STATE OF MALAWI CLIMATE IN 2023

MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE
Department of Climate Change and Meteorological Services

WORLD METEOROLOGICAL ORGANIZATION

CREWS CLIMATE RISK & EARLY WARNING SYSTEMS

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The State of Malawi Climate in 2023

Department of Climate Change and Meteorological Services

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Foreword

Malawi has in the past nine years witnessed extreme weather and climatic events, from heavy rains resulting in floods to prolonged dry spells, and very wet seasons to drought. Impacts of climate change and climate variability have been largely felt in all climate sensitive socio-economic sectors. Devastating impacts of weather ranging from heat-wave of October 2019, the tropical cyclones Idai and Kenneth in 2019, Anna and Gombe in 2022, and Freddy in 2023 have aroused significant interest among the population, climate dependent institutions and sectors to know more about weather and climate. These and other many weather-related events have made news headlines and attracted a lot of media attention both locally and internationally.

There is now a growing demand for climate information as well as evidenced increase in the uptake of weather updates and related climate information. The need to integrate climate information in sectors' plans speaks for itself. With the growing need to enhance the resilience of Malawi's communities, infrastructure and services to negative impacts of climate change and variability, relevant government institutions, non-governmental organizations and development partners that supports Malawi in resilience enhancement agree on the need to coordinate even better and have reliable impacts data and information to enable meaningful interventions.

The Ministry saw the need to start issuing the State of Climate in Malawi annually, the documentation that contains detailed summaries of performance of a season by considering the spatial and temporal variation and distribution of key weather parameters such as precipitation and temperatures. Variations of these are explained and connected to the impacts that they caused.

The 'State of Malawi Climate in 2023' has been produced with the aim of presenting and summarizing the 2023 climate on monthly basis, single out extreme weather events by comparing with the long-term climatic averages of 1991-2020 that define the climate of Malawi. In addition, the document has also detailed how the weather extremes in the year impacted various social and economic sectors.

The development of the 'State of Malawi Climate in 2023' has involved analyzing 2022-2023 rainfall records and 2023 records for the other weather parameters in comparison with 1991-2020 climatological normal. These are climatic records that are in custody of DCCMS. Monthly summaries have been produced and presented as maps and tables; extreme weather occurrences have been

highlighted and linked with sectoral impacts that resulted. Impacts details on various sectors were collected from responsible government institutions and the print and electronic media. Prevailing large scale circulation systems that influenced weather and climate in 2023 have also been presented.

It is expected that the 'State of Malawi Climate in 2023' document will help institutions involved in adaptive capacity building for a resilient Malawi to weather and climate change impacts to ably relate weather and climate to impacts, thereby enabling well informed interventions. The success of this also calls for enhanced data collection, records management and information sharing by institutions that work in climate sensitive sectors.

Yusuf Mkungula, PhD

Secretary for Natural Resources and Climate Change

Preface

In 2023, a series of severe events took place, notably Tropical Cyclone Freddy that led to widespread flooding and mudslides that impacted more than 2.2 million people in Southern Malawi. This disaster struck at a difficult time, as Malawi was in the process of recovering from the effects of Tropical Storm Ana and Tropical Cyclone Gombe, which had caused significant damage to the same districts in the south of the country.

This 'State of Malawi Climate in 2023' report provides a snapshot of how 2023 season performed. The 2022/2023 rainfall season started very slowly, with many areas registering below-normal rainfall during the October-November-December sub-season. The northern part of the country experienced moderate to severely drier conditions than normal during this sub-season.

However, the season picked up along the way and registered above-normal rainfall during the January-February-March sub-season. By February, the crop stand was very promising until Tropical Cyclone Freddy hit Malawi in March 2023. The northern tip of Malawi also experienced prolonged dry spells in February, affecting crop production in the area.

The onset of the rainfall season was generally normal for the majority of southern and central areas of the country, with a slightly earlier onset for northern areas. Rainfall cessation was normal in many places, with the tailing off starting from southern Malawi from the third week of March 2023 and progressing northwards. Consequently, most areas of the country experienced a normal length of the season.

An examination of the mean, maximum, and minimum temperatures in 2023 shows that the southern and central regions experienced slightly higher temperatures than the historical average, both in summer and winter months. Conversely, the northern and southeastern areas of Malawi saw temperatures that were lower than the usual norms in 2023. Extremely high temperatures were recorded in the Lower Shire, Southern Highlands, and lakeshore

areas. On average, the temperature anomaly for the country was +0.7°C higher than the long-term average.

The Department of Climate Change and Meteorological Services acknowledges and sincerely appreciates the continued collaboration with various stakeholders and partners. The Department will continue to improve its services to the general public and beyond in order to fulfil its mandate of monitoring and predicting weather and climate, thereby contributing to the socio-economic development of the country.

Lucy Mtilatila, PhD

Director of Climate Change and Meteorological Services

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Abbreviations

APES	Agriculture Production Estimate Survey
CAB	Congo Air Boundary
DCCMS	Department of Climate Change and Meteorological Services
DMI	Dipole Mode Index
DoDMA	Department of Disaster Management Affairs
EGENCO	Electricity Generation company
ENSO	El Niño and Southern oscillations
FEWS NET	Famine Early Warning Systems Network
IOD	Indian Ocean Dipole
IPC	International Phase Classification
ITCZ	Inter-Tropical Convergence Zone
LEAD	Leadership for Environment and Development
JFM	January, February, March
MASL	metres above sea level
MDF	Malawi Defence Force
MJO	Madden-Julian Oscillation
MT	Metric Ton
MW	Mega Watts
NWRA	National Water Resources Authority
OND	October, November, December
SPEI	Standardized Precipitation Evapotranspiration Index
SST	Sea Surface Temperature
TC	Tropical Cyclone
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Key Messages

The October-November-December sub-season of 2022 was drier than normal, while the January-February-March sub-season of 2023 was above normal.

Though the rainfall season started slowly, the distribution of rainfall was fairly good over many places especially Central and Northern areas.

Flooding that came with Tropical Cyclone Freddy towards the end of the season destroyed what would have been a good agricultural harvest in the Southern Region districts.

Tropical cyclone Freddy produced an extraordinary intensity of rainfall reaching 159mm/hour on 14 March at Nkhulambe in Phalombe. The 4-day cumulative rainfall of 1078mm exceeded the station's total annual rainfall.

At least 2.2 million people were affected by Tropical Cyclone Freddy of whom 659,278 were displaced in 14 District councils.

