

In summary, there are equal chances of La Niña and ENSO-neutral conditions during February-April 2025, with ENSO-neutral favored through the June–August period. The likelihood of El Niño remains very low throughout the forecast period.

Therefore, it is crucial to monitor ENSO conditions closely, as they play a significant role in seasonal climate patterns. Keeping up with updates from the World Meteorological Organization (WMO), the Kenya Meteorological Department, and other monitoring centers will provide valuable insights into the key climate drivers for the upcoming seasons.

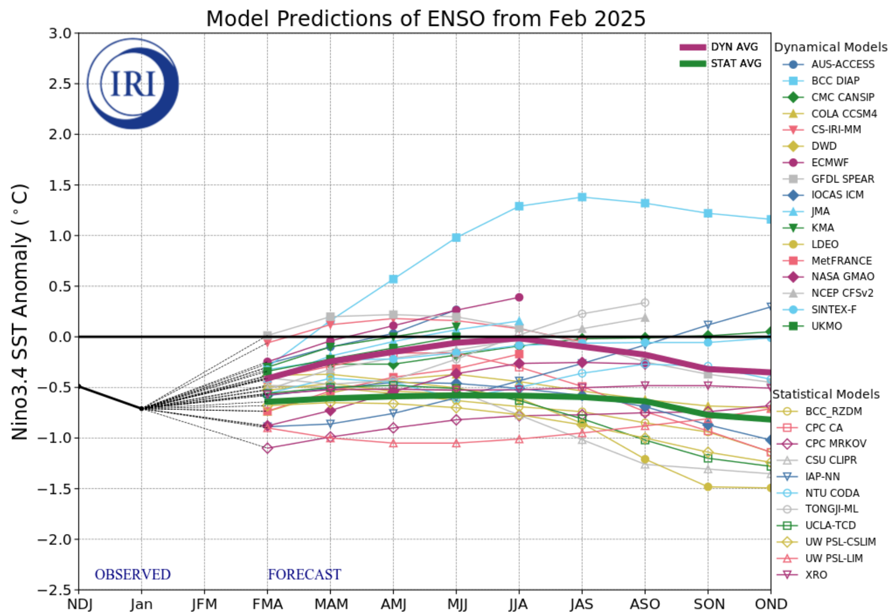


Figure 17: Plume of forecasts of the Nino3.4 SST anomaly from dynamical and statistical models - courtesy of IRI.

Indian Ocean Dipole (IOD)

The Indian Ocean Dipole (IOD) is defined by the difference in sea surface temperatures between the eastern and western tropical Indian Ocean. Its influence varies in conjunction with other climate indicators such as the El Niño–Southern Oscillation (ENSO). During a negative IOD event, waters are typically warmer than average in the eastern tropical Indian Ocean and cooler than average in the west. Conversely, a positive IOD event features cooler-than-average waters in the east and warmer-than-average waters in the west. Specific regions in the eastern and western Indian Ocean are monitored to track the development of IOD events. A negative IOD is generally associated with suppressed rainfall over Kenya and East Africa, while a positive IOD tends to enhance rainfall, leading to above-average precipitation.

As of February 2025, the IOD is in a neutral state. The latest IOD index value is +0.47, slightly above the positive IOD threshold. However, positive index values have not been consistently sustained, limiting their significance at this time of year. Additionally, the IOD typically has little influence on Kenyan climate between December and April. Therefore, it is important to keep up with updates from the World Meteorological Organization (WMO), the Kenya Meteorological Department, and other monitoring centers on key climate drivers for the upcoming seasons.

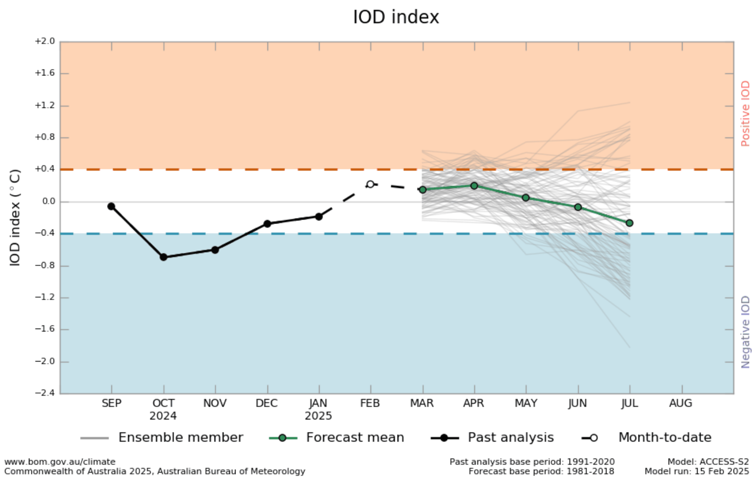


Figure 18: IOD index - courtesy BOM

Rainfall and Temperature Projections for 2025

March-April-May (Mam) 2025 "Long-Rains" Season

March to May (MAM) is Kenya's major rainfall season, influencing much of equatorial Eastern Africa. High rainfall amounts, often exceeding 300mm, typically occur in the Lake Victoria Basin, Highlands West of the Rift Valley, and both the Central and South Rift Valley. Significant rainfall is also expected in the Highlands East of the Rift Valley (including Nairobi County) and the Coastal Strip. The consolidated MAM 2025 forecast indicates near to above-average rainfall over the Lake Victoria Basin, South Rift Valley, Highlands West of the Rift Valley, southern Southeastern Lowlands, and northern Northwestern Kenya. Near to below-average rainfall is expected over the Central Rift Valley, Highlands East of the Rift Valley (including Nairobi County), most of Northwest Kenya, the Coastal region, Southeastern Lowlands, and some areas in the Highlands West of the Rift Valley, while below-average rainfall is expected over the northeastern regions and the north coast.

