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TANZANIA METEOROLOGICAL AUTHORITY

Statement on the Status of Tanzania Climate in 2024

March, 2025

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Abbreviations

CEPO	Central Equatorial Pacific Ocean
CPC	Climate Prediction Center
ENSO	El Niño Southern Oscillation
IDW	Inverse Distance Weighting
IOD	Indian Ocean Dipole
ITCZ	Inter Tropical Convergence Zone
JNIA	Julius Nyerere International Airport
KIA	Kilimanjaro International Airport
MAM	March to May
NCEP	National Centers for Environmental Prediction
NDJFMA	November 2022 to April 2023
OND	October to December
PMO–DMD	Prime Minister’s Office – Disaster Management Department
SSTs	Sea Surface Temperatures
SSTA	Sea Surface Temperature Anomalies
TMA	Tanzania Meteorological Authority
Tmax	Maximum temperature
Tmean	Mean temperature
Tmin	Minimum temperature
WMO	World Meteorological Organization

Foreword

Tanzania, like many other developing countries, is experiencing the growing impacts of climate change and variability, affecting key sectors such as agriculture, water resources, and public health. In response to these challenges, comprehensive and continuous monitoring and documentation of weather and climate parameters are essential for enhanced understanding of the climate patterns and dynamics, and provide valuable contributions in informing potential and effective adaptation initiative and efforts.

Each year, the Tanzania Meteorological Authority (TMA) conducts a comprehensive climate monitoring and analysis to assess, and document changes in the country's climate over time. The findings provide a historical perspective and valuable insights into Tanzania's climate trends, variations, and extremes. This information serves a diverse range of stakeholders, including the public, government institutions, policymakers, academia, research communities, and planning agencies, both nationally and internationally. Furthermore, this statement plays a vital role in enhancing resilience, supporting adaptation planning, and informing efforts to mitigate the growing social, environmental, and economic impacts of climate change and variability.

This assessment report is grounded on the most up-to-date observational datasets collected from TMA's extensive network of meteorological stations. The continued reliance on these observations highlights the critical need to maintain and expand these monitoring networks to ensure the accuracy and reliability of climate assessments.

The 2024 Annual Statement on the Status of Tanzania's Climate marks the 14th edition in this important series of publications by TMA. I therefore extend my gratitude to all stakeholders for their unwavering support, valuable contributions, and constructive feedback, which have greatly enriched this publication. I would also like to commend all individuals involved in preparing this report, particularly the experts responsible for reviewing the statement. Your dedication and expertise are instrumental in advancing climate knowledge and preparedness in Tanzania.

Dr. Ladislaus B. Chang'a
Acting Director General
Tanzania Meteorological Authority

1. Introduction

The 2024 Annual Climate Statement for Tanzania provides a comprehensive overview of the country's climatic conditions throughout the year, emphasizing key temperature and rainfall trends, extreme weather events, and their associated impacts. It also offers a historical context for the observed climate patterns and severe weather occurrences. This statement aims to inform decision-makers, researchers, and the general public about the state of this year's climate variability and its implications for critical sectors such as agriculture, water resources, health, and disaster risk management.

The information presented in this statement is based on data collected from TMA observation networks. Additionally, weather-related impact data were sourced from the Prime Minister's Office – Department of Disaster Management (PMO–DMD), as well as from media reports. Climate anomalies were assessed against the 1991–2020 reference period, with comparisons made to historical observations of similar weather events.

The statement is structured to provide insights into the monthly, seasonal, and annual temperature trends, rainfall patterns, extreme weather events and their impacts, and key climate drivers in 2024. All maps and graphs presented in this statement characterize the climate status observed in 2024 relative to the 1991–2020 baseline climatology. Moreover, the major drivers of weather and climatic conditions that have contributed to severe and extreme climate events are included in this statement. Throughout this statement the terms, 'above/below average', and 'above/below long-term average' refer to the 1991– 2020 reference period.

Generally, the year 2024 was marked by significant climatic variations, with record-breaking temperatures and a mix of above-normal and below-normal rainfall across different regions. Influencing these conditions were major climate drivers, including the El Niño and La Niña conditions, variations in the Indian Ocean Dipole (IOD), and the unusual landfall of Tropical Cyclone Hidaya.

2. Temperature

In 2024, Tanzania experienced significantly warmer-than-average temperatures, making it the warmest year since 1970, breaking the previous record set in 2023 by a small margin of 0.1°C.

Notably, minimum temperature (Tmin) anomalies exceeded 1°C above the long-term average (1991–2020) in February, March, April, and May. These anomalies were higher compared to maximum temperatures (Tmax) anomalies highlighting the intensification of night-time warming. Furthermore, the country's average mean temperature (Tmean) anomalies consistently exceeded 0.5°C in February, March, May, June, July, August, September, and November, aligning with the observed warming in minimum temperatures (Tmin). Overall, both minimum and maximum temperatures were above average, but the anomalies were higher for minimum temperatures compared to maximum temperatures. Notably, in 2024 five new high temperature records in the country were set since 1970: a new annual record, and a new May, June, July and November records.

2.1 Annual mean, maximum and minimum temperature anomalies

The country's annual mean temperature (Tmean) for 2024 was 24.3°C, which is 0.7°C above the long-term average, making 2024 the warmest year on record since 1970. Across the country, annual mean temperature anomalies (Figure 1, bottom left) were predominantly between 0°C and 1°C. However, some areas surrounding Lake Victoria recorded higher anomalies, ranging between 1°C and 2°C above the long-term average.

The country's average annual maximum temperature (Tmax) for 2024 was 28.8°C, which is 0.4°C warmer than the long-term average. Across the country, Tmax anomalies (Figure 1, top left) ranged from 0°C to 1°C above the long-term average, except for a few locations in Tabora and Shinyanga regions, where temperature anomalies ranged between 0°C and -1°C.

On the other hand, the country's average annual minimum temperature (Tmin) for 2024 was 19.3°C, which is 1.1°C higher than the long-term average. The annual Tmin anomalies (Figure 1, top right) across the country show that the highest temperature anomalies, ranging between 1°C and 2°C above the long-term average, were observed in the northeastern parts, including much of the Lake Victoria basin, northeastern highlands, and the northern coastal belt together with Unguja and Pemba islands. Similar temperature anomalies were also recorded over the southern parts of the country, extending to the southwestern highlands. In contrast, temperature anomalies ranging from 0°C to 1°C were observed in the central and western regions, including the hinterland of the northern coast, and southern coastal belt.

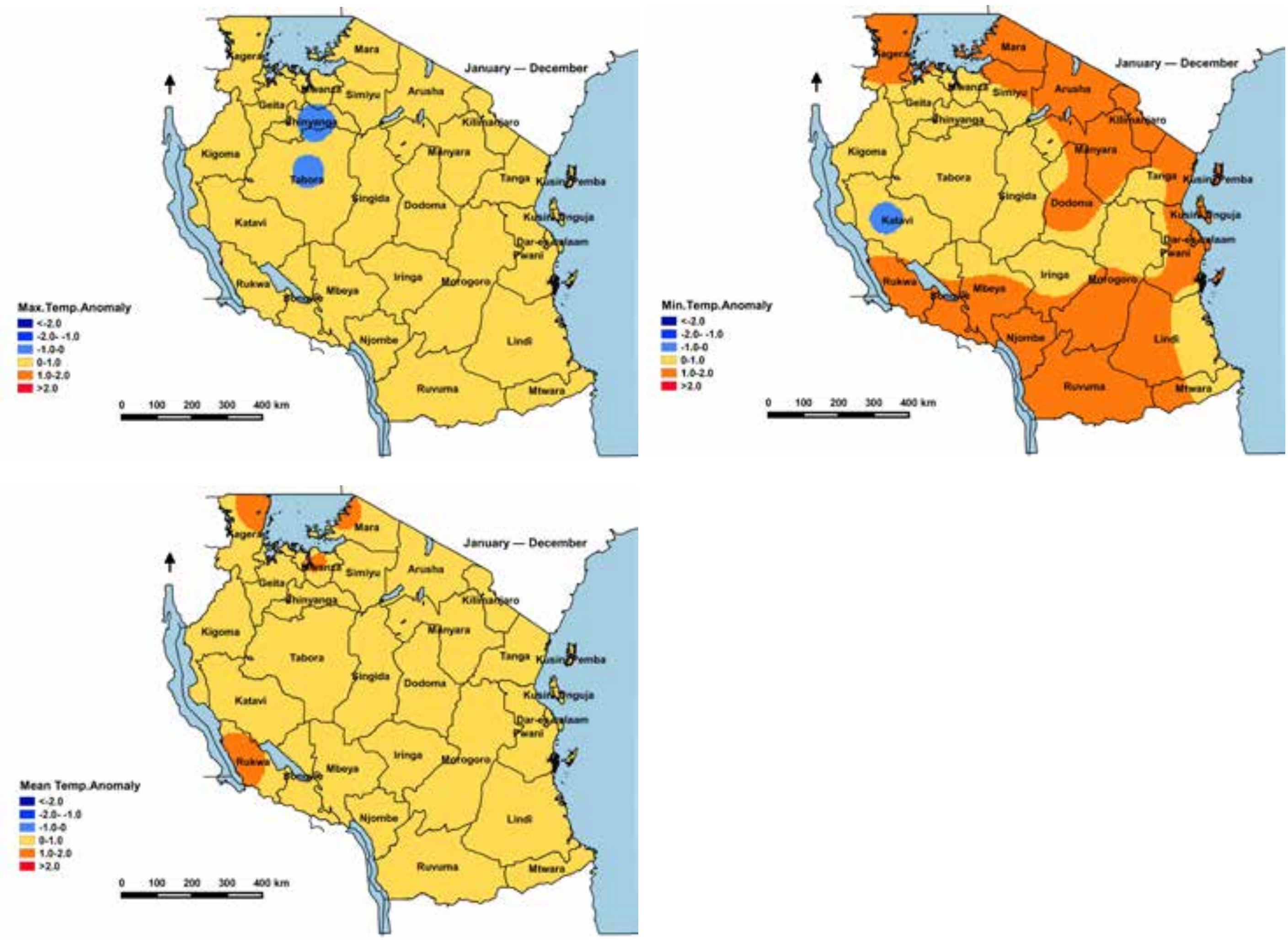

Figure 1: Annual temperature anomalies (°C) for Tanzania in 2024 relative to the long-term average (1991–2020), showing maximum temperature (top left), minimum temperature (top right), and mean temperature (bottom left).

2.2 Monthly average mean, maximum and minimum temperature anomalies

The country experienced slightly warmer-than-average mean temperatures during February, March, May, June, July, August, September, and November 2024, with notable higher temperature anomalies of 0.9°C in March, May, June, and August, 1.0°C in February, and 0.8°C in September and November (Figure 2). Remarkably, July experienced the highest temperature anomaly reaching 1.1°C. The elevated warmth during these months was primarily associated with the observed slightly warmer-than-average minimum temperatures except in July, when it was driven by slightly higher-than-average maximum temperatures (Figure 2). The maximum and minimum temperature anomalies in July, were 1.3°C and 0.9°C, respectively.

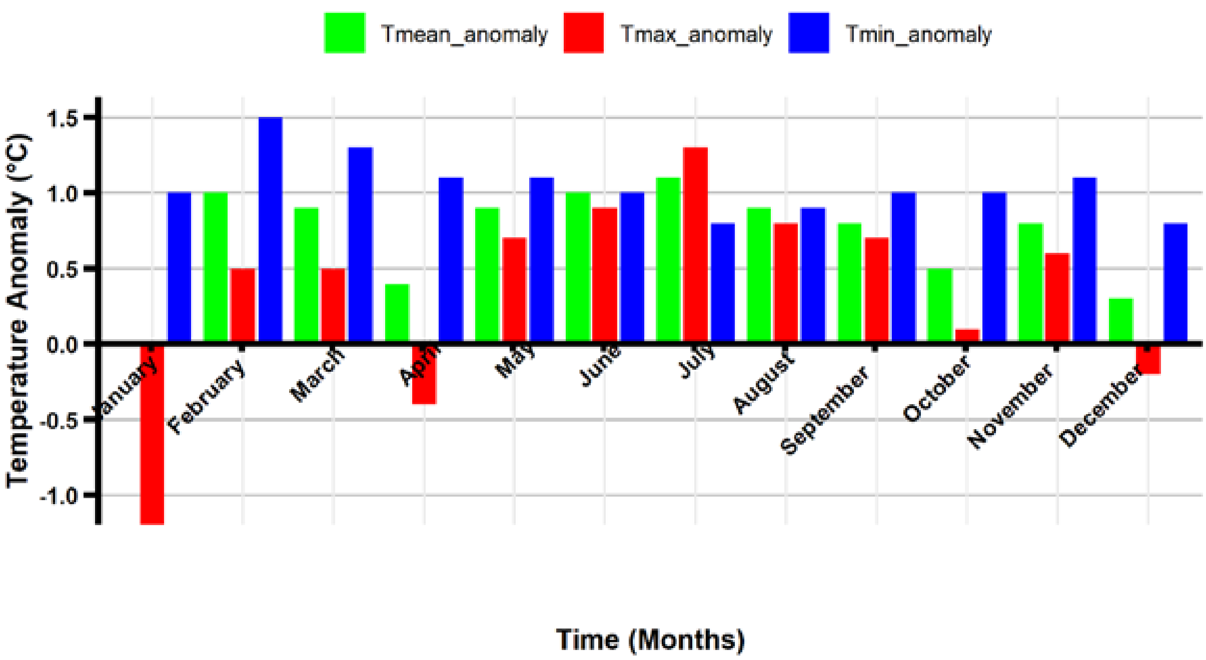

Figure 2: Monthly anomalies (°C) of mean temperature (Tmean), maximum temperature (Tmax), and minimum temperature (Tmin) for Tanzania in 2024, relative to the long-term average (1991–2020).