In summary, a total of MWK147.8 billion is required to recover and reconstruct the damages and losses caused by tropical cyclone Freddy.

On average, annual mean temperature in Malawi was about +0.7°C warmer than the 1991 to 2020 average.

The hottest months of September and October had the highest positive anomalies

Chapter one

1.0. Background Information

Malawi is a landlocked country in southeastern Africa with a total area of 118,484 km² and a population of over 18 million. Approximately a quarter of the country is covered by water, with Lake Malawi encompassing 29,600 km² of its territory. The lake lies within the Great Rift Valley, which traverses Malawi from north to south. The topography of Malawi is heavily influenced by the Rift Valley, characterized by high plateaus and mountains to the west and north of the valley. South of Lake Malawi, the landscape is dominated by the Shire Highlands and mountain ranges. The highest elevation in Malawi is Sapitwa on Mulanje Mountain, reaching slightly over 3000m above sea level. The lowest elevation is found in the southernmost part of Malawi, in the lower Shire valley, with an elevation just below 50m above sea level.

1.1 Climatic Conditions

1.1.1 Temperature and Rainfall Patterns

The climate in Malawi is subtropical, characterized by one rainfall season that occurs during the southern hemisphere summer. Annual precipitation ranges between 700 and 2,500 mm, with approximately 95% of the precipitation falling during the warm-wet season from November to April. The winter season falls between May and August, with mean temperatures varying from 17 to 27°C and lowest temperatures ranging between 4 and 10°C. Winters are generally dry, with occasional rains, particularly in high-lying areas. Temperatures begin to rise in September and October, with average temperatures exceeding 25°C. The climate of Malawi is significantly influenced by its topography.

1.1.2 Extreme Weather Events

Malawi is prone to extreme weather events such as floods, droughts, and occasional tropical cyclones. These events have devastating effects on communities, infrastructure, and the economy. Floods often result in displacement, loss of infrastructure and lives, and destruction of crops, while droughts exacerbate food insecurity and strain water resources.

The agriculture sector in Malawi is highly susceptible to climate variations. Erratic rainfall and temperature changes affect crop growth cycles leading to reduced yields and food insecurity. Maize, the staple crop, faces significant challenges due to climate-induced stresses, impacting the nation's food supply.

Access to clean water is a critical concern exacerbated by climate change. Droughts diminish water sources, affecting both agricultural practices and human consumption. Additionally, increased variability in rainfall patterns strains water availability, especially in rural areas where communities rely on surface water for domestic use.

Malawi's rich biodiversity, including diverse flora and fauna, is under threat due to changing climate patterns. Loss of habitat, altered rainfall patterns, and temperature fluctuations impact ecosystems and endanger various species, threatening the country's ecological balance.

Chapter Two

2.0. Observed weather and climatic parameters analysis

2.1 Rainfall

The rainfall season monitoring in Malawi officially runs from October to April. In recent years, the characteristics of the season have been changing, including the onset, cessation, rainfall intensity, spatial and temporal distribution, as well as the occurrence of extreme rainfall events.

2.1.1 Seasonal rainfall distribution

The onset of the 2022/2023 rainfall season was generally normal for the majority of southern and central areas of the country, with a slightly early onset for northern areas as shown in Figure 1a. The planting rains began in the second dekad of November 2023 for the southern highlands and Mchinji, with the majority of southern and central areas experiencing onset from the third dekad of November 2023, and eventually reaching northern areas and the Shire Valley in the first dekad of December 2023. The cessation of rainfall was normal for the majority of areas in the country, with the tailing off starting from southern Malawi in the last dekad of March 2023 and progressing northwards, as depicted by the map in the middle of Figure 1b. n terms of seasonal length, the majority of areas experienced a season ranging from 110 to 130 days, which is generally considered normal, as depicted by the map on the right side of Figure 1c.

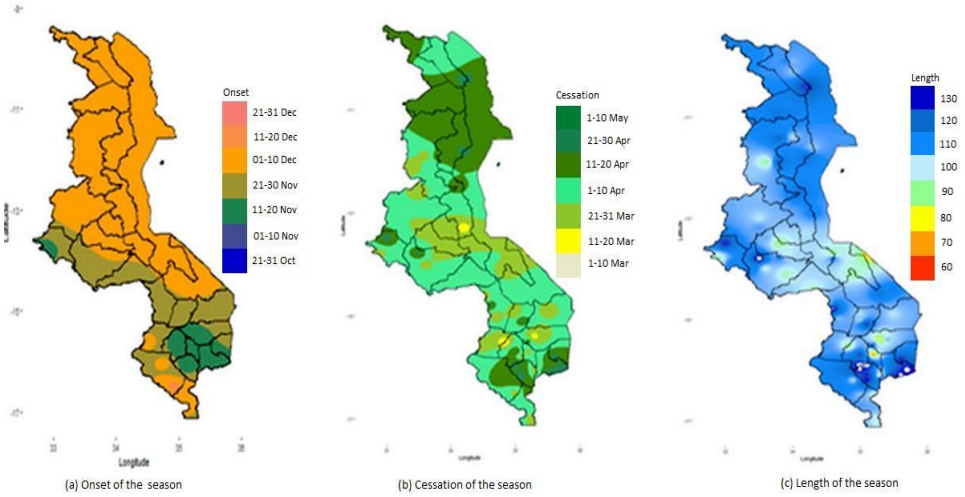


Figure 1:2022/23 seasonal onset (a), cessation (b) and length (c)

In terms of rainfall distribution, normal to below-normal rainfall amounts were observed during the October-November-December (OND) sub-season over the majority of areas. However, there were areas in central and southern lakeshore where rainfall was normal to above-normal, as shown in Figure 2a.

During the January-February-March (JFM) sub-season, above-normal rainfall conditions were experienced over southern areas, while central and northern areas observed normal to above-normal conditions, as depicted by the map in Figure 2b. This pattern was largely influenced by Tropical Cyclone Freddy in March 2023. However, some parts of Karonga, a district in northern Malawi, experienced normal to below-normal conditions.

In summary, the country experienced generally normal to above-normal rainfall conditions. However, below-normal conditions were recorded in northern areas such as Chitipa and Karonga, as shown in Figure 2c.