Temperature Outlook for MAM 2025

Warmer-than-average temperatures are expected across the entire country, with increased probabilities of higher temperatures in Central Kenya, the Southeastern Lowlands, the South Coast, and parts of the Northeast.

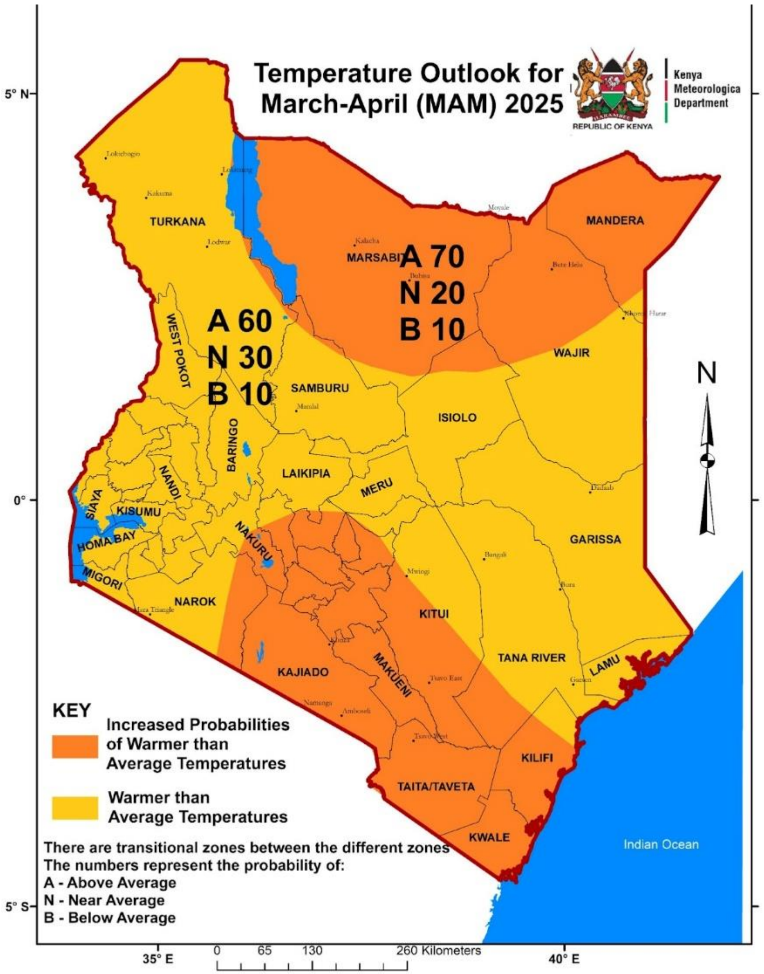


Figure 19: Temperature outlook for March-May 2025.

Warmer-than-average temperatures are expected across the entire country from March-May 2025.

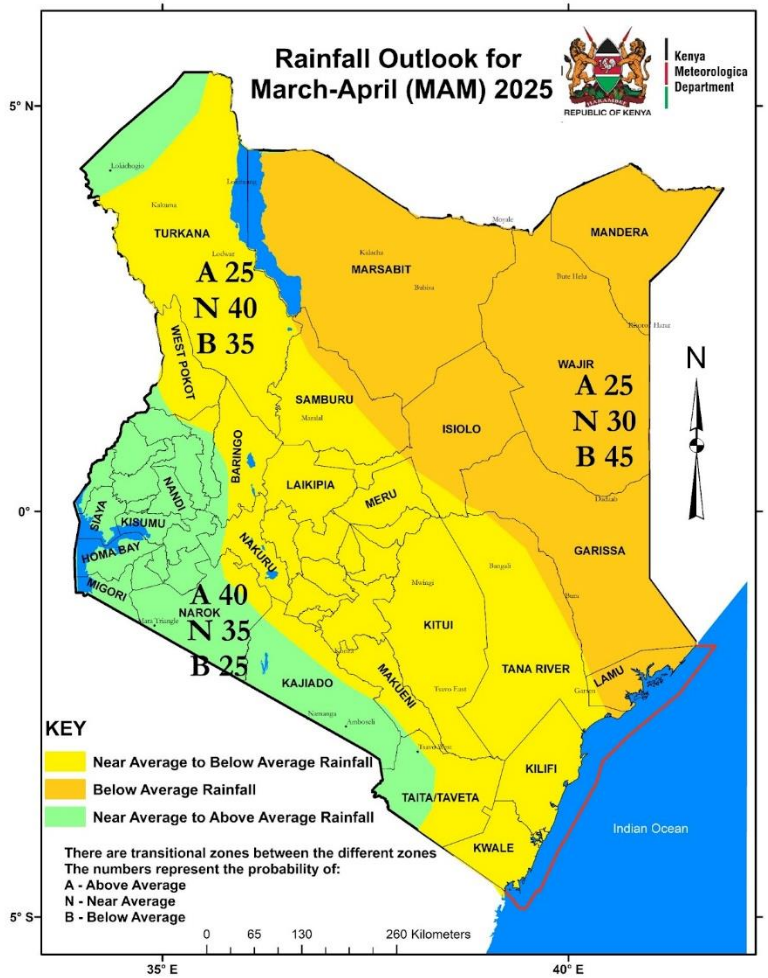


Figure 20: Rainfall outlook for March-May 2025.

Below-average rainfall is expected over the northeastern regions and the north coast from March-May 2025.