On the other hand, the country's average monthly maximum temperature (Tmax) in 2024 was slightly higher than the long-term average during May, June, July, August, September, and November. Their corresponding temperature anomalies ranged from 0.6 °C to 1.3 °C above the long-term average. In contrast, the maximum temperatures were slightly cooler than average in April and December, with a more notable decrease of -1.1 °C in January (Figure 2). However, the country's average monthly minimum temperature (Tmin) was consistently warmer than the long-term average throughout the year, with anomalies reaching as high as 1.5 °C in February (Figure 2).

Notably, the country experienced record-breaking higher temperatures (Tmean) in May, June, July, and November 2024, marking the highest records since 1970. Additionally, February ranked as the third warmest, while August and September were the second warmest months on record for their respective months since 1970

2.3 Spatial monthly maximum temperature anomalies

Slightly above long-term average maximum temperatures, ranging from 0°C to 1°C, were observed in most areas of the country during February, March, May, June, August, September, and November (Figures 3a and 3b). In contrast, a notably large Tmax warming anomaly ranging between 1°C and 2°C, was observed over a large part of the country in July, and across the northeastern highlands, northern coast, and Lake Victoria basin in June. The latter temperature anomaly was also evident in a few selected areas of the northern coast, northeastern highlands, Lake Victoria basin, and western regions of the country during February, March, May, June, August, September, and November.

Despite the generally warmer-than-average Tmax in 2024, below-average Tmax was observed during other months of the year. Specifically, maximum temperature anomalies in January ranged from 1°C to 2°C below average across much of the country. In contrast, anomalies ranged from 0°C to 1°C below average across many areas of the country in April, October, and December, as well as in specific areas such as Lake Victoria basin, northeastern highlands, and western regions during February and November (Figures 3a and 3b). This cooling trend was primarily attributed to widespread rainfall, with increased cloud cover reducing the amount of solar radiation reaching the surface.

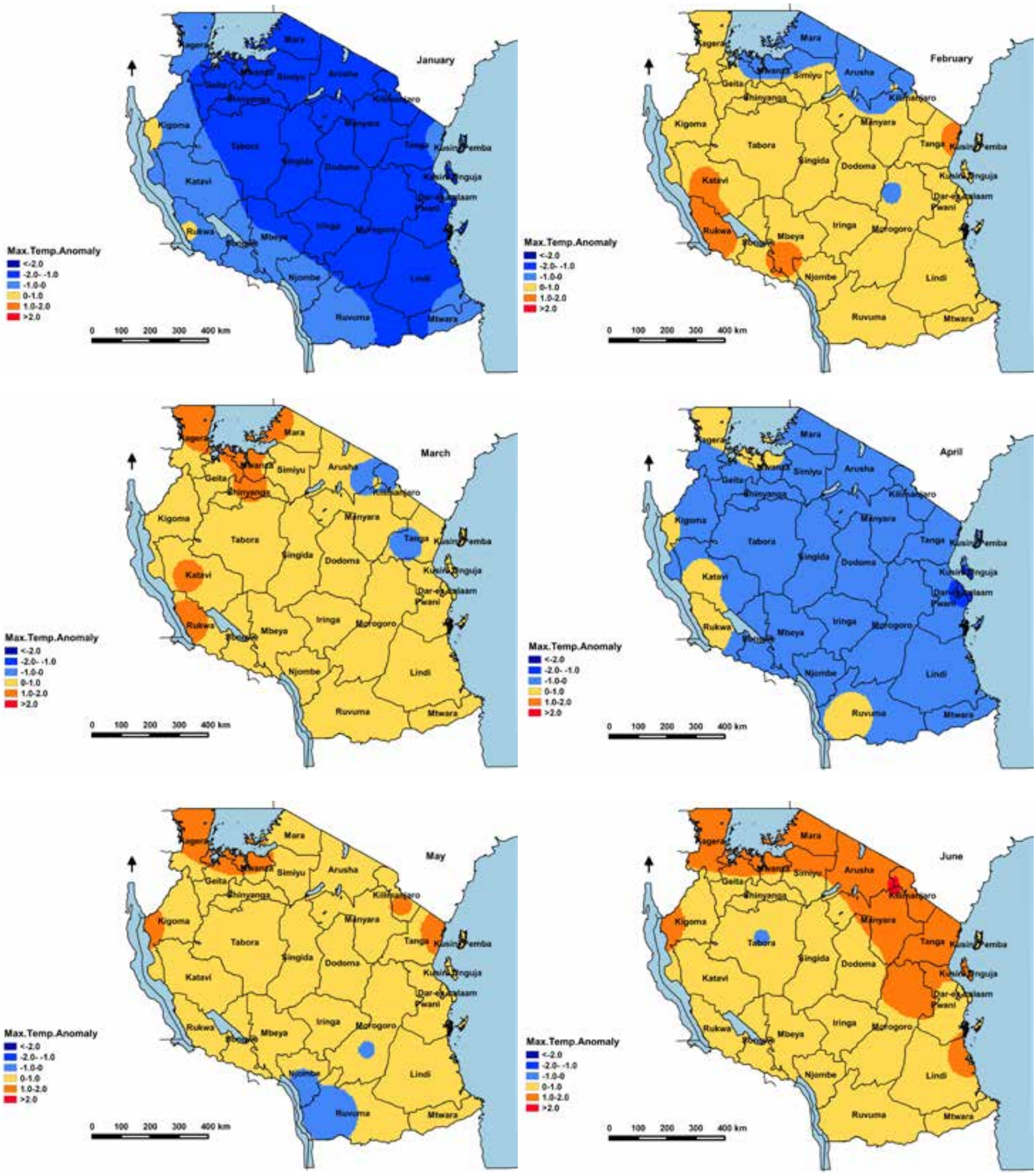

Figure 3a: Monthly maximum temperature anomalies (°C) for January–June 2024 relative to long term average (1991–2020).

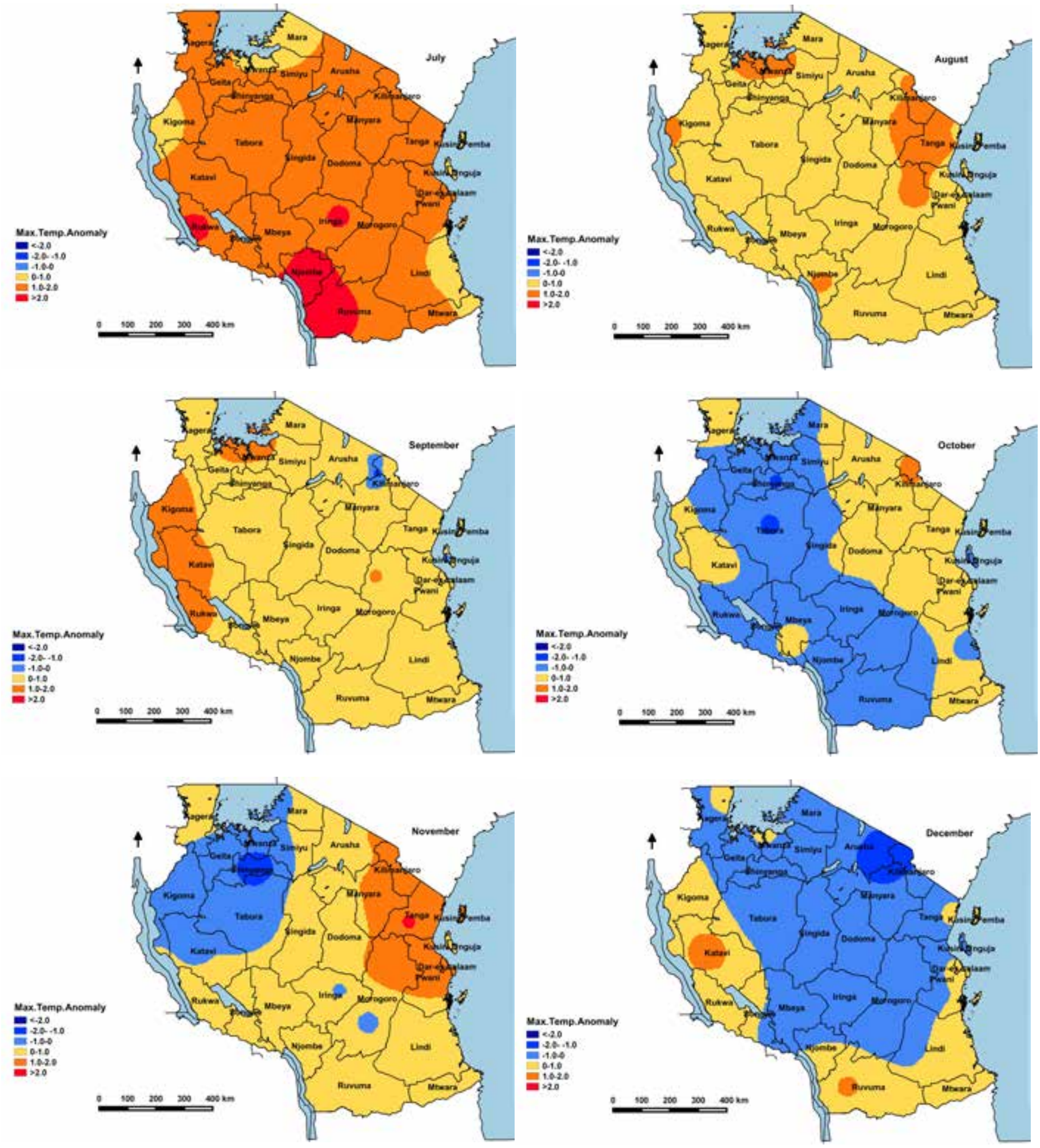

Figure 3b: Monthly maximum temperature anomalies (^{0}C) for July–December 2024 relative to long term average (1991–2020).

2.4 Spatial monthly minimum temperature anomalies

Minimum temperatures were above average across much of the country during several months of 2024, with anomalies ranging from 1°C to 2°C, predominantly occurring in February, March, April, September, October, and November. Likewise, temperatures in specific areas, such as the northern parts of the country (including the northern coast and Zanzibar Islands) and southern parts extending to the southwestern highlands, also showed anomalies of 1°C to 2°C above average during January, May, June, July, and December (Figures 4a and 4b). However, Tmin anomalies ranging from 0°C to 1°C were predominantly observed across much of the country during January, May, June, July, August, and December. Overall, the observed Tmin patterns indicate that warmer-than-average nights occurred in various parts of the country throughout the year.