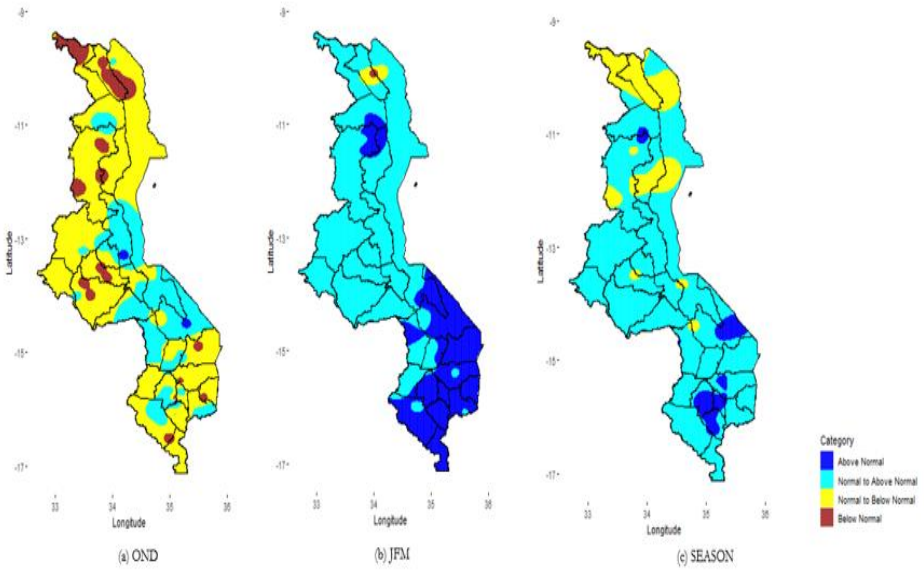


Figure 2: Performance of rainfall in the sub-season of October-November-December (OND) - a , January-February-March (JFM) - b and the whole Season – c as a percentage of normal

2.1.2 Monthly rainfall distribution

The month of October experienced below-normal rainfall amounts throughout the entire country. In November, below-normal rainfall was experienced in northern and Shire Valley areas, whereas normal to below-normal rainfall amounts were observed in some central areas, southern lakeshore areas, as well as the Shire Highlands (see Figure 3b).

The rainfall situation further improved in December. Most areas of southern Malawi and the central lakeshore experienced normal to above-normal rainfall amounts. Normal to below-normal rainfall amounts were observed over northern and most central areas, as well as in Nsanje district (see Figure 3c)

Wet conditions continued during the month of January, with normal to above-normal conditions observed over the majority of areas in the country. Specifically, Mzimba, Rumphi, and Nkhata Bay experienced extremely wet conditions, receiving above-normal rainfall in January, as illustrated in Figure 3d

In February, generally normal to above-normal rainfall amounts were experienced over the majority of areas in the country, with isolated cases of normal to below-normal rainfall amounts, as shown in Figure 3e.

In March, extremely wet conditions were observed over the southern and central areas of the country. However, Karonga district in the north experienced normal to below-normal rainfall amounts, as shown in Figure 3f.

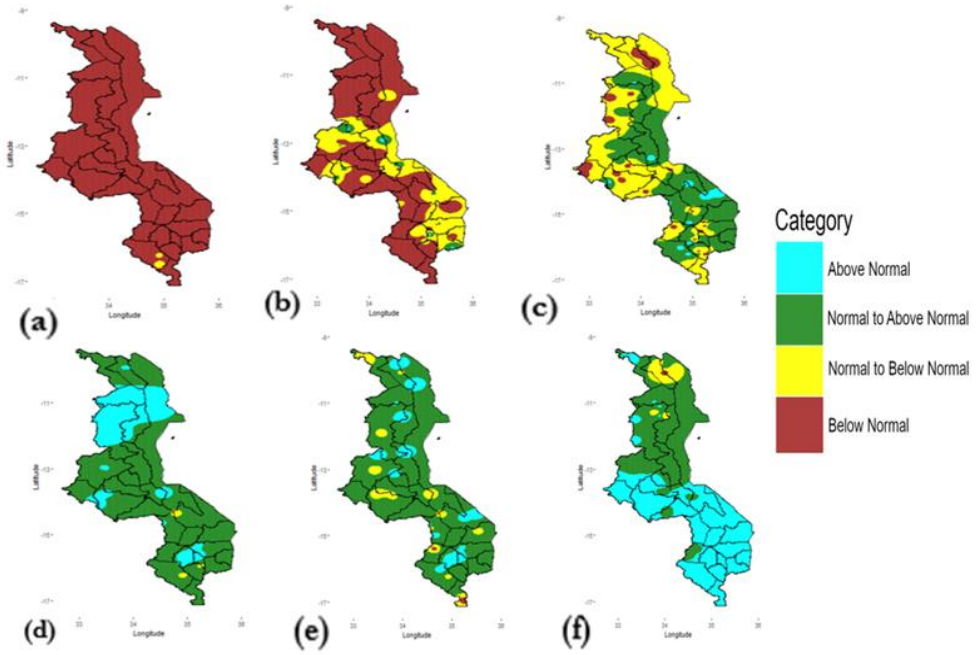


Figure 3: Monthly rainfall distribution as percentage of normal (a) October, (b) November, (c) December, (d) January, (e) February and (f) March

2.1.3 Cumulative rainfall

Cumulative rainfall analysis has been used to characterize observed rainfall performance and trends in different areas of the country. Cumulative rainfall

departure from the long-term average provides an indication of either insufficient or abundant rainfall during the season. On average, the cumulative rainfall plots for 2022-2023 indicate that most parts of the country received normal to above-normal rainfall amounts compared to the long-term average.

During the 2022-2023 season, the accumulated rainfall for the following stations—Makoka, Dedza, Chitedze, Ngabu, Mzimba, and Karonga—was below the long-term mean of 1991-2020, as shown in Figure 4. However, towards the end of the season in March, the 2022-2023 rainfall accumulation became above the average at Ngabu and Makoka stations, mainly due to the influence of Tropical Cyclone Freddy.

The accumulated rainfall amounts for Salima, Chileka, Bolero, and Mimosa during the 2022-2023 season were similar to the mean during the OND sub-season. However, thereafter, the 2022-2023 season became above normal at Chileka and Salima, while it was below normal at Bolero and Mimosa, as shown in Figure 5.