June-July-August (JJA) 2025 Season

During the JJA season, rainfall is mainly concentrated in the Lake Basin, Highlands West of the Rift Valley, the Rift Valley, some areas in the Highlands East of the Rift Valley, and the Coastal Strip. The rest of the country generally remains dry during this period. Most areas in the Central Highlands and Nairobi typically experience cool/cold and cloudy conditions with occasional light rains/drizzles.

September Climatology

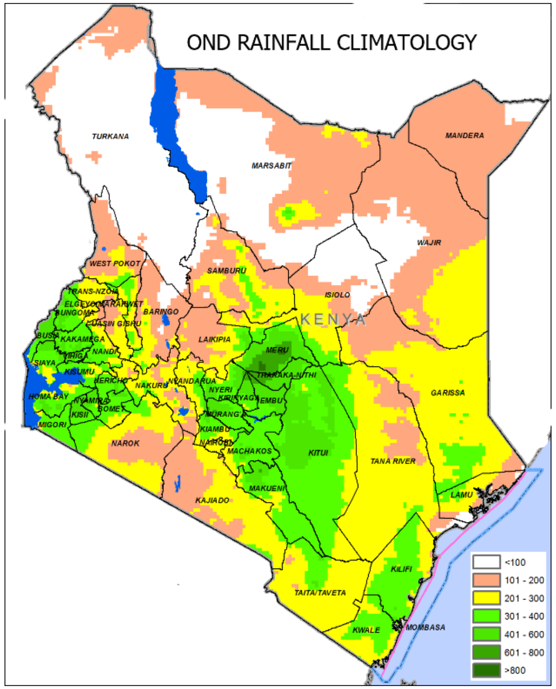


Figure 21: Projected rainfall for October-November-December 2025.

September is generally dry across most parts of the country. However, occasional rainfall usually occurs over Western Kenya, the Rift Valley, the Lake Victoria Basin, and the Central Highlands. While most regions experience minimal precipitation, localized showers can occur, especially in the western highlands.

October-November-December (OND) Season

The October-November-December (OND) "Short Rains" season is a crucial rainfall period in Kenya, particularly for the Central and Eastern regions. October typically marks the onset of the short rains across many parts of the country, while November is generally the peak month of the season. December signals the cessation of the short rains, except in southern Kenya near the Tanzanian border, where rains normally persist for longer.

The predictability of the OND season is influenced by two primary climate drivers: the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). Currently, both ENSO and IOD are in a neutral phase. However, forecasting sea surface temperatures (SSTs) beyond the March-May period presents challenges due to the spring predictability barrier. As a result, it remains crucial to monitor updates issued by the meteorological department for more accurate seasonal outlooks and potential changes in climatic conditions.

Associated Socioeconomic Impacts

The projected rainfall and temperature patterns will have various socioeconomic implications across Kenya.

- Agriculture: Farmers will need to prepare for potential rainfall deficits in some regions, impacting crop yields and food security. In areas expecting above-average rainfall, the risk of flooding and waterlogging should be considered.
- Water Resources: Water availability will fluctuate depending on the rainfall distribution, influencing water supply for domestic, agricultural, and industrial use.
- Health: Warmer-than-average temperatures could exacerbate heat-related illnesses, while regions experiencing higher rainfall might see increased vector-borne diseases such as malaria and dengue.
- Infrastructure and Disaster Management: Flood-prone areas should anticipate possible disruptions to transport and infrastructure, necessitating proactive disaster risk management strategies.

Given the expected variability in weather conditions, stakeholders in agriculture, water resource management, and disaster preparedness should stay informed through regular climate updates and advisories from relevant meteorological agencies.

Chapter 6: Available Resources

State of Climate Services in Kenya

The need for climate services to inform decision-making has never been greater, especially in view of rapidly increasing climate extremes. The WMO 2024 report on the State of climate services indicates that investments in climate services improvement is rising in Africa and Asia stating that in Africa, there has been notable improvement in user engagement platforms, capacity development and governance.

The application of weather, climate and water information and related services helps to improve the safety and well-being of people, reducing poverty, increasing prosperity and protecting the environment for future generations. Climate services offer critical contributions to meeting the targets of the country's goals such as Kenya's Vision 2030, the National Climate Change Action Plan, the United Nations (UN) Sustainable Development Goals (SDGs), the Sendai Framework for Disaster Risk Reduction and other relevant environment and climate-related conventions.

To facilitate improvement in its provision of climate services, Kenya has completed the development of its National Framework for Climate Services. User engagement is done through Regional Climate Outlook forums, National Climate outlook Forums and Participatory Scenario Planning at county level. Data availability is absolutely fundamental for the provision of effective climate services.

(a) (b)