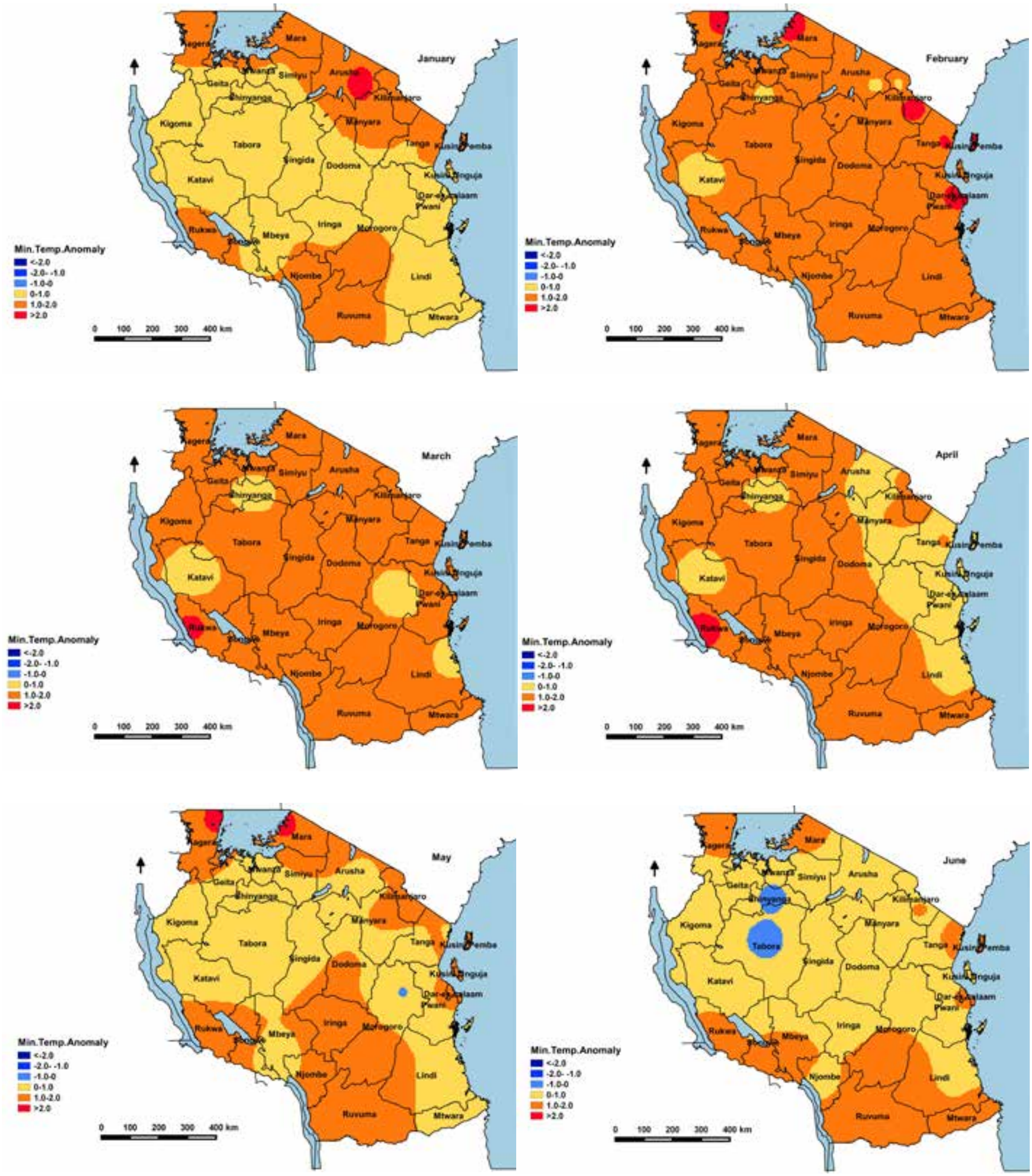

Figure 4a: Monthly minimum temperature anomalies (°C) for January–June 2024 relative to long term average (1991–2020).

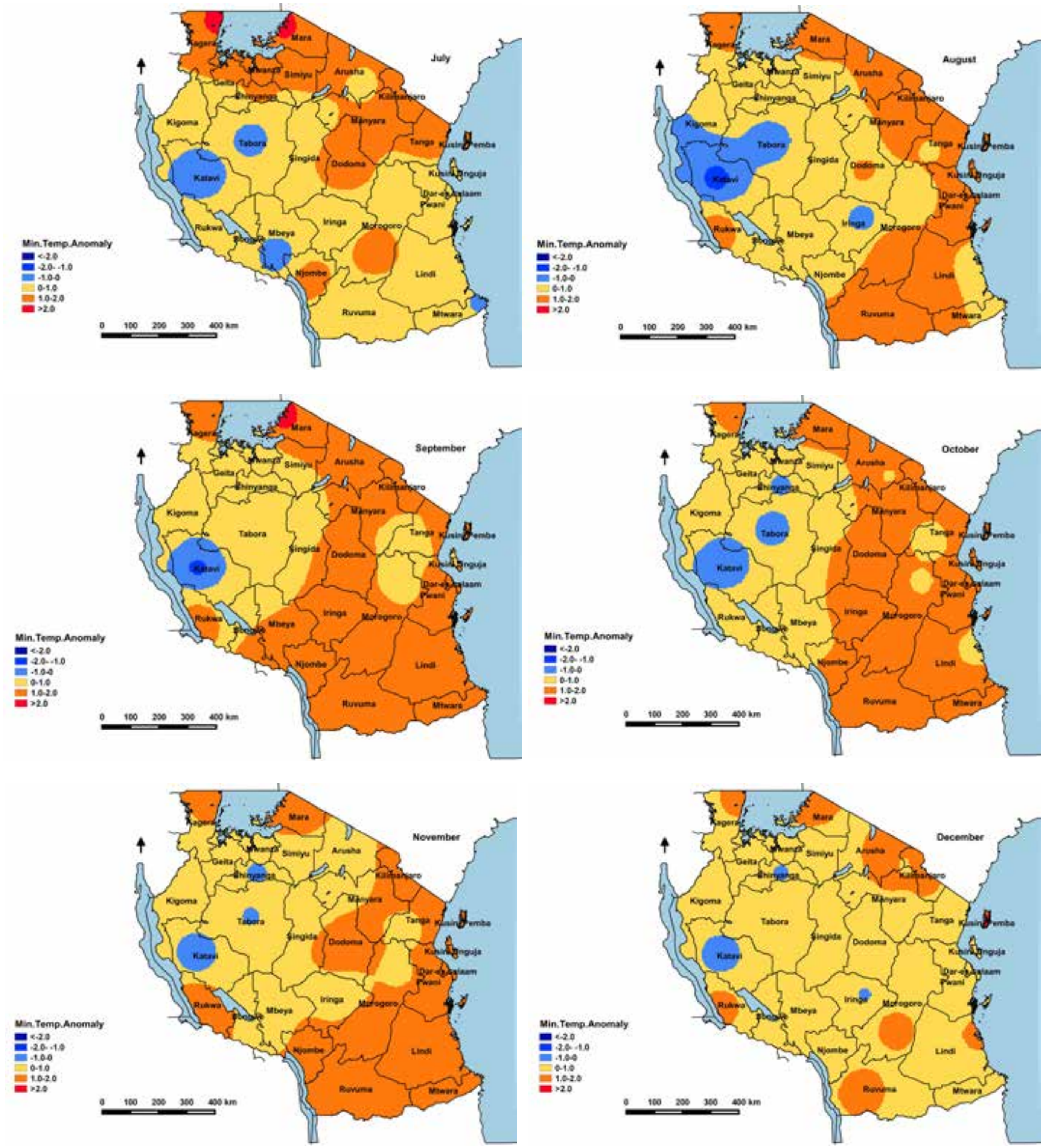

Figure 4b: Monthly minimum temperature anomalies (°C) for July–December 2024 relative to long term average (1991–2020).

3. Rainfall

In 2024, the country experienced wetter conditions across much of the country, particularly in January, February, April, and December. Mainly above-normal rainfall was observed during the November 2023–April 2024 (NDJFMA) rainy season, while normal rainfall was observed during the March–May (MAM) and October–November (OND) 2024 rainy seasons. However, a significant rainfall deficit was observed across a large part of the country in May 2024.

3.1 Spatial annual rainfall distribution

The country's total rainfall for 2024 was 1307.6 mm, which is 285.2 mm higher than the long-term average and equivalent to 128% of the average. Most areas of the country observed above-normal annual rainfall, ranging from 125% to 150% of the average. However, the Lake Victoria Basin, parts of the northern coast, northeastern highlands, and western region experienced normal rainfall (Figure 5). Overall, 2024 ranked as the fourth wettest year on record since 1970 and the wettest in the past two decades.

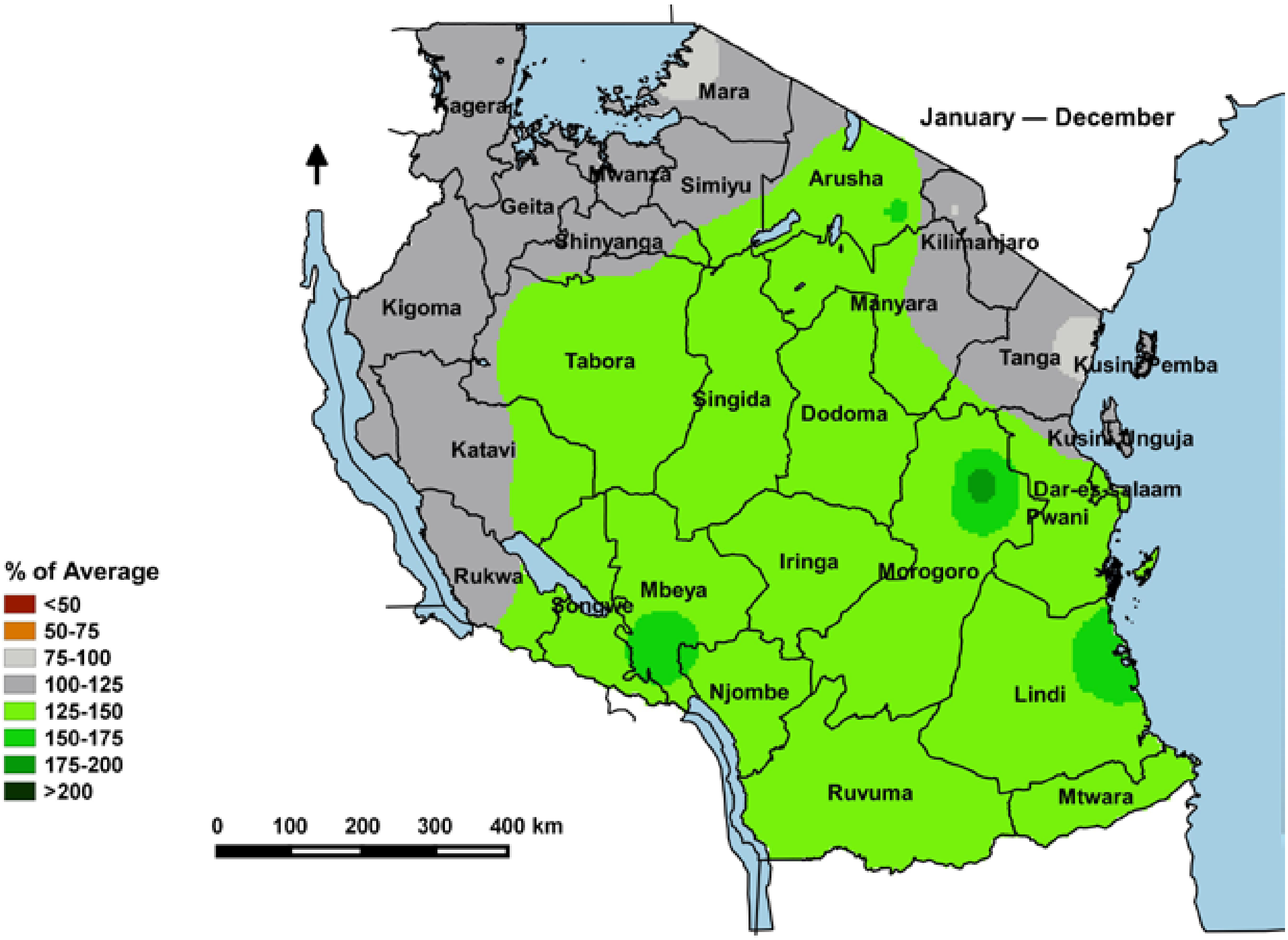

Figure 5: Annual rainfall anomalies for 2024 expressed as percentage of the long term (1991–2020) average.

3.2 Spatial seasonal rainfall distribution

During the November 2023 to April 2024 (NDJFMA) rainy season, much of Tanzania experienced above-normal rainfall, marking it as the wettest season since 1970. The country's total rainfall was 1354.6 mm equivalent to 172% of the long-term average. Above normal rainfall, exceeding 175% of the long-term average, was recorded in the northern coast and northeastern highlands, while the rest of the country experienced rainfall ranging between 125% and 175% of the average (Figure 6, top left). A similar rainfall pattern was observed during the January-February transition period (Figure 6, top right), with much of the country receiving above-normal rainfall. Notably, significant rainfall exceeding 200% of the average were recorded in the Pwani and Dar es Salaam regions, Unguja Island, as well as parts of northern Morogoro, Tanga, and Lindi regions.

On the other hand, the country's total rainfall during the MAM and OND 2024 rainy seasons were 531.7 mm and 313.9 mm, respectively, corresponding to 119% and 112% of the long-term average for each season. Rainfall across most parts of Tanzania was observed to be normal, ranging from 100% to 125% of the long-term average (Figure 6, bottom). However, during the MAM season, above-normal rainfall of 125% to 150% of the average was observed in the southwestern highlands and southern coastal areas, with rainfall exceeding 150% of the average notably observed in the Lindi region. Similarly, during the OND season, above-normal rainfall (125% to 150% of the average) was observed in the northeastern highlands, central Tanzania, and northern Morogoro region. In contrast, below-normal rainfall, ranging from 50% to 75% of the average, was recorded in the central part of the country during the MAM season and in the southern coastal belt during the OND season. According to historical meteorological records in Tanzania, the 2024 MAM and OND rainy seasons are ranked as the ninth and eighteenth driest seasons, respectively, since 1970.

The MAM and OND rainfall seasons are typical for areas that exhibit a bimodal rainfall regime (March-May and October-December rainy seasons). These areas include the northern coast (Tanga, Dar es Salaam, north Morogoro, Coast regions, and Zanzibar Islands), northeastern highlands (Kilimanjaro, Arusha, and Manyara regions), and areas surrounding Lake Victoria (Mara, Kagera, Simiyu, Shinyanga, Geita, and Mwanza regions). The seasons also partly coincide with the long rainy season of November-April, specifically over the southern, western, and central parts of the country and southern parts of Morogoro region.