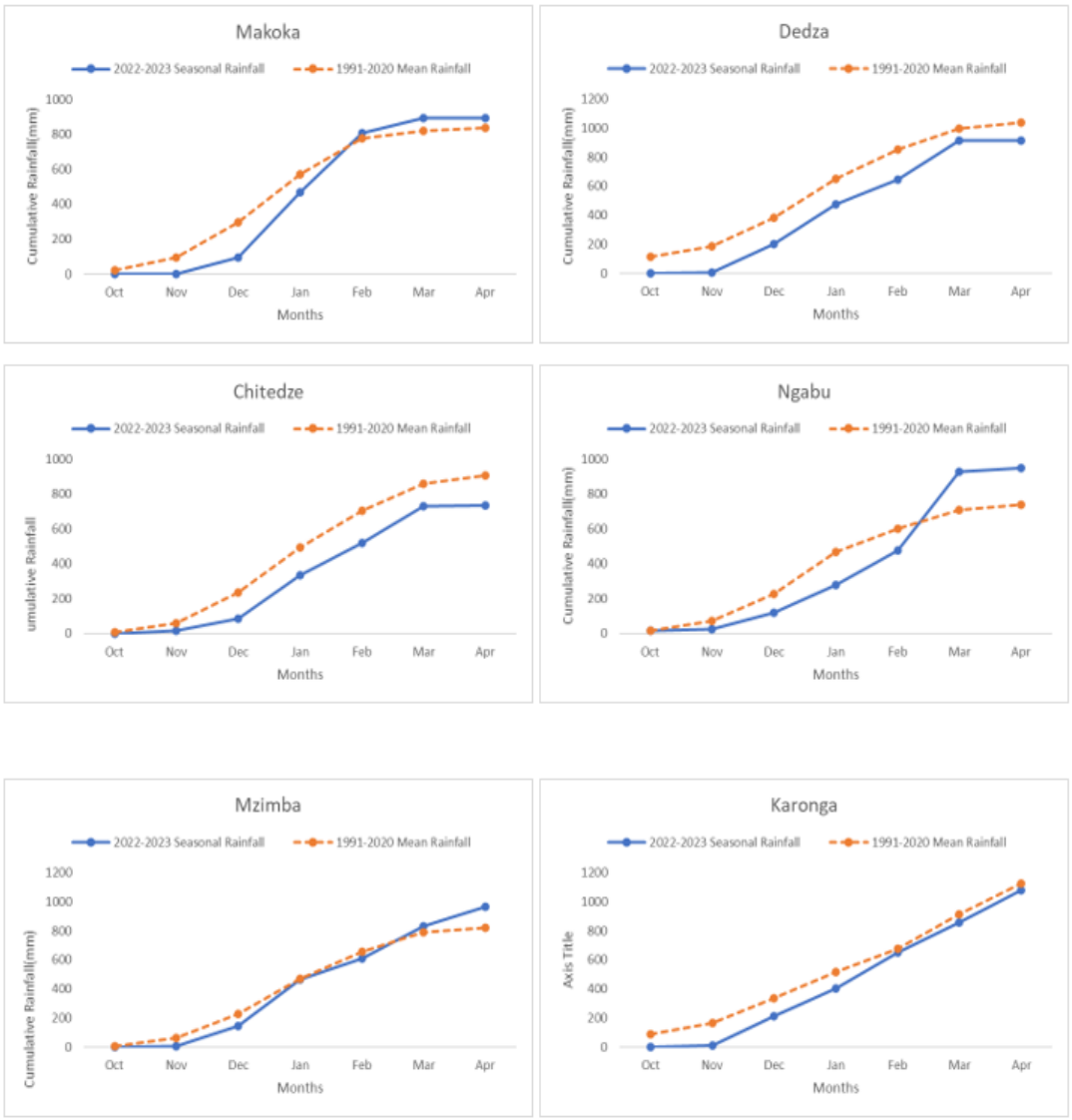


Figure 4: The cumulative rainfall for Makoka, Dedza, Chitedze, Ngabu, Mzimba, and Karonga stations for 2022-2023 season versus 1991-2020 mean

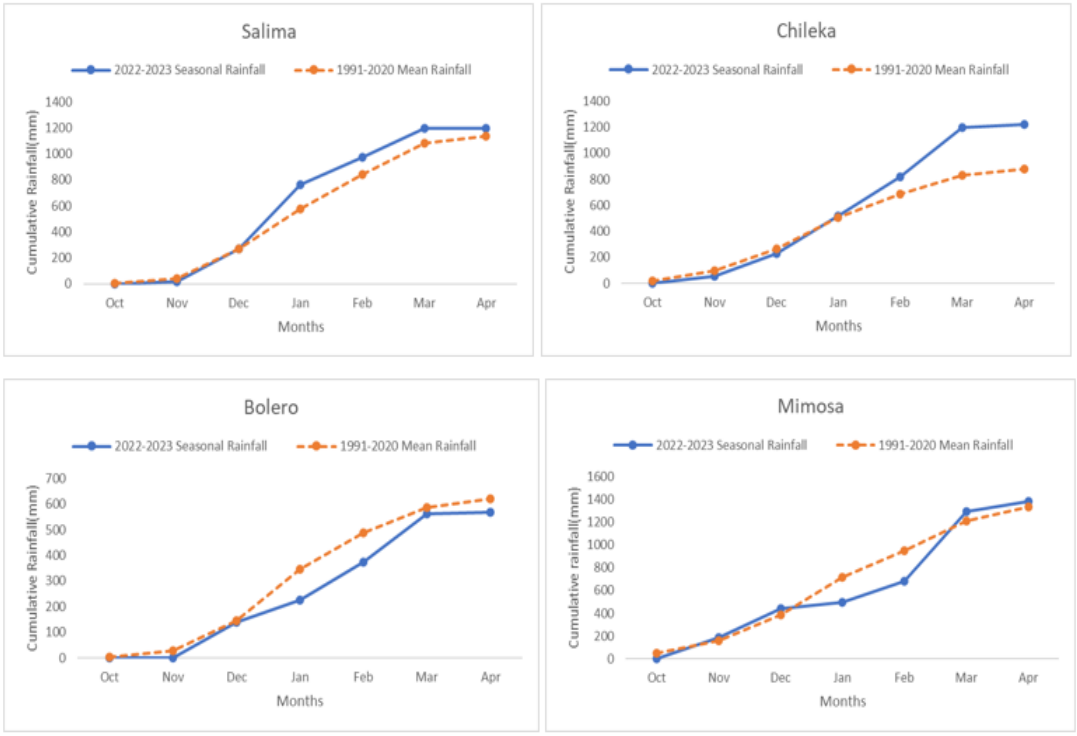


Figure 5: Cumulative rainfall for Salima, Chileka, Bolero, Mimosa stations for 2022-2023 season versus 1991-2020 mean

2.2 Temperature

The temperature analysis for mean, maximum, and minimum values in 2023 indicates that southern and central areas experienced warmer temperatures than the long-term average during both summer and winter months. However, some northern and south-eastern areas experienced cooler temperatures than normal, showing a negative departure from the average. In 2023, there were also instances of extreme high temperatures. For example, on October 14th, 2023, Ngabu recorded a temperature of 44.6°C, while Chileka recorded 40.1°C. Conversely, extreme low temperatures of 6.0°C were recorded in June and July in Mzuzu in the north, as well as in Dedza and Kamuzu International Airport in the central areas of Malawi.