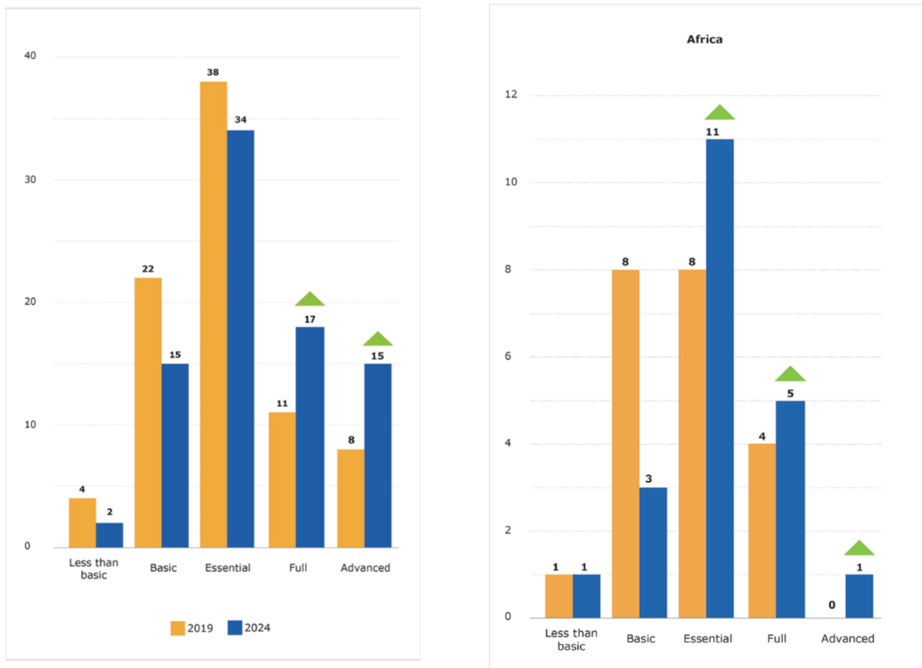


Figure 22: (a) Climate services capacities for 2019 and 2024, based on the 83 NMHSs that responded in 2019 and updated their data in 2024 (b) Regional distribution of climate services capacities, showing number of NMHSs in each category of climate services capacity level (less than basic, basic, essential, full, advanced). Source: WMO State of Climate Services 2024.

KENYA'S NATIONAL FRAMEWORK FOR CLIMATE SERVICES

Linking climate knowledge with action on the ground

What is the NFCS?

an institutional mechanism to coordinate, facilitate and strengthen collaboration among national institutions to improve the co-production, tailoring, delivery and use of science based climate predictions and services

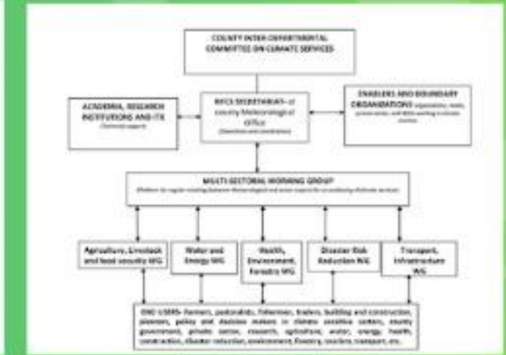
NFCS Objectives

to increase availability of improved climate information products and services to key sectors among them agriculture and food security, disaster risk reduction, energy, health and water

NFCS Pillars

NFCS Governance Structure

NFCS County & Sub county Governance Structure



Additional benefits

expanded scope and improved institutional coordination leading to increased knowledge of climate services within sectors and institutions, efficiency and cost-effectiveness in providing climate services, better informed planning and decision -making within climate-sensitive sectors and institutions, reduced risks associated with climate change and variability and improved livelihoods

Manual meteorological observations

KMD manages and maintains 41 synoptic observation stations as part of its mandate. These stations include airports and agrometeorological stations with staff who run shifts between 12-24 hours a day. This number of stations compared to the land area served is significantly below the WMO acceptable standard. This data on key weather parameters is crucial for monitoring, trend detection as well as supporting downscaling of climate projections.

The distribution of stations under the operation and maintenance of KMD is sparse (see Figure 23). This does not comply with WMO standards for station density. The support and maintenance of these existing stations remains a prioritized national development budget item. Kenya could also benefit from initiatives such as the Systematic Observation Financing Facility (SOFF) aimed at supporting developing countries improve their observational networks, with the goal of achieving Early Warning for All.

The stations are equipped with digital instruments for measurement and monitoring atmospheric pressure, air temperature, and relative humidity (PTU) to replace the mercury-in-glass thermometers and to facilitate the observation of basic weather parameters. In addition, other instruments such as evaporation pans, wind systems, and soil thermometers are employed to measure various meteorological parameters.

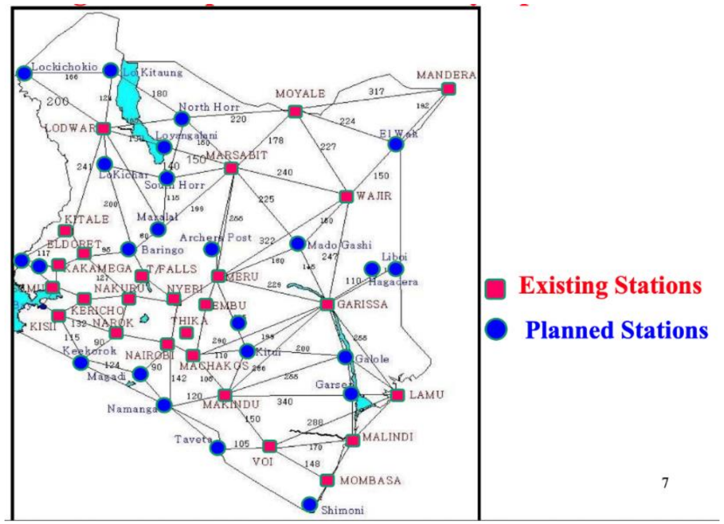
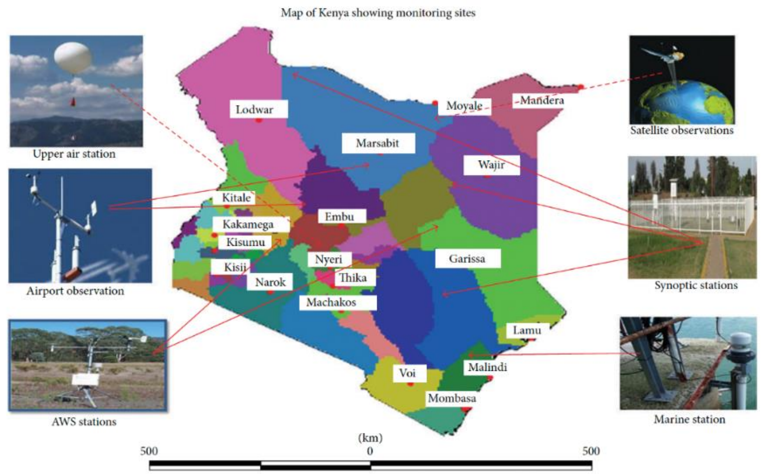