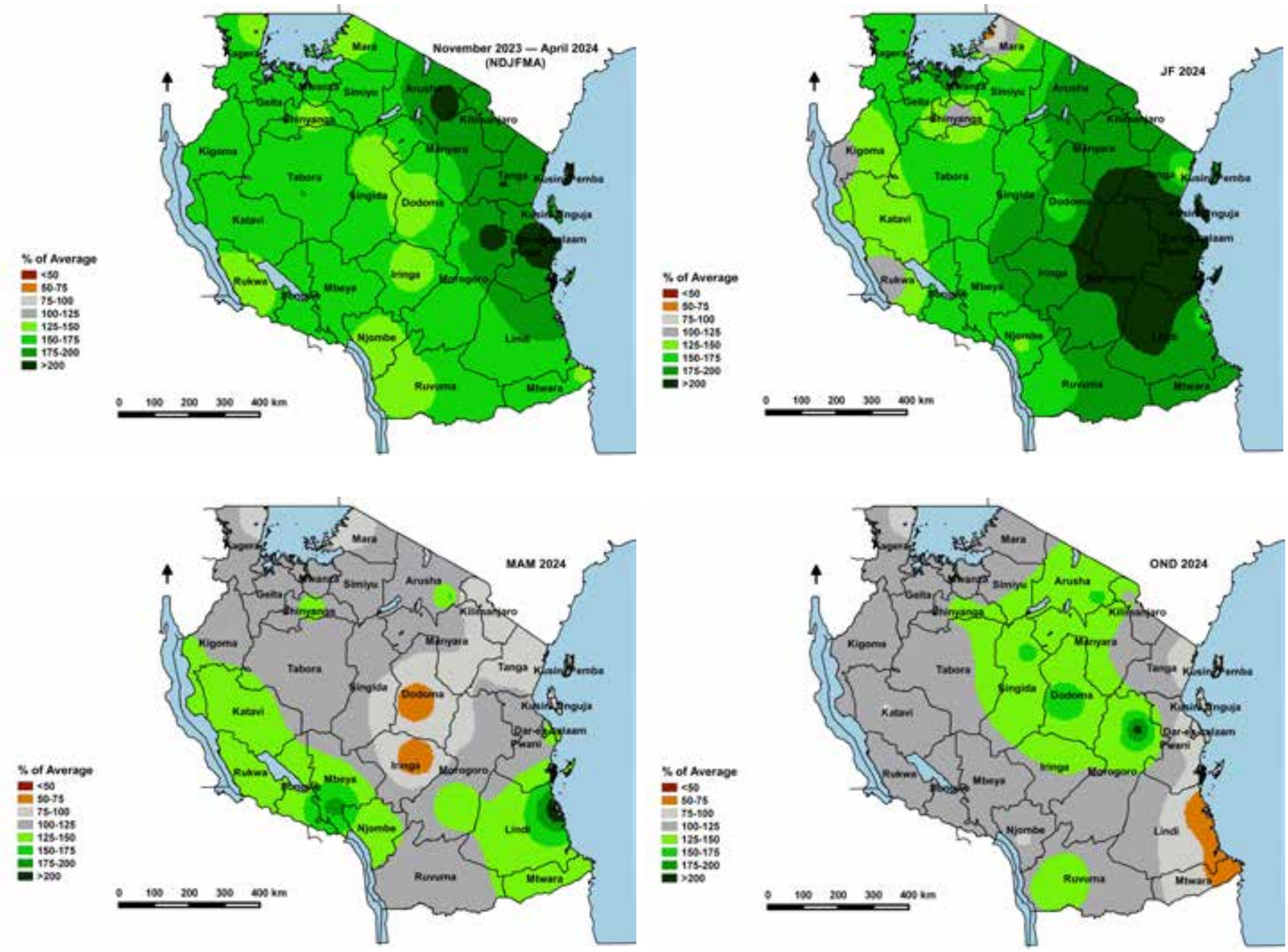

Figure 6: Seasonal rainfall anomalies as percentage of long-term average (1991–2020) for November 2023 to April 2024 (top left panel); January and February 2024 (top right panel); March to May 2024 (bottom left panel); and October to December 2024 (bottom right panel).

3.3 Spatial monthly rainfall distribution

In 2024, Tanzania experienced considerably wetter conditions in January, February, April, and December, with rainfall recorded at 212%, 137%, 144%, and 128% of the average, respectively, indicating a substantial increase in rainfall compared to the long-term average. Conversely, the country was notably drier in May, and relatively dry in October and November, with rainfall reaching only 64%, 94%, and 99% of the average, respectively. Specifically, most regions experienced wetter conditions in January and April, with rainfall exceeding 175% of the average, while the western, central, and southern regions received above-normal rainfall ranging between 125% and 175% of the average in February. In contrast, the northern coast and northeastern highlands observed increased rainfall exceeding 175% of the average in December, while the Lake Victoria basin saw an increase in rainfall ranging between 125% and 150%. Detailed information on spatial monthly rainfall is described below:

January 2024 was a particularly wet month across much of Tanzania, marking the wettest January on record since 1970. Above-normal rainfall, exceeding 200% of the long-term average, was observed throughout the eastern half of the country (Figure 7a). This unusually high rainfall was attributed to off-season rains driven by El Niño and Positive Indian Ocean Dipole conditions, especially in the northeastern regions. Meteorological stations in these areas, notably along the northern coast, including Dar es Salaam (JNIA), Kibaha, Morogoro, Zanzibar, and Tanga, reported exceptionally high rainfall totals, ranging from three to six times their long-term averages. For instance, the Morogoro station recorded 608 mm of rainfall in January, which is six times its long-term average. Similarly, JNIA and Kibaha recorded rainfall nearly six times their normal values. It is important to note that January is typically a relatively dry month, particularly in the northern and northeastern parts of the country, which experience a bimodal rainfall regime. This highlights the extraordinary nature of the January 2024 rainfall event.

February was also a relatively wet month, particularly in the central, southern, and western parts of the country. Rainfall totals in these areas ranged from 125% to 150% of the long-term average, with some individual locations recording totals between 150% and 200% of the average. Similarly, March was somewhat wet, especially for the coastal areas, northeastern highlands, and southern parts of the country. Rainfall in these regions was primarily between 125% and 150% of the average. In contrast, April was a notably wet month across much of Tanzania, ranking as the 5th wettest April on record since 1970. Above-normal rainfall, exceeding 200% of the average, was observed across much of the country, except for central Tanzania and a few areas in the western, northeastern highlands, and southern regions (Figure 7a).

In May 2024, much of the country experienced a significant rainfall deficit, making it the ninth driest May on record since 1970 (Figure 7a). The northern half of the country was particularly dry, with total rainfall ranging from 50% to 75% of the average. Regions along the northern coast and northeastern highlands recorded notably low rainfall, amounting to just one-third to half of their long-term average for May. For instance, the Zanzibar meteorological station reported only 46.8 mm of rainfall, approximately one-sixth of the long-term average for May. In contrast, the southern coast, particularly Kilwa and Mtwara, experienced above-normal rainfall, influenced by Tropical Cyclone Hidaya. The Kilwa meteorological station recorded a record-breaking for 24-hour rainfall of 316.6 mm on 4th May 2024, which was 327% of the station's long-term May average of 96.6 mm, of this, 200 mm fell within just six hours. In the same event, a total of 428 mm was recorded over a 48-hour period from 3rd to 5th May 2024. Kilwa's total monthly rainfall for May 2024 reached 439.2 mm, with much of this rainfall occurring during the two-day period of intense precipitation.

June, July, August, and September were relatively dry months (Figure 7b). The observed rainfall totals across much of the country ranged between 50% and 75% of the long-term average. However, in the northern coast, northeastern highlands, and southwestern highlands, particularly in June and August, normal to above-normal rainfall was observed. It is important to note that these months are climatologically dry for most parts of the country. Therefore, the observed wet and dry conditions in various locations generally align with the long-term climatology. For instance, rainfall recorded at Igeri meteorological station in the southwestern highlands during June, July, August, and September were 0.5 mm, 0.0 mm, 21.8 mm, and 20.1 mm, respectively, accounting for 11%, 0%, 574%, and 143% of the long-term average for these months.

October was relatively wet, particularly in the central, southwestern, southern (Ruvuma), and western parts of the country, where above-normal rainfall exceeding 200% of the 1991–2020 average was recorded. Most meteorological stations in these regions observed rainfall amounts three to four times higher than the long-term average. It is worth noting that October is typically a dry month for these areas, as the rainy season usually begins in November. These regions follow a unimodal rainfall pattern, with rainfall starting in November and continuing until April of the following year. However, occasional rains often linked to atmospheric disturbances can sometimes occur during this period.

In November, rainfall totals for the country were near average, reaching 99.2% of the long-term average. Normal rainfall, ranging between 75% and 125% of the average, was observed across most areas, except for the central and southern parts of the country. Central Tanzania experienced above-normal rainfall totals, generally ranging between 125% and 175% of the average. However, the southern coast, along with a few locations in the southwestern highlands and Ruvuma region, recorded below-normal rainfall, ranging from 50% to 75% of the average.

Furthermore, December was relatively wet across most parts of the country, with the country's rainfall totals reaching 128% of the long-term average. Much of the northeastern highlands, northern coast, Lake Victoria Basin, and Ruvuma region experienced above-normal rainfall, ranging from 150% to over 200% of the long-term average, particularly in some areas of the northern coast and northeastern highlands. In other parts of these regions, rainfall ranged between 125% and 150% of the long-term average. However, normal rainfall, within 75% to 125% of the long-term average, was predominantly observed on the southern coast, western parts, and southwestern highlands.

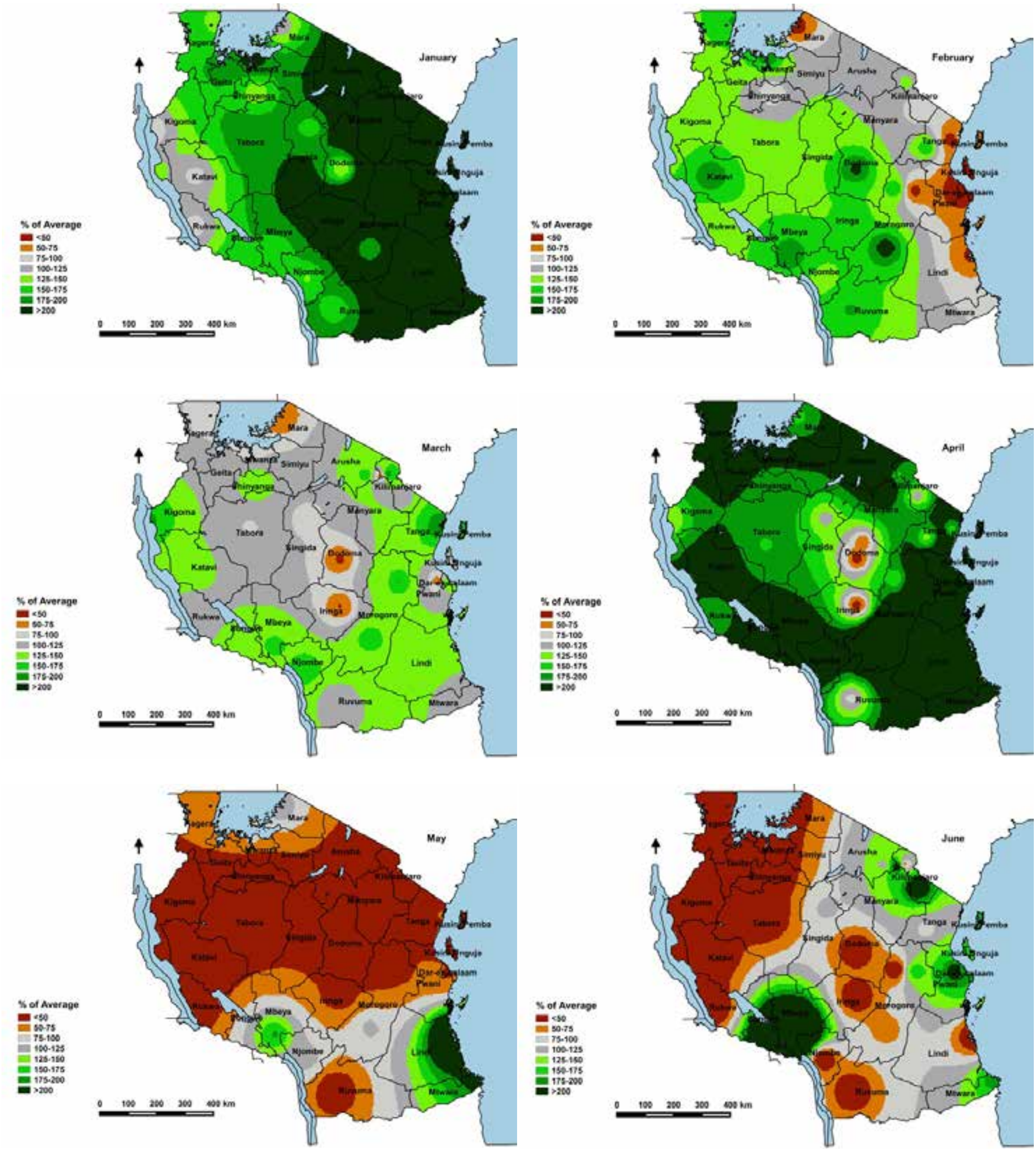

Figure 7a: Monthly rainfall anomalies as percentage of long-term average (1991–2020) for January to June 2024.