2.2.1 Annual Mean Temperature

Compared to the long-term average temperatures from 1991 to 2020, most areas experienced warmer conditions in 2023, with a positive anomaly ranging between 1°C to 2°C, as shown in Figure 6. Some places, such as Nkhatabay and Thyolo, showed even higher increases, with a positive anomaly as high as 3°C. However, the northern tip of Malawi experienced cooler weather conditions compared to the long-term average, with temperatures being 1°C below the long-term average. On average, the annual mean temperature in Malawi was about +0.7°C warmer than the 1991 to 2020 average.

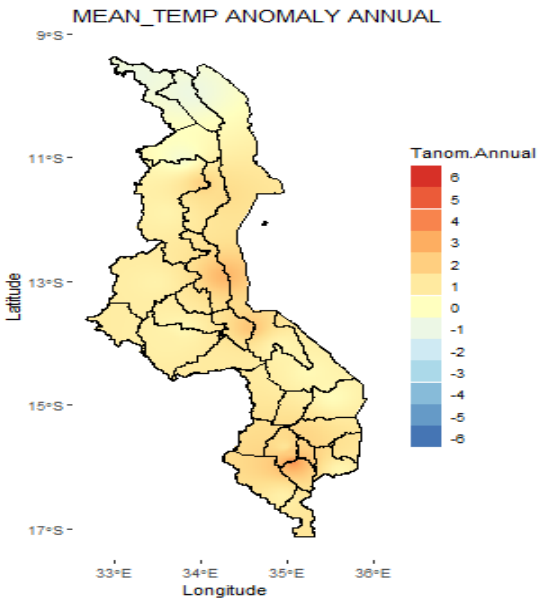


Figure 6: Observed annual mean temperature anomaly for Malawi in 2023

2.2.2 Annual Maximum Temperature

Most areas recorded temperatures exceeding normal levels by up to 3°C as in Figure 7. Stations like Ngabu and Chileka witnessed extreme highs, reaching 44.6°C and 40.1°C in October, respectively. Mangochi also experienced scorching heat, with maximum temperatures reaching 39.2°C during the same month. The warming trend was particularly noticeable at the Bvumbwe station, with an annual maximum anomaly of 4.0°C.

In contrast, the northern tip of Malawi experienced cooler temperatures than normal, with an anomaly ranging from -1 to -2°C compared to the 1991-2020 long-term average maximum temperatures

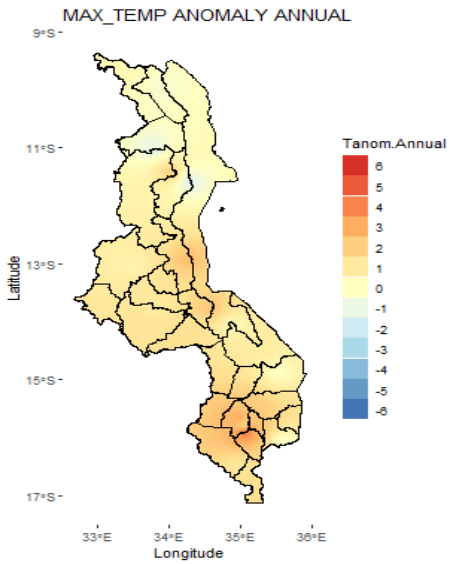


Figure 7: Observed annual maximum temperature anomaly for Malawi in 2023

2.2.3 Annual Minimum Temperature

The nights in Malawi exhibited warmer than average temperatures during the period under analysis. Notably, areas surrounding certain northern and central lakes, such as Nkhata Bay and Nkhotakota, experienced temperatures over 4°C higher than the long-term average from 1991 to 2020. Additionally, the southern highlands, particularly Bvumbwe and the surrounding areas, saw significant warming, with nighttime temperatures approximately 2°C above historical averages. However, in a departure from this trend, the northernmost tip of Malawi, specifically Chitipa, recorded cooler nights, with temperatures falling 1-2°C below the long-term average.

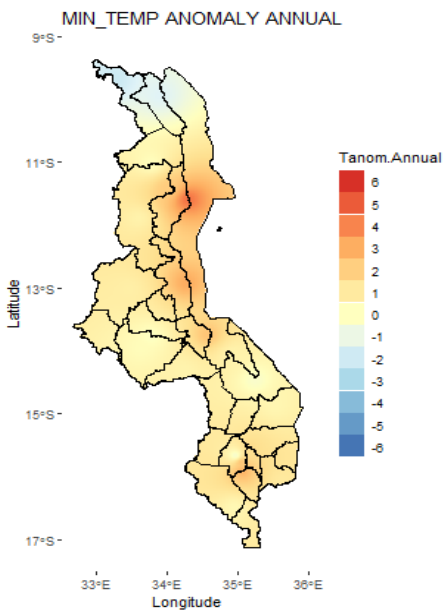


Figure 8: Observed annual minimum temperature anomaly for Malawi in 2023

2.2.4 Monthly Mean Temperature

The northernmost area of Malawi consistently experienced cooler nights throughout most of the year, as indicated by negative anomalies in Figure 9. However, October stood out as the sole exception, with slightly warmer nights observed during that month.

The rest of the country encountered a warm year, with temperatures surpassing the long-term average by 2-4°C from June to November. Notably, September and October emerged as the hottest months across most areas. Furthermore, the southern areas, particularly the Shire Valley, consistently experienced warmer nights compared to the average, except for March.