Figure 23 (a): Distribution of various observation stations across the country. Source: Shilenje & Ogwang 2015 (b): Station distribution & future plans.Source: KMD



Automatic Weather Station Network

There are currently 625 AWS in Kenya, with only half of them operated by KMD. A study done under Kenya Climate Smart Agriculture Programme (KCSAP) determined that Kenya needs a total of 2400 AWS by 2030 for optimal results. Besides the increased spatial coverage, the advantages of such AWS networks include the availability of data in near real time, as AWS are usually equipped with data loggers and telecommunication systems that enable continuous data transmission. The automatic reporting occurs at mostly very fine temporal resolutions (15 minutes, on average).
KMD manages a heterogeneous AWS network from different initiatives as depicted by Figure 24 (Faniriantsoa and Dinku, 2022).

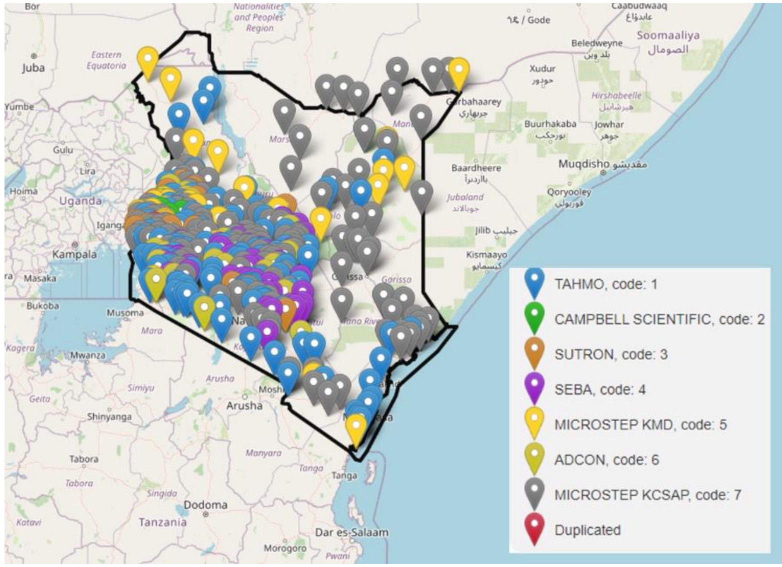


Figure 24: Overview of automatic weather station networks. Source: modified from (Faniriantsoa and Dinku, 2022)

Atmosphere Watch Stations

Ozone research and monitoring activities in Kenya are the country's effort to complement the international systematic atmospheric observations in support of the spirit of the Vienna Convention. Kenya is committed to provide, in line with the objectives of GAW-GO3OS, long-term records of ozone and other species that are essential for determining the variability of these species and their impacts on life and climate. Notably, the goal is the continued monitoring of tropospheric and stratospheric ozone and the assessment of its variations that are relevant to the wellbeing of the environment. Profiles of Ozone are taken weekly at Kenya Meteorological Department, while continuous measurements of surface ozone and daily column ozone are measured at the Mount Kenya GAW station and the University of Nairobi respectively. The station on Mt. Kenya (see Figure 25) is one of 30 World Meteorological Organizations (WMO) Global Atmosphere Watch (GAW) stations.

Figure 25: WMO Global GAW station distribution.

State of Meteorological Data in Kenya

Thirteen of the 41 stations share their data globally on the WMO Global Telecommunication System (GTS, now WMO Information System WIS2.0). These data are important in the development of datasets with global coverage, i.e. CHIRPS Rainfall Estimates from Rain Gauge and Satellite Observations. The manned stations provide ground truth of the Automatic Weather stations as well as satellite data. Rainfall data can be found for about 38 stations from 1961 to the present while both maximum and minimum temperature data is available from 1975 to present.

The KMD Maproom

Data source built by combining station data and proxy data (satellite and reanalysis dataset) at each grid point. The portal is organised to enable the user navigate through use of administrative boundaries ranging from county to ward level. To support research, the portal, (http://kmddl.meteo.go.ke:8081/maproom/index.html) provides tabs to web pages for historical, current and future climate conditions of a particular location.

Some of the key analysis include:

- Climate analysis: The maproom explores historical data by calculating simple seasonal statistics such as mean, standard deviation, total cumulative rainfall, no. of wet days, rainfall intensity, number of dry spells as well as rainfall performance based on the main teleconnections affecting our region e.g Indian Ocean Dipole (IOD) and ENSO (El Nino Southern Oscillation) etc.
- Climate monitoring: Accessing recent and past climate data, which can be analysed as either dekadal or through monthly rainfall extremes i.e. standard precipitation index (SPIs).
- Climate forecast: Users can access seasonal forecasts rolling on a monthly basis. The flexible seasonal forecasts are displayed in full probability distribution.
- Climate change: Using the maproom one can access past and future changes in seasonal climate with reference to a historical climatological period.
    - Sector specific climate valuation: Under Climate and Agriculture, one is able to explore crop climate suitability, historical rainfall season onset dates based on user-defined thresholds, total cumulative rainfall in a season, onset and cessation dates, probability of exceeding certain thresholds etc.