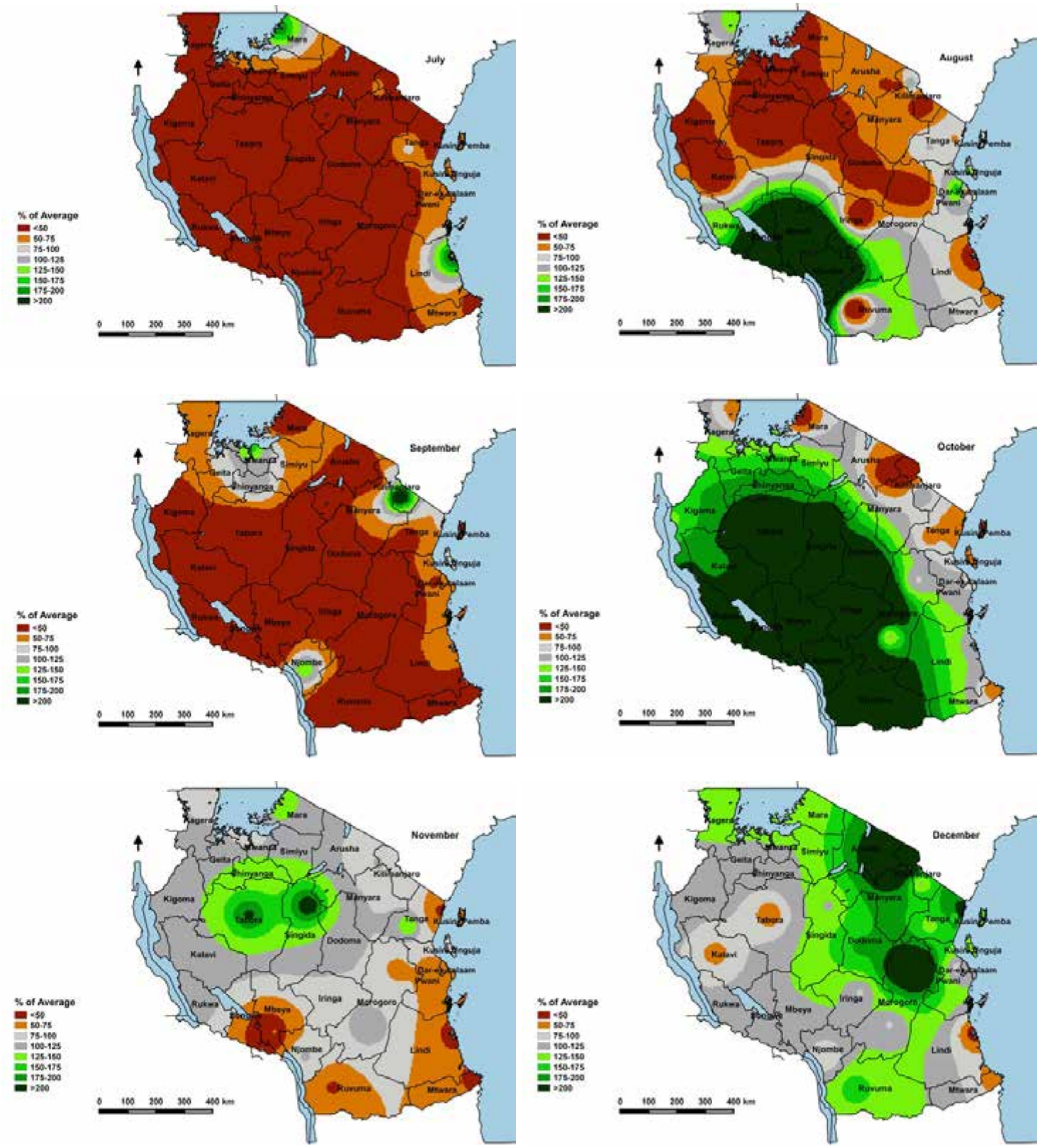

Figure 7b: Monthly rainfall anomalies as percentage of long-term average (1991–2020) for July to December 2024.

3.4 Cumulative rainfall

Cumulative rainfall curves are used in this statement to describe the performance and trends of observed rainfall for different areas in the country. The observed deficit or surplus of rainfall in 2024 is indicated by the deviation of observed cumulative rainfall from the long-term average of the cumulative rainfall for the respective season and area. Thus, when the observed cumulative rainfall is lower than the long-term average cumulative rainfall then a deficit of rainfall was observed in a respective season and vice versa.

During the NDJFMA (2023–2024) rainy season, cumulative rainfall exceeded the long-term average for most meteorological stations experiencing the unimodal rainfall regime. Notably, Uyole, Mtwara, and Mahenge stations recorded significantly higher cumulative rainfall for the season (Figure 8a). Cumulative rainfall at Uyole and Mtwara stations surpassed the long-term average by approximately 534 mm, while Mahenge station recorded an exceptional increase of 1,048 mm. The greater amount of rain at these stations was observed from the third dekad of March to the second dekad of April, with a similar pattern evident at Igeri station. However, Mtwara station differed, by showing a significant rainfall increase occurring in January. Overall, cumulative rainfall curves for other stations indicate that rainfall was fairly distributed throughout the season.

In the MAM rainy season, most meteorological stations, including Moshi, Tanga, Zanzibar, and Bukoba, experienced near-average cumulative rainfall. However, slightly below-average rainfall was recorded in Musoma (Figure 8b). Conversely, Arusha, Morogoro, Dar es Salaam, and Mwanza meteorological stations observed above-average cumulative rainfall, with Dar es Salaam and Morogoro receiving elevated amounts of around 500 mm, Arusha recording 323 mm, and Mwanza reporting 180.2 mm. Rainfall onset at most stations followed the expected climatological patterns, except for Morogoro, Dar es Salaam, Zanzibar, and Mwanza, where significant rainfall was recorded as early as January. The rainfall totals for January in these stations were 608 mm, 372.4 mm, 253 mm, and 250.6 mm, respectively. Additionally, April experienced the highest rainfall intensity across nearly all stations, aligning with climatological trends but exceeding the long-term average. Rainfall cessation was generally observed in the first and second dekad of May for most stations. Notably, at Pemba Meteorological Station (figure not shown), rainfall extended into June 2024, with significant rainfall amounts recorded during this period.

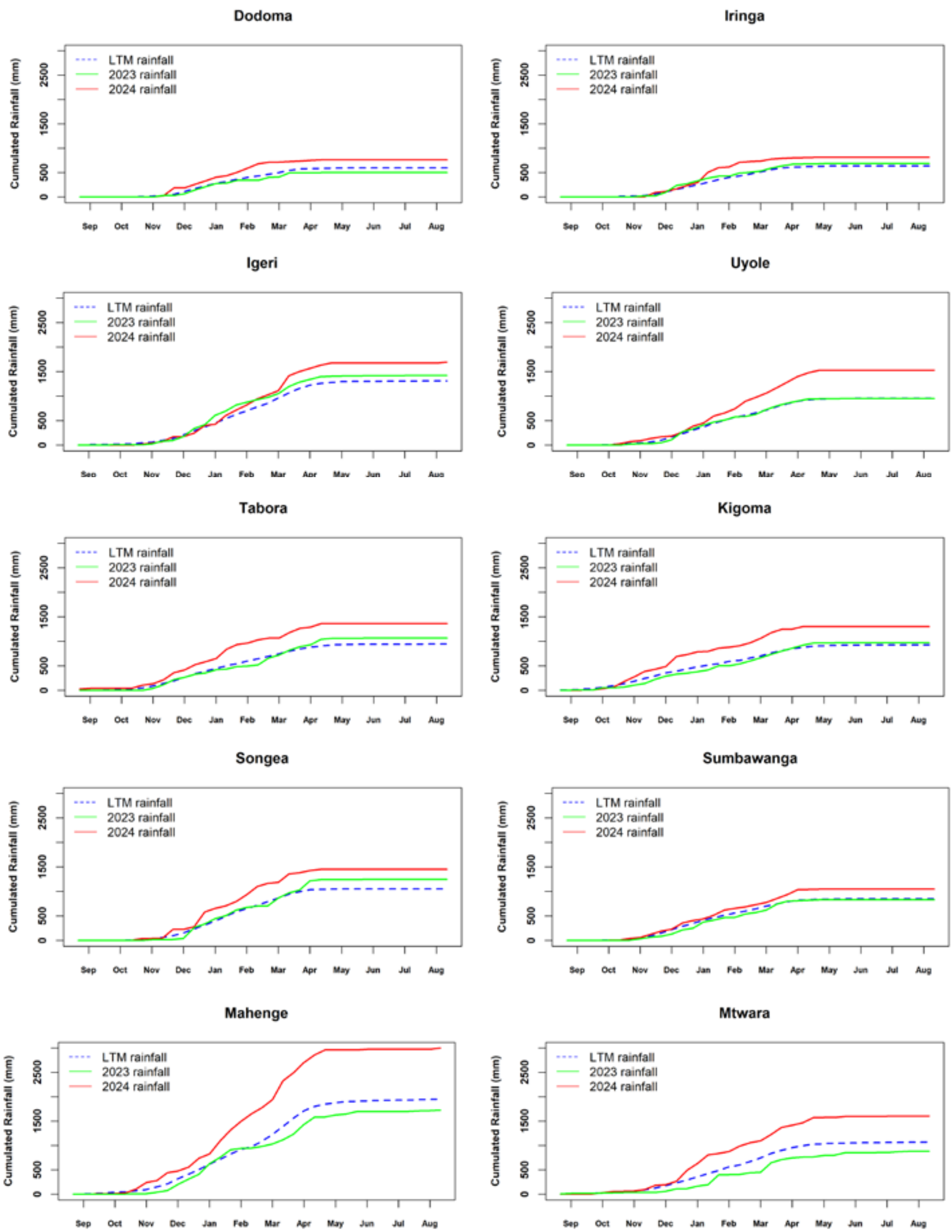

Figure 8a: Cumulative rainfall for the NDJFMA season for Dodoma, Igeri, Tabora, Songea, Mahenge Iringa, Uyole, Kigoma, Sumbawanga and Mtwara meteorological stations, presented as accumulation of dekadal rainfall totals for each month starting from September 2023 to August 2024.

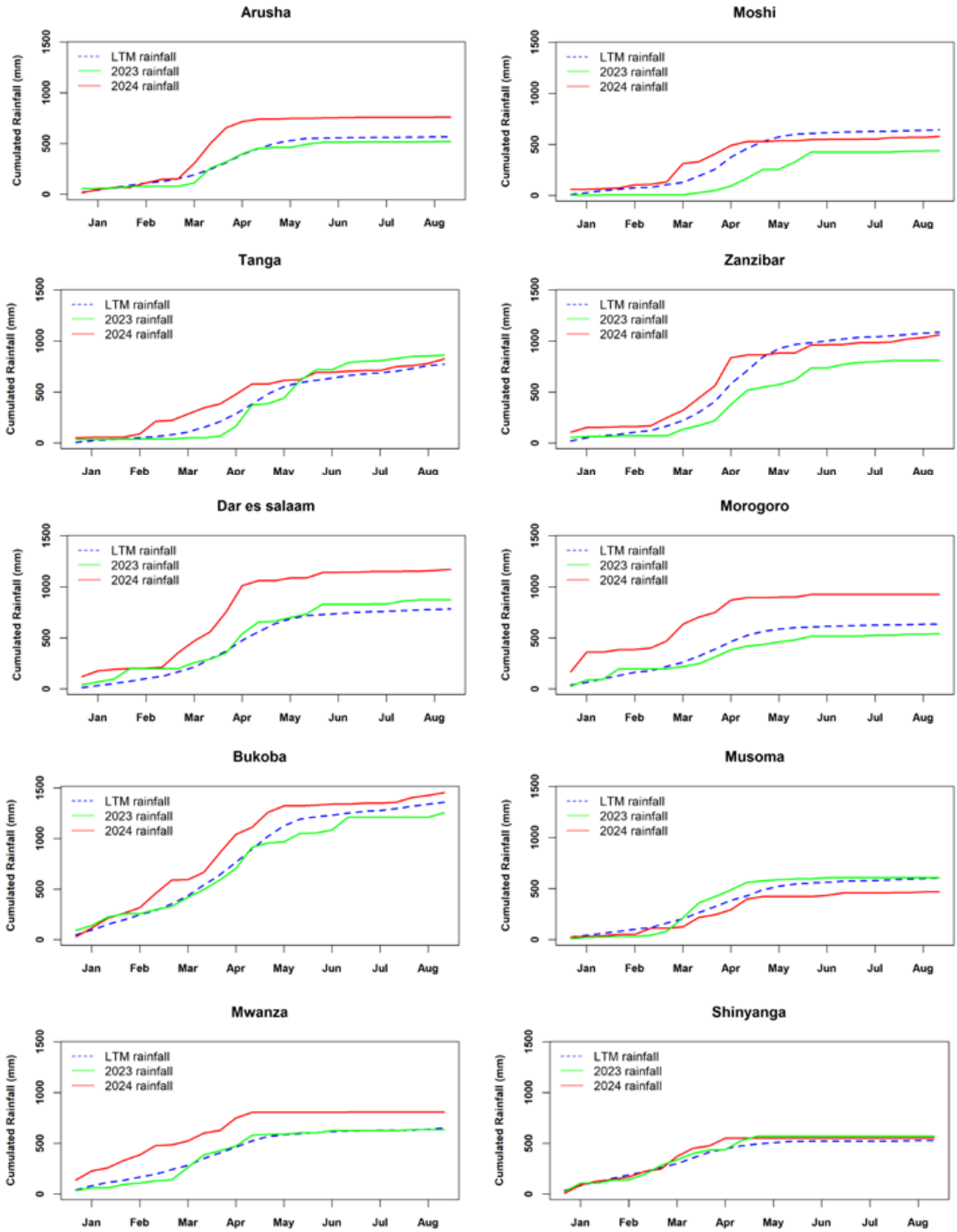

Figure 8b: Cumulative rainfall for MAM season for Arusha, Tanga, Dar es Salaam (JNIA), Bukoba, Mwanza, Moshi, Zanzibar (Kisauni), Morogoro, Musoma and Shinyanga meteorological stations, presented as accumulation of dekadal rainfall totals for each month starting from January to August 2024.