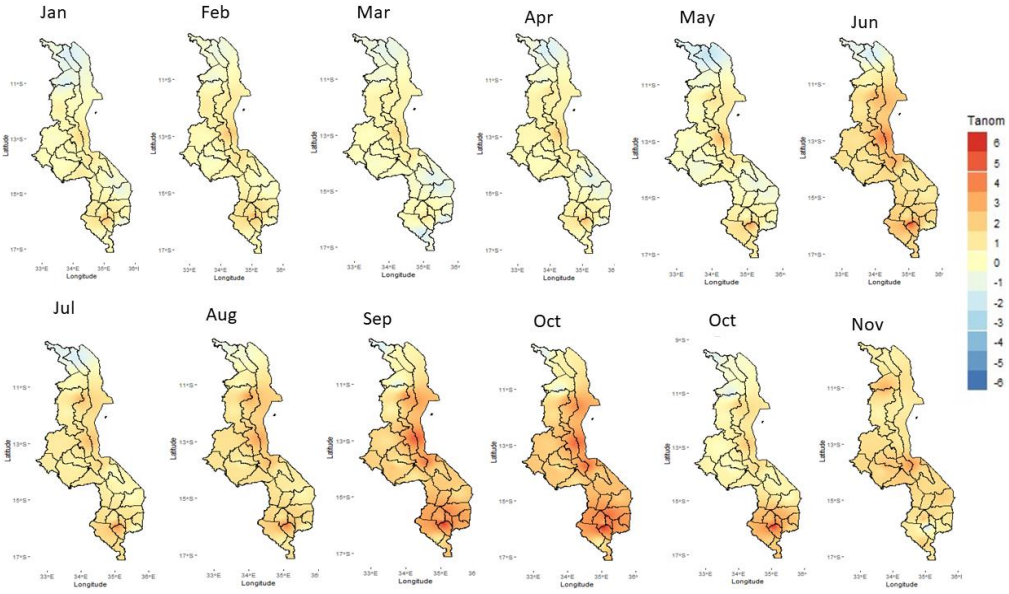


Figure 9: Observed monthly average temperature anomaly for Malawi in 2023

2.2.5 Monthly Maximum Temperature

Southern and central Malawi generally encountered warmer temperatures compared to the average, as evidenced by the positive anomalies depicted in Figure 10. This warming was most prominent during the hottest months (September, October, and November) with anomalies ranging from 3°C to 4°C above average. Notably, Bvumbwe recorded exceptionally high temperatures in July, exceeding the long-term mean by 7.0°C. Similarly, stations like Chileka, Salima, and Makoka observed significant positive anomalies in October (6.1°C, 4.4°C, and 5.5°C, respectively). However, Bvumbwe deviated from the trend in September, October, November, and December, registering cooler than normal maximum temperatures with anomalies between -2°C and -4°C.

Conversely, the northern and southeastern parts of the country witnessed cooler than average maximum temperatures during the early months of the year (January, February, March, and April). The most significant negative anomalies occurred in March at Mimosa and Ntaja, reaching -3.3°C and -2.8°C, respectively.

While most northern regions experienced anomalies of -1°C to -2°C, central and southern areas maintained slightly positive anomalies (1.0°C) during these months.

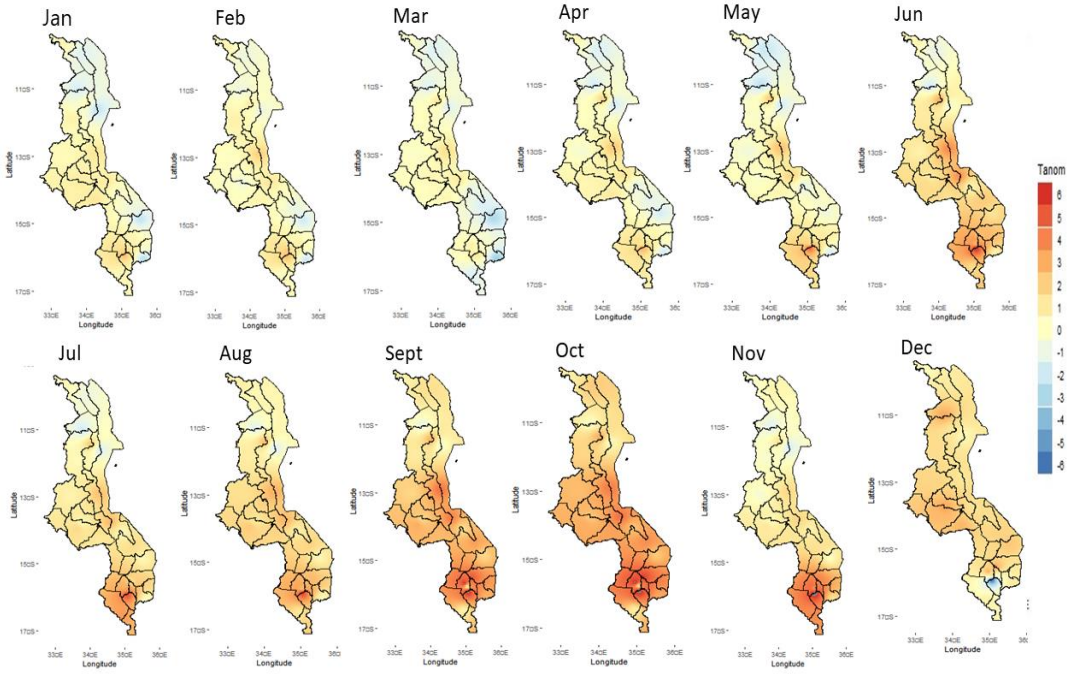


Figure 10: Observed monthly maximum temperature anomaly for Malawi in 2023

2.2.6 Monthly Minimum Temperature

Throughout the country, higher than average minimum temperatures were observed, with the exception of Chitipa District in the northernmost part of Malawi. Chitipa's minimum temperature anomaly ranged from -1°C cooler in January, February, and March to -3°C in May, June, and July, during the winter months.

The highest positive departures from normal were observed over Nkhata Bay and Nkhotakota in the Northern and Central lakeshore regions, as well as Bvumbwe in the southern highlands. From July to October, Nkhata Bay and Nkhotakota were approximately 5 to 6°C warmer, while Bvumbwe registered about 3°C higher than usual temperatures from June to November 2023, as depicted in Figure 11. The lakeshore and southern highlands were the warmest areas.