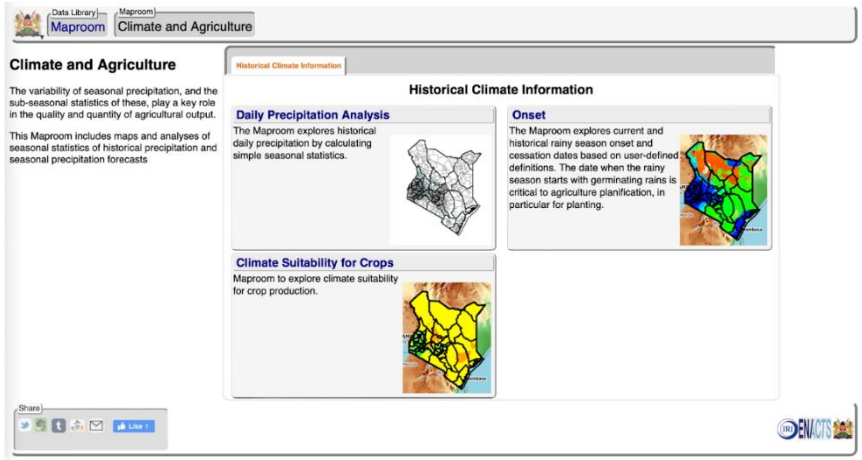
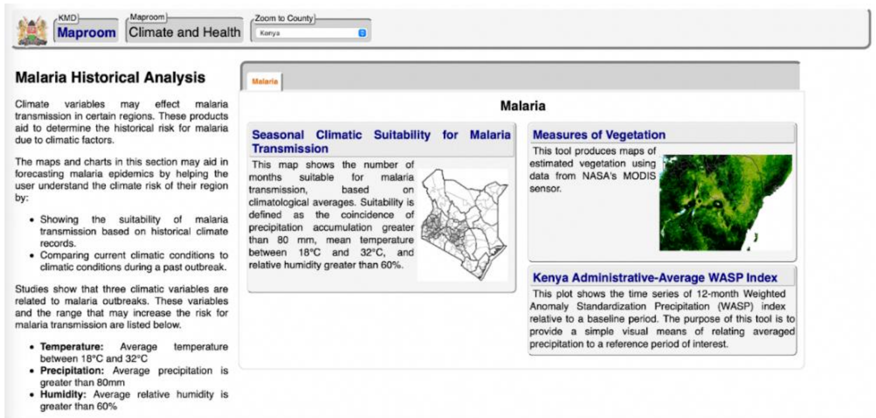


Image: KMD Maproom Climate and Agriculture and Malaria pages.



Chapter 7: Meteorological Training

The Kenya Meteorological Department is at the forefront in ensuring that meteorological personnel and climate scientists are competent by providing training that continuously develops their capacity. Under KMD, is the Institute for Meteorological Training and Research (IMTR), which opened in 1964 and was established as a World Meteorological Organization (WMO) Regional Training Center (RTC) in 1965. IMTR has been training personnel in Meteorology, Operational Hydrology and related geo-sciences in the Kenya and in English-speaking countries of Africa for six (6) decades by offering regular courses as prescribed by WMO and tailor-made courses depending on the training needs of WMO Regional Association I.

Image: Graduands during a graduation ceremony at IMTR

The Institute has the capacity and ability to organise and host specialised training courses, workshops and seminars in various fields of meteorology, hydrology, environmental science, disaster management and related geo-sciences due to its existing infrastructure, manpower and collaboration with other institutions both locally, regionally and internationally.

Training in support of EW4ALL Initiative

IMTR, as a WMO Regional Training Center has prioritised training to support the EW4ALL initiative with a focus on Pillar 2: Detection, observation, monitoring, analysis, and forecasting.

Activity 1: Training of Trainers workshops on PUMA and ClimSA Systems.

With the support of the EUMETSAT, Joint Research Commission, Tecnavia and Africa Union Commission under the umbrella of the ClimSA program and in collaboration with IMTR, the training of trainers on meteorological data access infrastructure (PUMA Stations) and Climate infrastructure (ClimSA Stations) was held for three (3) weeks to impart skills and knowledge on the use and maintenance of the PUMA system and ClimSA station.

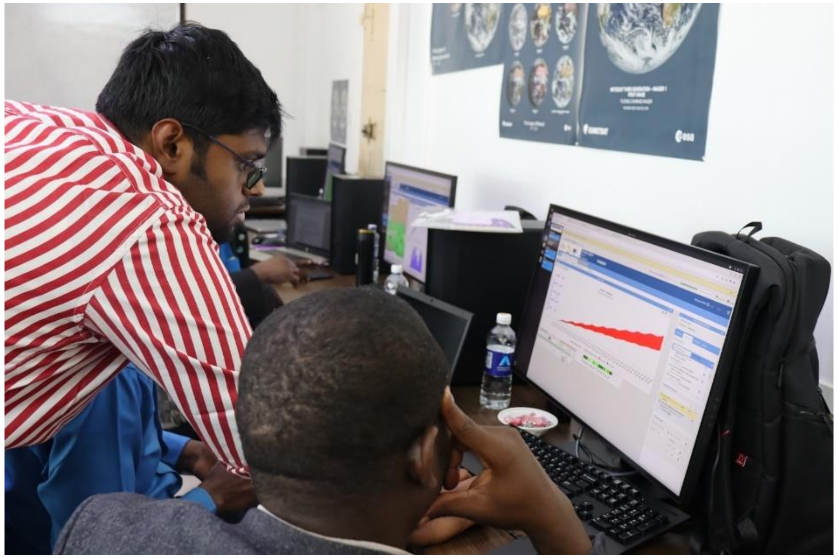


Image: Training session on the use of ClimSA for Climate Services

The three-week training fully equipped the experts to efficiently utilize and maintain the systems and provided them with an opportunity to train other users and technical personnel within their respective Regional Climate Centers and National Meteorological and Hydrological Services (NMHSs) across Africa.