Similarly, most meteorological stations recorded near-average cumulative rainfall during the OND season, as shown in Figure 8c. However, the curves indicate a slight rainfall deficit in October for Bukoba, Musoma, Moshi, Arusha, and Tanga meteorological stations, likely due to a delayed onset of rainfall in these areas. Notably, a significant rainfall increase was observed at Morogoro Station in December, reaching 307.1 mm. Additionally, Shinyanga station recorded a slight increase in rainfall during November and December 2024 compared to other stations.

Overall, the cumulative rainfall for the NDJFMA 2023/2024 and MAM 2024 rainy seasons was relatively higher than that of the corresponding seasons in 2023 across all stations. However, it was lower than the rainfall observed during the OND 2023 season.

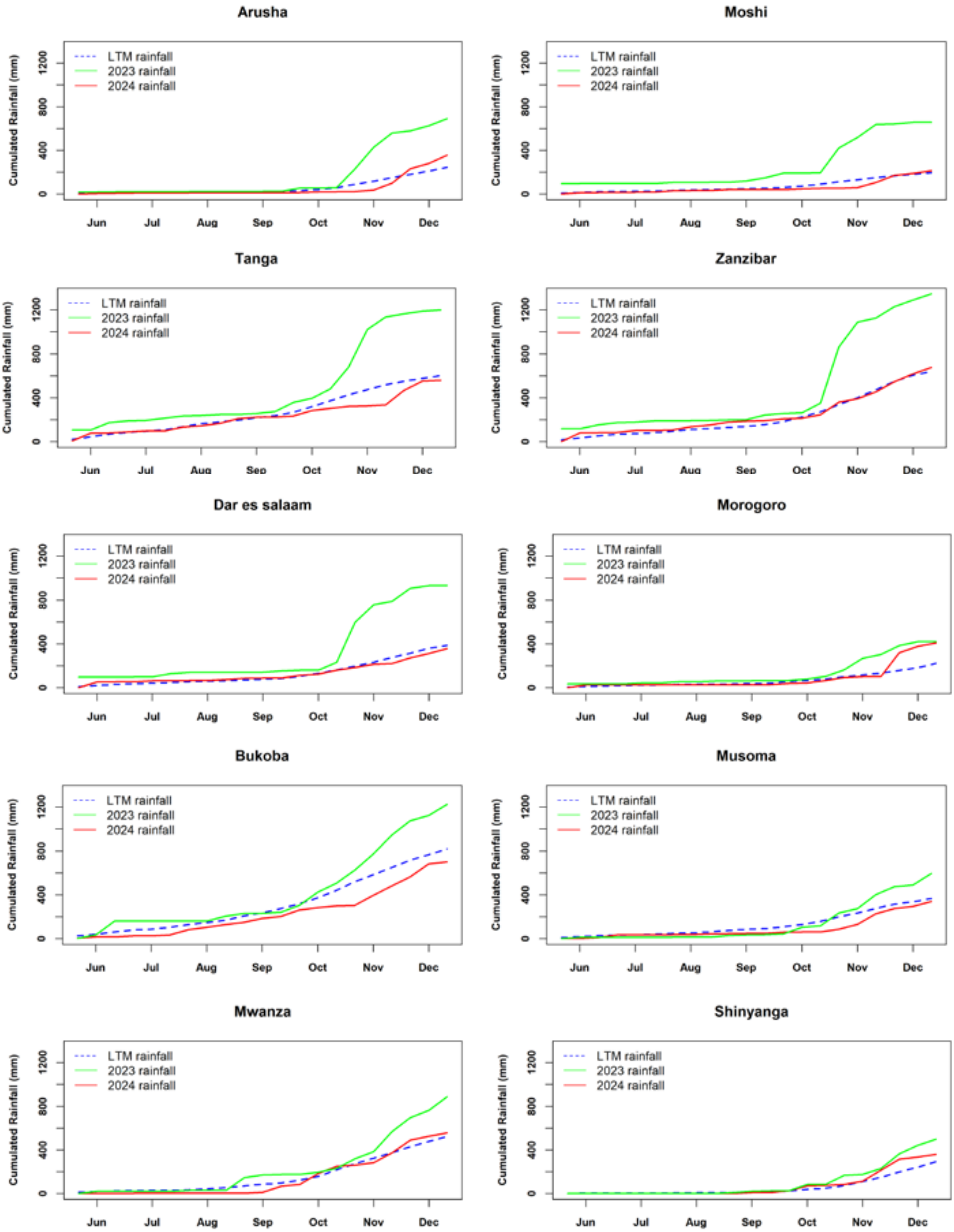

Figure 8b: Cumulative rainfall for MAM season for Arusha, Tanga, Dar es Salaam (JNIA), Bukoba, Mwanza, Moshi, Zanzibar (Kisauni), Morogoro, Musoma and Shinyanga meteorological stations, presented as accumulation of dekadal rainfall totals for each month starting from January to August 2024.

4. Extreme Weather and Climate Events of 2024

In 2024, various weather and climate extremes were reported across the country. Notable incidents included widespread flooding in the southeastern and northeastern regions, particularly in Kilwa (Lindi), Mafia and Rufiji (Pwani), and Mlimba and Kilombero (Morogoro). Localized thunderstorms were also reported in different areas. Some of these flood events were intensified by heavy rainfall, notably influenced by the landfall of Tropical Cyclone Hidaya on Mafia Island in early May 2024.

4.1 Extreme rainfall events

In 2024, a significant number of heavy rainfall and flood events were reported across various parts of the country. This section highlights some of the extreme rainfall events that exceeded 100 mm within 24 hours, as well as rainfall events below 100 mm that were exceptional either due to their historical significance or the impacts they caused.

The highest daily rainfall total in 2024 was 316.6 mm, recorded at Kilwa meteorological station on May 4th. This was a particularly wet day for the Lindi region and its surroundings due to the landfall of Tropical Cyclone Hidaya. The observed 24-hour rainfall set a record for Kilwa station, amounting to 327% of the station's long-term average for May (96.6 mm). Of this, 316.6 mm, 200 mm fell within just six hours. In the same event, a total of 428 mm was recorded over a 48-hour period from 3rd to 5th May 2024. In May 2024, Kilwa recorded a total monthly rainfall of 439.2 mm, with the majority occurring in two-day period of intense precipitation. During May 2024, 10 instances of heavy rainfall exceeding 50 mm were recorded in different areas of the country, out of these, five events surpassing 80 mm. Despite these extreme events, May was relatively dry overall, apart from a few significant rainfall episodes in the first dekad.

On April 14th, 2024, Lyamungo meteorological station recorded heavy rainfall of 179.1 mm. In addition, there were four other days with rainfall exceeding 100 mm, and four days with rainfall between 50 mm and 100 mm. The station's total monthly rainfall amounted to 1,189.7 mm, which is 263.9% of the average monthly rainfall. Apart from Lyamungo station, Pemba meteorological station recorded 140.1 mm of rainfall on April 18th, while Mahenge meteorological station observed 105.1 mm on April 6th. In general, April was a wet month for various parts of the country, with 34 rainfall events exceeding 50 mm, including 12 events that surpassed 80 mm.

Likewise, January was wetter for the larger part of the country, at least 45 instances of rainfall exceeding 50 mm were reported across the country out of which 10 events recorded rainfall exceeding 80 mm. Specifically, 113 mm of rainfall was recorded at Naliendele meteorological station on 3rd January while 112.2 mm was recorded at Tumbi meteorological station on 26th January 2024.

February and March 2024 were relatively wet for some areas across the country, though they recorded less rainfall extremes compared to January and April. Thus, there were 18 occurrences of rainfall exceeding 50 mm, of which four exceeded 80 mm in February and six in March. Specifically, Mahenge Meteorological station recorded 128.4 mm of rainfall on 11th February, while 108.2 mm was recorded in Moshi on 22nd March 2024.

Furthermore, October, November, and December 2024 were generally dry, with only a few instances of extreme rainfall recorded. During this period, the country experienced four, nine, and fifteen occurrences of rainfall exceeding 50 mm in October, November, and December, respectively. However, an exceptional rainfall occurred on October 17th in Mwanza, where 100 mm of rain was recorded at the Mwanza meteorological station within just seven hours. Additionally, a nearby station (Mwanza marine) reported 107.3 mm of rainfall.

4.2 Extreme temperature events

The highest temperature recorded in 2024 was 38.4°C at Ilonga Meteorological Station on November 29th. This marks the second highest maximum temperature recorded at the station since 1961 and the highest in the past four decades. Additionally, a temperature of 37.2°C was recorded at the neighboring Morogoro station. These extreme heat events were preceded by five consecutive instances of temperatures exceeding 35°C. Furthermore, on the same day, about six stations in the northeastern part of the country reported maximum temperatures surpassing 35°C. The third highest temperature of the year, 37.1°C, was recorded at Kilimanjaro International Airport (KIA) on February 18th, maintaining its ranking from the previous year. Notably, this temperature was the 10th highest for February since the station's establishment in 1972.

Remarkably, a high number of hot days, with maximum temperatures reaching 35°C or more, was recorded mainly in the northeastern parts of the country during February (38 events) and November (23 events). Similarly, numerous hot days were observed in the southern and western regions during September and October, with 17 and 14 occurrences, respectively.

The highest minimum temperature in 2024 was 29.1°C, recorded at Pemba Station on 5th March, ranked as the third-highest minimum temperature since 1974. However, multiple days with elevated minimum temperatures (Tmin) exceeding 26°C were recorded, including 91 occurrences in February, 54 in January, 51 in March, 49 in December, and 33 in November. This pattern was predominantly observed at coastal meteorological stations, including Mtwara, Kilwa, Naliendele, Tanga, Zanzibar, Pemba, Mlingano, and Dar es Salaam.

In contrast, the lowest maximum temperature in 2024 was 11.4°C, recorded on June 10th at Igeri Station in the southwestern highlands. Igeri remained the coldest location in the region throughout the year. Similarly, the lowest minimum temperature in 2024 was 3°C, recorded at Uyole Meteorological Station on July 27th.

Moreover, minimum temperatures of 10°C or lower were observed across the southwestern highlands and southern regions from May to September 2024. Specifically, June recorded at least 62 instances, while July and August recorded even higher numbers, with 95 and 61 occurrences, respectively. Notably, a few cases of minimum temperatures falling below 5°C were recorded in the southwestern highlands during June, July, and August, with one, eight, and five occurrences, respectively. It's important to note that during the colder months of June, July, and August, normal temperature fluctuations in the region often cause minimum temperatures to drop to 5°C or lower.

4.3 Tropical cyclone events

Tropical Cyclone Hidaya, which made landfall over Mafia Island in the Lindi region (southeastern Tanzania) on 4th May 2024, was the third recorded tropical cyclone or depression to make landfall in Tanzania, following an unnamed cyclone in 1952 and Tropical Depression Atang in 2002. Moreover, it was the most intense cyclone ever recorded in this region of the Indian Ocean, highlighting the increasing significance of extreme weather events in the area.

5. Major drivers of weather and climate events in 2024

The observed seasonal rainfall and extreme events in 2024 were influenced by several factors, including variations in Sea Surface Temperatures (SSTs) across the Atlantic, Indian, and Pacific Oceans, the position and movement of the Intertropical Convergence Zone (ITCZ), active phases of the Madden-Julian Oscillation (MJO), tropical depressions and cyclones over the southwestern Indian Ocean, as well as mesoscale atmospheric processes.

The year began with a strong El Niño in January and February, gradually weakening to a moderate El Niño in March and April before transitioning to ENSO-neutral conditions from May through October 2024. By November, ENSO conditions shifted to La Niña, which persisted through December (Figure 9).