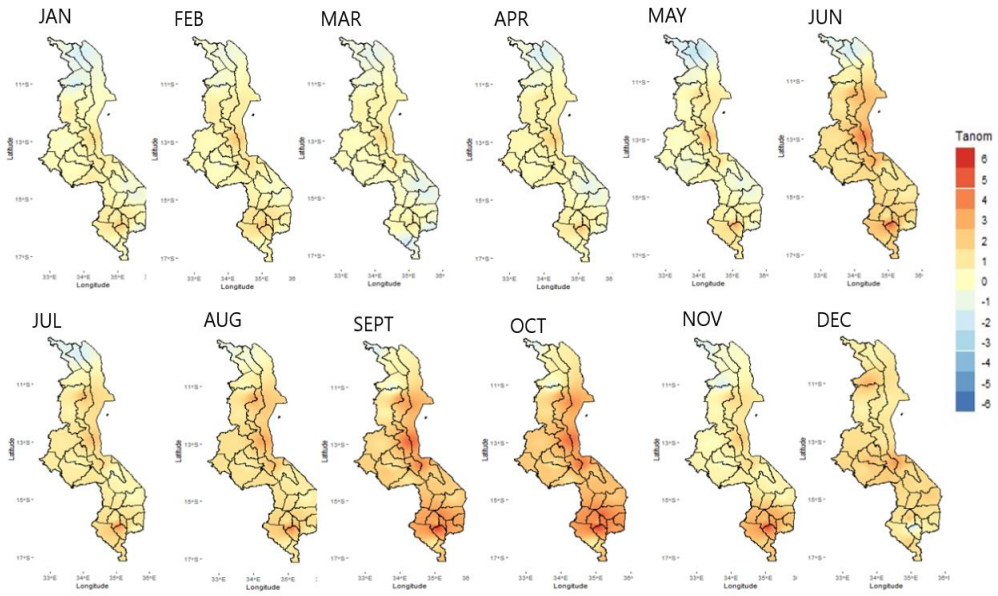


Figure 11: Observed monthly minimum temperature anomaly for Malawi in 2023

Chapter Three

3.0. Extreme weather and climatic events

3.1 Standardised Precipitation Evapotranspiration Index (SPEI)

The standardized precipitation evapotranspiration index (SPEI) serves as a drought index, offering a means to assess and monitor drought conditions across various time scales. The SPEI takes both precipitation and potential evapotranspiration (PET) into account to evaluate drought.

Using precipitation and air temperature data spanning from 1991 to 2023 from 21 meteorological stations across Malawi, drought indices were computed. Figure 12 represents results for 1-month SPEI index from October 2022 to March 2023. In October 2022, southern areas of Malawi experienced near-normal drought conditions, while the majority of the northern region faced moderate to severe drought. Drought conditions persisted in November 2022, leading to a delayed onset of rainfall across the country, with most areas experiencing moderate to severe drought. December 2022 saw a return to normal rainfall in the majority of Malawi, marking a shift in weather patterns. Overall, the OND sub-season was characterized by dry weather conditions.

Moving into the JFM sub-season of 2022-2023 season, most areas of the country witnessed generally near-normal to wet conditions. However, some districts, including Zomba, Phalombe, Mulanje, and Rumphi, experienced pockets of dry spells in January. Moderate-intensity dry spells affected some parts of Chitipa during February. Notably, southern areas of Malawi encountered extremely wet conditions, attributed to the influence of Tropical Cyclone Freddy.

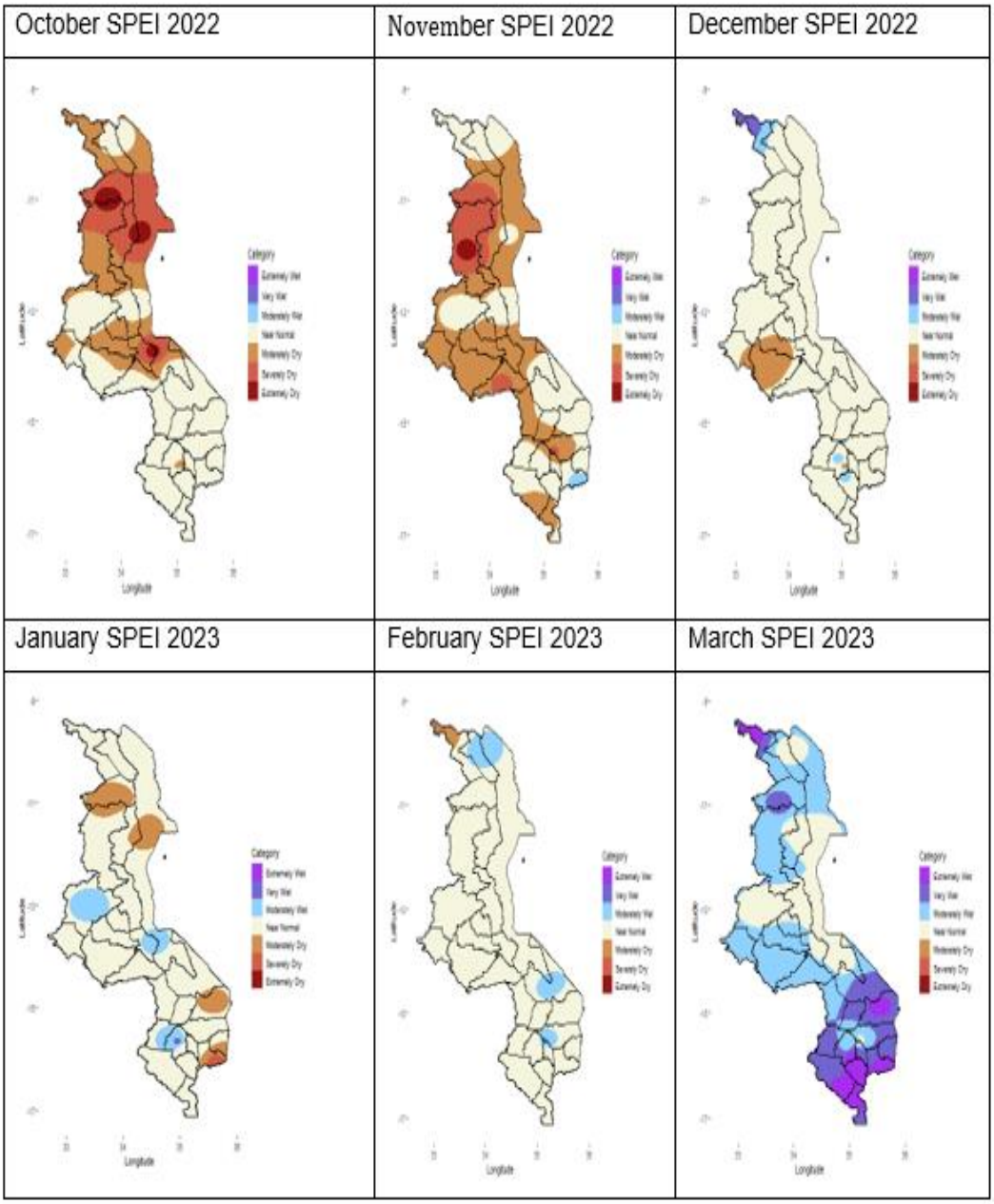


Figure 12: Observed Monthly standardised precipitation and evapotranspiration index (SPEI) for Malawi in 2023 during the rainfall season based on 1-month analysis