Image: Group photo of ClimSA training

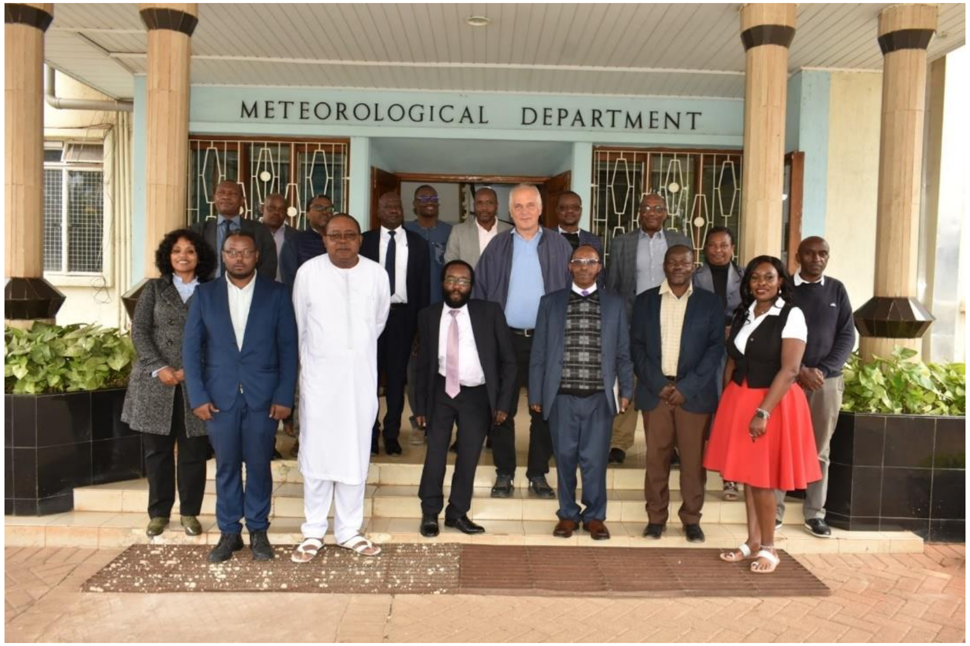


Image: Director, KMD, AUC, KMD Management and Staff during the Onsite Acceptance of PUMA 2025 at IMTR and KMD

By understanding and applying the knowledge and skills gained during these training sessions, the Regional Climate Centers (RCCs) and NMHSs in the African region will be able to access advanced satellite observations and products from the new Meteosat Third Generation (MTG) satellites. This access is expected to significantly enhance the ability to provide accurate and timely weather and climate information that is vital for providing tailored weather updates and warnings, ultimately supporting various sectors, including agriculture, disaster management, and public safety.

The ClimSA project has not only greatly contributed to the EW4ALL initiative by improving meteorological data quality and access across the African region by deploying and installing PUMA and ClimSA stations in 49 intra-ACP countries, but was also keen to develop capacity on the necessary skills and knowledge required so as to access the meteorological data and maintain the data access infrastructure. High-quality data and capacities form the backbone of weather, climate and water services. The three training workshops brought together 59 experts from Burkina Faso, Cameroon, Democratic Republic of Congo, Gaborone, Kenya, Morocco, Niger, Senegal and South Africa, with a wealth of expertise, knowledge, and experience from across the region.

Activity 2: Capacity Development of NMHSs Satellite data applications for Nowcasting in Africa - WMO Course Nowcasting Severe Weather Events in Africa

The training was organized and supported by WMO and EUMETSAT in collaboration with an objective of enhancing forecasters' skills and knowledge in monitoring and analysis of near real time weather at the country and regional level, issuing of warnings and alerts on hazards and extremes related to weather and climate to the public and communities and generating and providing essential near real time weather forecasts especially for the public, aviation and marine sectors. By the end of the course, the participants successfully achieved the following outcomes. They were able to:

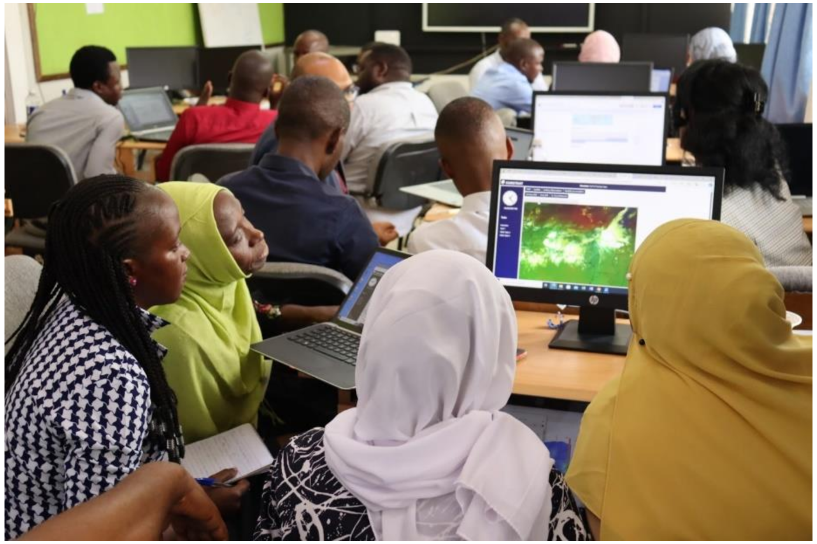
1. Utilize and interpret satellite products to analyze and monitor continually the evolving meteorological situation and warn of hazardous phenomena.
2. Use forecasting tools to monitor the weather for timely issuance of warning and alerts on weather related hazards
3. Analyze, interpret and compare satellite data, NWP and in-situ data to generate impact based nowcasts and carry out forecast Verification