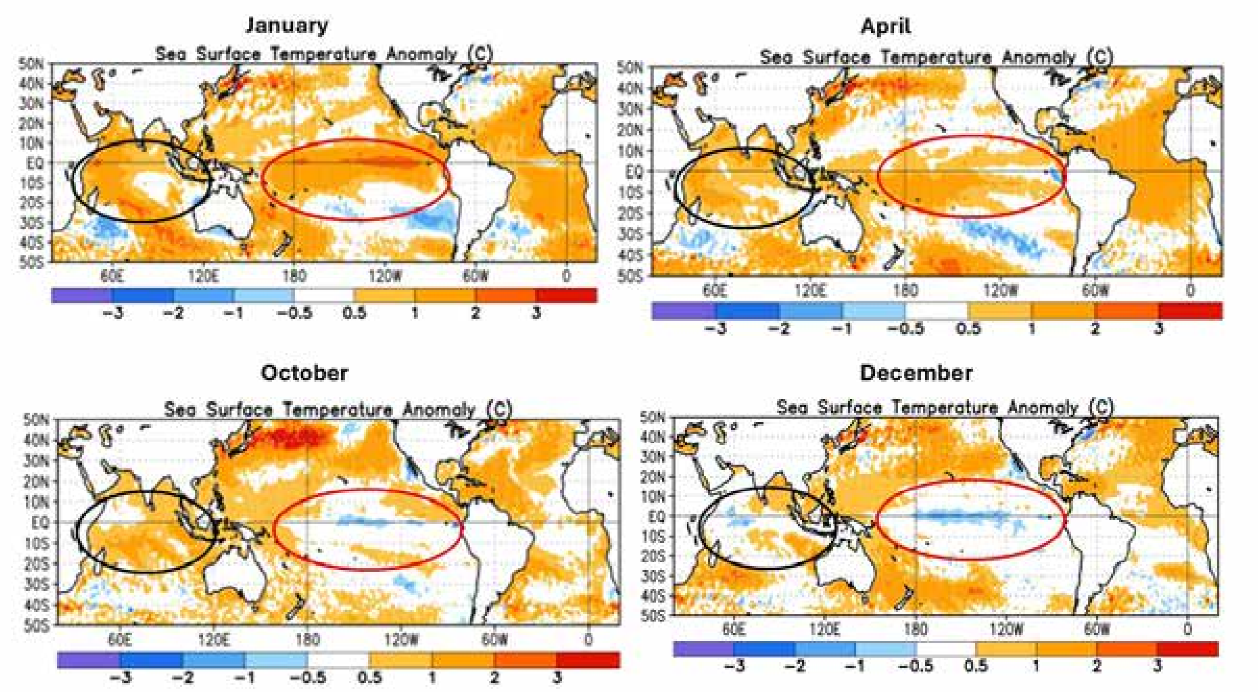

Figure 9: Sea Surface Temperature Anomalies for January, April, October and December 2024 showing evolution of Sea Surface Temperatures across Pacific Ocean (red cycled) and Indian Ocean (black cycled). Anomalies are departures from the long-term average (1991–2020). Source: https://www.cpc.ncep.noaa.gov/products/CDB/CDB_Archive_pdf/pdf_CDB_archive.shtml.

Meanwhile, the tropical Indian Ocean experienced strong positive Sea Surface Temperature Anomalies (SSTAs) from January to March, with more pronounced warming in the western region compared to the eastern region (Figure 9), indicating a positive phase of the IOD. The dipole mode transitioned to a neutral phase from April through August. However, from September 2024 onward, positive SSTAs intensified significantly in the Southeastern Tropical Indian Ocean (SETIO), driving the IOD into a negative phase.

These conditions contributed to the above-normal rainfall and widespread flooding observed across the country in early 2024, particularly in January and February. Wind patterns (Figure 10) also played a crucial role in modulating the intensity and distribution of rainfall. For instance, during January and February, much of the coastal Tanzania experienced enhanced southeasterly wind anomalies, which facilitated increased moisture transport to the country and hence heavy rainfall.

As ENSO transitioned to neutral conditions from March through May and the influence of the positive IOD weakened, rainfall in the country gradually decreased, with a more pronounced reduction observed in May and the following months. Similarly, easterly wind anomalies over the tropical Indian Ocean weakened as they approached the Tanzanian coast, leading to a reduced influx of moisture into the country during this period.

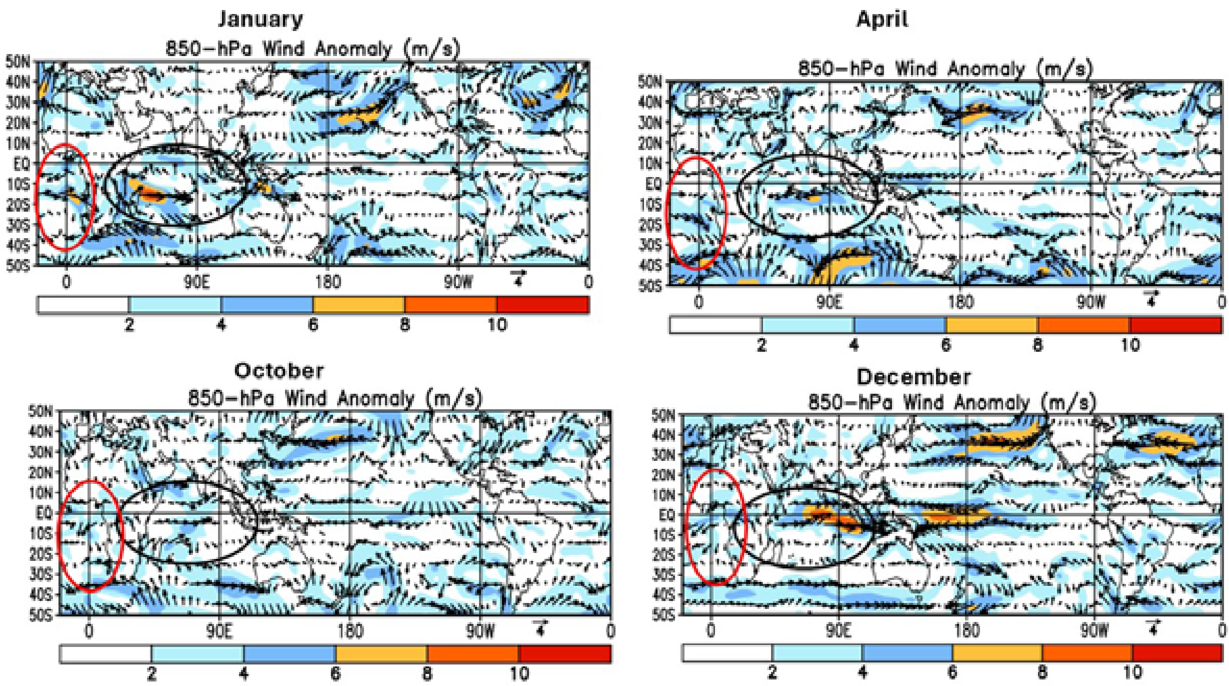

Figure 10: Wind anomaly (vector and its amplitude) at 850 mb (right panel) for January, April, October and December, showing evolution of low-level winds across the Indian Ocean (black cycled) and East Atlantic Ocean (red cycled). Anomalies are departures from the long-term average (1991–2020). Source: https://www.cpc.ncep.noaa.gov/products/CDB/CDB_Archive_pdf/pdf_CDB_archive.shtml.

Later in the year, during October and November 2024, enhanced westerly wind anomalies (Figure 10) dominated the central Indian Ocean, restricting moisture influx into the country and contributing to suppressed rainfall. This effect was further intensified by the concurrent presence of a negative IOD phase and La Niña conditions. The effects were particularly notable in regions with a bimodal rainfall pattern, such as the northern coast, northeastern highlands, and the Lake Victoria basin. A significant reduction in rainfall was observed in October and November, with both months ranking among the driest on record since 1970. October 2024 was the 23rd driest, and November 2024 was the 28th driest.

Furthermore, positive SSTAs persisted over the eastern Atlantic Ocean, particularly off the coasts of Angola and Congo, from January through October. This sustained warming intensified easterly wind anomalies, which became more pronounced in October, November, and December. These anomalies contributed to the diversion of moisture away from the continent, reducing the transport of moisture from the Congo Forest into Tanzania and further suppressing rainfall during this period.

Despite variations in global SSTs, other synoptic features played a significant role in modulating Tanzania's rainfall throughout the year. Among the most influential were tropical depressions and tropical cyclones over the southwestern Indian Ocean basin. For instance, between January and April, low-pressure systems were occasionally observed south of Tanzania and over the Mozambique Channel, pulling moisture toward the southern parts of the country and resulting in increased rainfall in those areas. Notably, Tropical Storm Filipo, which developed over the Mozambique Channel from 2nd to 14th March, enhanced rainfall, particularly in the western, southwestern highlands, and southern regions of Tanzania. Whereas the Tropical Cyclone Hidaya, which made landfall over Mafia Island in the Lindi region (southeastern Tanzania) on 4th May 2024, brought heavy rainfall and strong winds to the area as well as the neighboring regions of Mtwara, Pwani and Morogoro.

6. Weather and climate related impacts

This section highlights the significant impacts of extreme weather events that affected the country in 2024. The events selected for discussion were chosen based on a combination of factors, including their spatial extent, severity, duration, and associated impacts. Information on the level of these impacts was primarily sourced from the Prime Minister's Office–Department of Disaster Management (PMO–DMD), as well as from media.

Earlier in the year, severe flooding was reported in four regions of Tanzania: Pwani (January–March), Morogoro (March), Arusha (April) and Lindi (May). These flood events were driven by prolonged heavy rainfall over the affected regions and their surrounding areas.

Pwani was particularly hard-hit, especially in the districts of Rufiji, Kibiti and Kisarawe. In addition to the intense and sustained downpours, flooding in this area was worsened by the overflow of River Rufiji, which is naturally prone to flooding, especially during MAM season. Moreover, excessive rainfall during the short rains of late 2023 exacerbates the extreme flooding event observed (Figure 11). Residents with long-term knowledge of the area noted that such flood events have occurred repeatedly over the years, highlighting the region's vulnerability to seasonal flooding.

Figure 11: Widespread devastation floods in Rufiji district (left) and the former Chama Cha Mapinduzi (CCM) Vice Chairman, Abdulrahman Kinana's paying special visit to console the flood victims (right). Source: Daily news of April 10th, 2024, accessed online on 5th Feb 2025 at https://dailynews.co.tz/floods-inundate-rufiji/.

As a result of these flooding events, five people lost their lives, and 92,090 individuals were displaced. Additionally, 23,963 households and four schools were affected. The floods caused significant damage, with 382 houses partially damaged and 638 houses destroyed. Furthermore, 105,463 acres of farmland were damaged, and four kilometers of roads, along with four bridges, were destroyed.

In the Morogoro region, the districts of Kilombero, Mlimba, and Malinyi experienced prolonged period of flooding. During this period, 40 people lost lives, and 15,621 people were displaced. The floods also affected 6,115 households, causing damage to 1,004 houses, 236 of which were destroyed. Furthermore, 48,571 acres of farmland were destroyed, and 105 kilometers of roads, along with 75 bridges, were destroyed.

Similarly, in Arusha region, the districts of Arusha, Karatu, and Monduli also experienced prolonged flooding. During this event, seven people lost their lives, and 20,469 individuals were displaced. Additionally, 4,329 households were affected, with 3,348 houses damaged, and 421 destroyed. Furthermore, three schools were impacted, and 116 acres of farmland were damaged. The flooding also caused significant damage to infrastructure, with 71 kilometers of roads, five bridges, and four electrical poles being destroyed.

On January 7, 2024, Same District in Kilimanjaro region experienced devastating mudslides, resulting in 11 deaths, four injuries, and the displacement of 407 people. Additionally, 25 households were affected, with 20 houses damaged and five destroyed. The disaster also led to the destruction of two schools and one health center. Infrastructure suffered significant damage, with six kilometers of roads affected and 320 acres of farmland devastated. Furthermore, road obstructions were reported, complicating recovery efforts.

On April 13, 2024, widespread flooding occurred in Katavi region, affecting the districts of Tanganyika, Mpimbwe, Mpanda, and Nsimbo. A total of 1,498 households, comprising 5,477 people, were impacted. Additionally, 571 houses were affected, with 519 sustaining damage and 52 completely destroyed. The floods also devastated 260 acres of farmland, and the loss of 79 livestock was reported.

Furthermore, Tropical Cyclone Hidaya made landfall over Mafia Island in the Lindi region (southeastern Tanzania) on May 4, 2024, bringing heavy rainfall and strong winds to the island and surrounding regions, including Mtwara, Pwani, and Morogoro. During the cyclone's passage, five people lost their lives, seven were injured, and 21,537 individuals were displaced. Additionally, 7,127 households were affected, with 1,412 houses damaged and 1,584 destroyed. The cyclone also caused partial damage to twelve schools and nine health centers. Infrastructure damage was severe, with 23 kilometers of roads and five bridges destroyed as seen in Figure 12. Furthermore, 4,310 trees and 182 electric poles were downed. According to the PMO-DMD, the districts most severely impacted by the cyclone were Mafia (Pwani), Kilwa (Lindi), and Ifakara Town Council (Morogoro).