The course was attended by 22 participants from 14 countries: Botswana, Egypt, Eswatini, Ethiopia, Gambia, Kenya, Liberia, Mauritius, Namibia, Sierra Leone, Somalia, Sudan, Tanzania, Zimbabwe. The course was structured as a blended course and for both phases, various training and learning activities were implemented.

a) Online Phase: 12 to 23 February 2024 which involved 3 Live webinar sessions, provision of reading resources, practical online forecasting simulations that allowed participants to interact with satellite and NWP data as if at the operational desk and produce nowcasts, discussions and quiz.

b) Classroom at RTC Nairobi, Kenya; 4 to 8 March 2024: The training was practical oriented where participants worked on weather case studies via the forecasting simulations and in groups that allowed for active discussions amongst the participants.

Activities involved; Discussions, practical simulations and development of nowcasts, presentations of individual weather events by participants from their respective regions and Assessments



Activity 3: Development of Meteorological simulators for training - Use of technological innovations for training

The "WMO Course on Nowcasting Severe Weather Events in Africa" required IMTR trainers to develop reusable, hands-on/practical training material and resources that can be implemented in the WMO Global campus and used by other RTCs for training purposes. As such, this called for a training solution that addressed these concerns; Meteorological simulators.

The IMTR/KMD task team carried out the following tasks over several months:

- Identified fifteen (15) weather case studies revolving around severe weather events experienced across Africa
- Requested and ordered for archived Satellite data for all the cases identified though the EUMETSAT data access portal and also requested for the NWP/ECMWF data with the support of EUMETSAT.
- Ingested the satellite data and the ECMWF data using McIDAS which allowed for the display, manipulation and analysis of satellite and NWP data. This was done on a case by case basis paying in mind the weather parameters, area of interest and weather phenomena to be discussed.
- Carried out in house development of capacity of the task team so as to gain the skills and knowledge necessary to carry out task (i) and task (ii) of handling both satellite and NWP data using McIDAS.
- Developed a detailed narrative for the weather cases. The narratives discussed the data from development of the weather phenomena to the event occurrence.
- Created the weather event as a simulation that would allow the participants/forecasters to interact with the data as though they were at an operational forecasters desk. Some of the simulations can be found here

These simulators can be used in training events to challenge the meteorologists in preparing actual forecasts and warnings.

Images: IMTR team during the development of the simulators

Activity 4: WMO Satellite Training Course on Meteosat Third Generation (MTG)

The WMO Satellite Training Course on Meteosat Third Generation (MTG) took place from 20th to 24th November 2023 at IMTR and was organized and supported by WMO and EUMETSAT in collaboration with IMTR. The objective of the training course was to develop skills and knowledge that support the WMO Competencies relating to the use of satellite data by operational meteorologists in weather forecasting.

The course was attended by 25 participants from 19 countries; Cote d'Ivoire, Egypt, Eswatini, Ethiopia, Gambia, Kenya, Madagascar, Mauritius, Morocco, Mozambique, Uganda, Rwanda, Seychelles, Sierra Leone, South Africa, South Sudan, Sudan, Tanzania, Zambia.

The WMO Satellite Course on MTG was a 5-day in-person training course that was intended to introduce the MTG to users, specifically Meteorologists, Meteorological Trainers and Remote Sensing Experts in the African Region. The participants learnt relevant background on MTG mission, MTG new products and MTG data interpretation and applications and were able to learn and explore the tools for satellite data acquisition, processing and visualization.

Other Training Activities

IMTR runs its programs in parallel and as such caters to a variety of training needs. A few more training activities that took place in 2024 include:

- **Meteorological Technicians training:** 41 participants were trained in the two (2) year Middle Meteorological Technicians Course (MMTC) equipping them with the basic knowledge and skills to accurately and objectively carry out routine meteorological and related observations.
- **Satellite Applications Course:** 80 forecasters from various African countries were trained on the interpretation of satellite imagery and products including Meteosat Third Generation (MTG) using a blended approach; 3 weeks online, 1 week classroom at IMTR in collaboration with EUMETSAT and South African Weather Service. (SAWS)
- **Forecasting:** 18 Kenyan Forecasters were trained in Operational Forecasting Course (OTC) that equipped trainees with knowledge, skills and attitudes that would enable them perform duties as professional operational Meteorologists

Centre of Excellence

IMTR is part of the WMO Virtual Laboratory for Meteorological Satellite Education and Training (VLab) and as such has a mandate as a Centre of Excellence to conduct training activities and support the African Regional Focus Group, representing the NMHSs in the region. IMTR/WMO-RTC is a designated "Centre of Excellence" for training Satellite Meteorology and is one of the implementers of African Satellite Meteorology Education and Training (ASMET - https://asmet.africa). n conjunction with COMET and EUMETSAT, the Institute published a freely available self-paced learning module for Forecasters on "An Approach to Impact-Based Weather Forecasts in Africa"

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We need your feedback

This year, the KMD team has launched a process to gather feedback on the State of the Climate reports. Once you have finished reading, we kindly ask that you give us your feedback by responding to this short survey. Your input is highly appreciated.

REPUBLIC OF KENYA

Kenya
Meteorological
Department