Figure 12: Aerial survey indicating the extent of damage of Lindi-Dar es Salaam Road after the landfall of the Tropical Cyclone Hidaya on 4th May 2024. Source: Tanzania Media of 7 May 2024, accessed online on 5th Feb 2025 at https://tanzania.eu.com/aerial-survey-of-lindi-dar-es-salaam-road-after-typhoon-hidaya/.

On November 24, 2024, severe flooding from Mori River in Tarime District resulted in the tragic loss of nine family members and left two others injured. The disaster affected two households, including two houses which were completely destroyed and washed away as seen in Figure 13. Additionally, 121 acres of farmland were devastated, and a bridge valued at TZS 750,000,000 was destroyed.

Figure 13: Some residents of Tarime stand in the area where two families once lived, before their homes were swept away by floodwaters, tragically claiming the lives of nine members of the same family. Source: Mwananchi Newspapers of 25th Nov 2024, Accessed online on 5th February 2025 at https://www.mwananchi.co.tz/mw/habari/kitaifa/mafuriko-yalivyoua-wanane-wa-familia-moja-48 and https://www.mwananchi.co.tz/mw/habari/kitaifa/watu-nane-wa-familia-moja-wafariki-dunia-kwa-kusombwa-na-mafuriko-tarime-4835404 35740.

A general assessment conducted by the PMO-DMD, covering the period from October 2023 to June 2024, revealed significant impacts of extreme weather events across the country. The assessment reported a death toll of 177, with over 212 casualties, and more than 234,482 individuals affected across 60,990 households. Additionally, 15,856 houses sustained varying degrees of damage. The disasters also caused extensive destruction of infrastructure, including schools, clinics and dispensaries, places of worship, roads, and bridges. Furthermore, the assessment highlighted severe losses in the agricultural sector, with widespread damage to farmland, crops, and livestock.

7. Summary

The observed climate of Tanzania in 2024 indicates that it was the warmest year on record since 1970. The country experienced record-breaking mean temperatures in May, June, July, and November, marking the highest levels recorded since 1970. Additionally, February, August, and September were the second warmest months on record. Throughout the year, the country's average monthly minimum temperature (Tmin) remained consistently above the long-term average (1991-2020). Overall, the country experienced higher temperature anomalies in minimum temperatures compared to maximum temperatures except for July.

A high number of hot days, with maximum temperatures reaching 35°C or higher, was recorded mainly in the northeastern parts of the country during February and November, while similar conditions were observed in the southern and western regions during September and October.

On the other hand, multiple days with minimum temperatures exceeding 26°C were predominantly recorded in January, February, March, November, and December, particularly in coastal areas. Conversely, minimum temperatures of 10°C or lower were observed across the southwestern highlands and southern regions from May to September 2024.

In addition to the record-breaking temperatures, Tanzania experienced notable rainfall variations throughout 2024, with significant differences in annual, seasonal, and monthly rainfall distribution. Wetter-than-normal conditions were experienced across much of the country, particularly in January, February, April, and December. The November 2023–April 2024 (NDJFMA) rainy season recorded predominantly above-normal rainfall, while the MAM and OND 2024 rainy seasons experienced near-normal rainfall. Overall, 2024 was the fourth wettest year on record since 1970 and the wettest in the past two decades.

Notably, the NDJFMA rainy season was the wettest since 1970, whereas the 2024 MAM and OND rainy seasons ranked as the ninth and eighteenth driest seasons, respectively, since 1970. Additionally, January 2024 was exceptionally wet across much of Tanzania, marking the wettest January on record since 1970.

In general, rainfall distribution in 2024 was largely influenced by El Niño, positive Indian Ocean Dipole, and the occurrence of Tropical Cyclone Hidaya in May 2024 which contributed to enhanced rainfall across much of the country.

8. Appendix

These appendices provide information about the underlying datasets and methodologies used in this statement. Much of the content is repeated from previous statements, with only minor updates, but they are included here in full for reference.

8.1 Climate of Tanzania

8.1.1 Temperature distribution

Temperatures across the country are normally characterized by relatively less fluctuation throughout the year. The annual long-term average temperature over different stations in the country ranges from 14.7 °C to 27.5 °C. Regions with the highest temperatures are along the coast and in the western parts of the country. The season with high temperatures starts in October and continues through February or March, while the cool season is from May to August. The annual minimum air temperature (Tmin) and maximum air temperature (Tmax) across the stations range from 9.9 °C to 24 °C and 19.5 °C to 31.2 °C, respectively.

8.1.2 Rainfall patterns

Rainfall in Tanzania is influenced by the migration of the Inter-Tropical Convergence Zone (ITCZ) north and south of the equator. The ITCZ moves to the southern regions of Tanzania from October to December, reaching the southernmost part of the country in January and February, before reversing northward in March, April, and May. This migration results in areas experiencing either single or double passages of the ITCZ. Regions that experience a single passage follow a unimodal rainfall regime, receiving rainfall from November to April or May in the subsequent year (also known as Msimu). These regions include the southern (Ruvuma, Mtwara, Lindi), southwestern highlands (Mbeya, Songwe, Njombe, Iringa, Rukwa), central (Dodoma, Singida), and western (Katavi, Kigoma, Tabora) parts of the country. Areas with double passages experience a bimodal rainfall regime, with two distinct rainy seasons: the long rains (Masika), which typically begin in March and continue through May (MAM), and the short rains (Vuli), which start in October and last through December (OND). These regions include the northern coast (Dar es Salaam, Pwani, Tanga, northern Morogoro, and Zanzibar Islands (Unguja and Pemba)), northeastern highlands (Kilimanjaro, Arusha, Manyara), Lake Victoria basin (Mwanza, Shinyanga, Simiyu, Kagera, Mara). However, January and February are relatively dry for areas with a bimodal rainfall regime, while June through September are dry months for the entire country. The spatial and temporal variability of rainfall patterns in Tanzania is driven by multiple factors, including the ITCZ, the East African Monsoon, ENSO, westerlies from Congo, and tropical cyclones.

8.2 Long-term average (1991-2020)

The long-term averages for the WMO standard 30-year climatological reference period, 1991– 2020 presented in this statement have been calculated from long term average monthly station data as a simple average spanning for 30-year period. The long-term averages for the country were calculated as the average of individual station monthly averages.

8.3 Rainfall anomaly (Percent of average)

The rainfall anomaly, expressed as a percentage of the long-term average, is calculated at three levels:

1. **Station-level calculation**:

   The anomaly at each station is determined by taking the ratio of the observed monthly rainfall to the station's long-term monthly average (1991–2020) and multiplying by 100.

2. **National-level monthly calculation**:

   The national rainfall anomaly for a given month is calculated as the ratio of the observed national average monthly rainfall (computed from all stations) to the long-term national average monthly rainfall (computed from all stations), multiplied by 100.

3. **Seasonal and annual calculations**:

   Seasonal and annual rainfall anomalies are computed by taking the ratio of the total observed country monthly average rainfall over a given period (e.g., January–December for annual or March–May for seasonal) to the total long-term national average rainfall for the same period, then multiplying by 100.

The percentage value greater than 125 is regarded as above normal rainfall and that between 75 and 125 is normal rainfall, while a percentage value of less than 75 is below normal.

8.4 Temperature anomaly

The temperature anomaly is calculated at three levels as follows:

1. **Station-level calculation:**

   The temperature anomaly at each station is determined by calculating the difference between the observed monthly temperature and the station's long-term monthly average temperature (1991–2020).

2. **National-level monthly calculation:**

   The national average temperature anomaly is computed by averaging the monthly temperature anomalies from all stations across the country for that specific month.

3. **Seasonal and annual calculations:**

   Seasonal and annual temperature anomalies are derived by averaging the national monthly temperature anomalies over the respective period (e.g., January–December for annual or March–May for seasonal).

8.5 Cumulative rainfall curves and their significance

Cumulative rainfall curves provide insights into seasonal rainfall distribution, intensity, and trends. They help identify rainfall patterns, such as steady precipitation, intense bursts, or prolonged dry spells. A steep incline indicates heavy rainfall over a short period, while a gradual slope suggests consistent, lighter rainfall. Sharp rises followed by plateaus highlight intense, short-duration rainfall, whereas a steady rise reflects prolonged, moderate rainfall. These curves are also valuable for detecting extreme weather events, including heavy rainfall and droughts.

In this statement, cumulative rainfall curves are plotted alongside long-term cumulative rainfall to assess rainfall performance across different regions. Deviations from the long-term average indicate rainfall deficits or surpluses for a given season, below-average cumulative rainfall signals a deficit, while above-average values indicate excess rainfall.

In this statement, cumulative rainfall refers to the total observed dekadal rainfall accumulated from a selected reference point for a specific season. The dekadal rainfall for 2024 was calculated as follows:

1. **Unimodal rainfall regions:**

    Rainfall was accumulated from September 2023 to August 2024, aligning with the rainfall season, which spans from November of the previous year to April of the following year (NDJFMA).

2. **Bimodal rainfall regions:**

    For the **March–May (MAM) season**, rainfall was accumulated from January to August 2024.

    For the **October–December (OND) season**, rainfall was accumulated from June to December 2024.

   The dekadal baseline climatology (1991–2020) was computed using the same methodology to allow for comparisons with the observed dekadal values for each season.

8.6 Spatial analysis for temperature and rainfall distribution

Temperature and rainfall data were analyzed as point data for selected stations across the country. A total of 29 meteorological stations were used for rainfall analysis, and 28 stations for temperature analysis. To generate spatial maps of temperature and rainfall anomalies, the Inverse Distance Weighting (IDW) interpolation method was applied using Quantum Geographic Information System (QGIS). The IDW method assumes that each input point exerts a local influence that diminishes with distance. Points closer to the processing cell are given more weight than those farther away. This moving average algorithm is particularly useful for interpolating highly variable data.

8.7 Severe weather

Severe weather is defined as any weather or climate event that poses a risk to life, property, or requires the intervention of authorities. The types of severe weather phenomena vary depending on factors such as latitude, altitude, topography, and atmospheric conditions. These include strong winds, hail, excessive precipitation, and wildfires. According to the World Meteorological Organization (WMO), severe weather is categorized into two groups: general severe weather (e.g., windstorms and associated phenomena) and localized severe weather (e.g., downbursts and tornadoes). Extreme weather refers to unusual events that fall at the extremes of historical distribution for a given area.

In this statement, severe weather is defined by rainfall events that reach or exceed 50 mm in 24 hours. However, extreme weather and climatic events may also be described using other statistical terms, such as percentiles, or based on the magnitude of their impact, even if they do not meet the prescribed thresholds.

Temperature thresholds for extreme weather events are set at 35°C or higher for maximum temperatures, and 5°C or lower for minimum temperatures.

8.8 Calculations of sea surface temperature anomaly for the IOD and ENSO

The IOD is calculated by taking the difference between the area-averaged monthly mean Sea Surface Temperature Anomaly (SSTA) for the South East Tropical Indian Ocean (SETIO) [90ºE-110ºE, 10ºS-0] and West Tropical Indian Ocean (WTIO) [50ºE-70ºE,10ºS-10ºN], while the Niño 3.4 index (ENSO), is calculated as the area-averaged monthly mean SSTAs (ºC) for the region (5ºN-5ºS, 170ºW-120ºW) over Central Equatorial Pacific Ocean (CEPO). Anomalies are departures of observed SSTs from the long-term average (1991-2020).

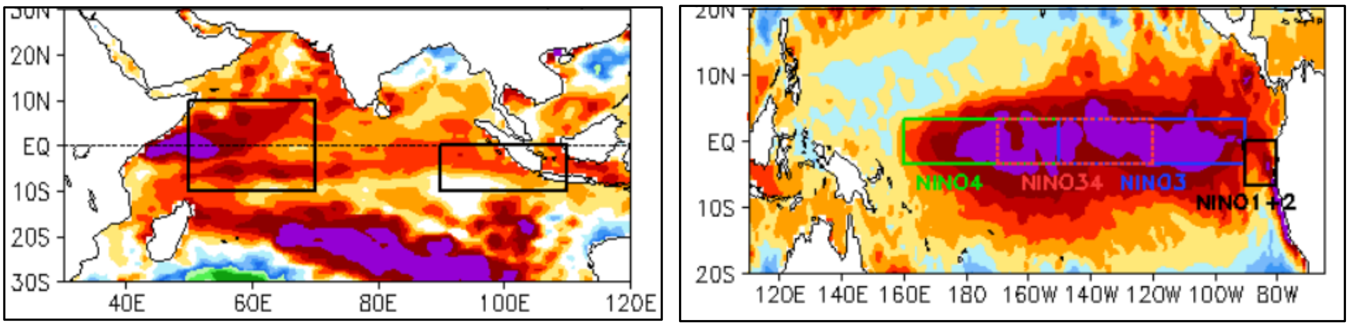

Figure 14: Blocks used to calculate the Indian Ocean Dipole (IOD) mode in the Indian Ocean (left) and the El Niño and La Niña indices in the Pacific Ocean (right).