3.2 Extreme rainfall and flood events

Between November and December, the highest 24-hour rainfall was 126mm which was recorded at Mimosa. During this period, a range of severe weather conditions, including storms, heavy rains, floods, strong winds, hailstorms, and lightning, affected a total of 9,321 households (approximately 41,944 people) in various districts including Balaka, Chikwawa, Chiradzulu, Chitipa, Dedza, Dowa, Karonga, Kasungu, Lilongwe District, Machinga, Mangochi District, Mchinji, Mulanje, Mzimba, Mzuzu City, Neno, Nkhotakota, Nsanje, Ntcheu, Ntchisi, Phalombe, Salima, Thyolo, and Zomba. Significant damages to homes, roads, schools, and hospitals were also reported.

Moving into January to March, Malawi experienced exceptionally high rainfall amounts, particularly during the period when the country was impacted by Cyclone Freddy. Most weather stations reported breaking record values within a three-day period, significantly surpassing monthly averages, and in some cases, even exceeding annual rainfall totals. Tropical Cyclone Freddy led to a significant meteorological event, marked by an exceptional intensity of rainfall reaching as high as 159 mm/hr on March 14th in specific areas of the southern region, including Nkhulambe in Phalombe and Chididi in Nsanje. On that day, most stations reported heavy rains with intensities ranging between 30mm/hr to 90mm/hr. Notably, most stations reported extreme rainfall for three consecutive days, with Nkhulambe in Phalombe district recording 241mm on March 12, 458.6mm on March 13, and 363.2mm on March 14. The cumulative value for 4 days was 1078mm, exceeding the station's typical annual rainfall total. Figure 13 depicts the cumulative rainfall over southern Malawi from the 11th to the 14th of March. This figure illustrates the specific areas that experienced peak rainfall. In contrast, Figure 14 provides a visual breakdown of the rainfall distribution throughout the four-day period.

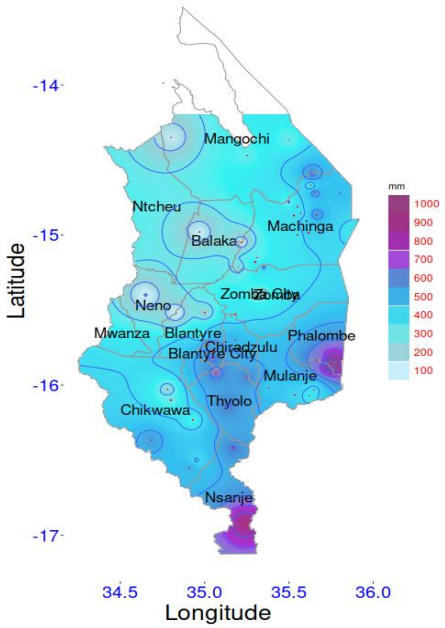


Figure 13: Cumulative rainfall over southern Malawi during Tropical Cyclone Freddy

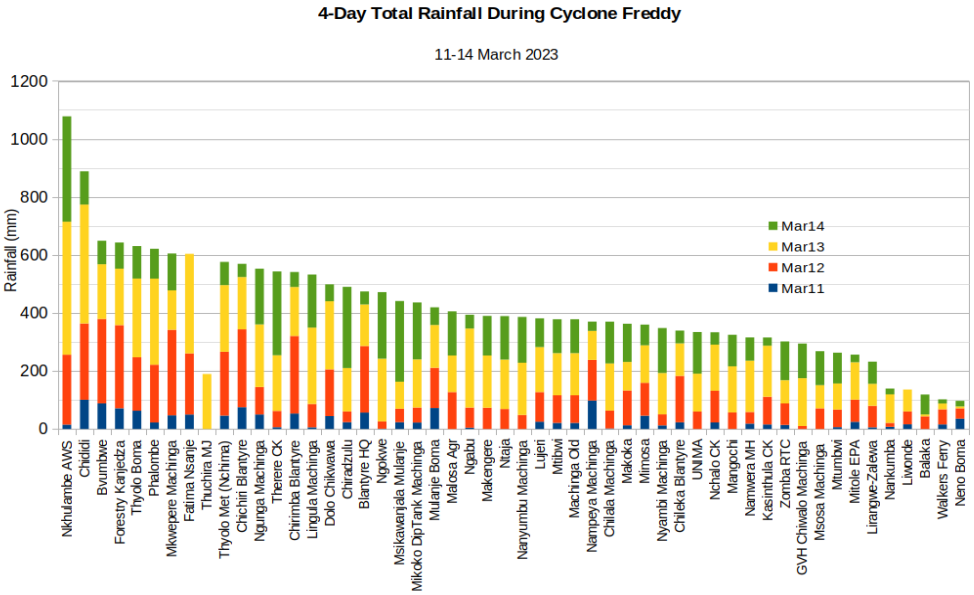


Figure 14: 4-Day Cumulative Rainfall During Tropical Cyclone Freddy

The intense rainfall triggered devastating floods, landslides, and mudslides in numerous districts of southern Malawi. The resulting deluge posed immediate challenges, as local drainage systems were overwhelmed. Addressing such

meteorological extremes requires a focused technical response and strategic planning to mitigate potential hazards and strengthen the resilience of local infrastructure against the severe impacts of intense rainfall, as illustrated in Figures 13 and 14 above.

Figure 15: Flooding in Nsanje, on March 16, 2023. Image courtesy of Malawi Red Cross Society

The region experienced severe consequences from these catastrophic events, significantly affecting lives, livelihoods, and the socio-economic structure, resulting in heightened poverty levels. The country experienced 679 fatalities and over 537 went missing who may be presumed dead (DoDMA, 2023). The floods and the mudslides brought extensive damage to infrastructure, including roads, bridges, power supply, and irrigation systems, and also caused communities' suffering and more harm as shown in the Figures 15 and 16. Additionally, crops in the maturation stage were adversely affected, and certain districts endured power supply disruptions lasting for over three days.

Figure 16: People wading in the mudslides during Cyclone Freddy in southern Malawi. Photo: WFP/Francis Thawani

3.3 Extreme temperature events

In the context of climate change, the frequency of extreme temperature events is expected to increase. Heat stress resulting from high temperatures significantly impacts the health of vulnerable populations. In Malawi, high temperatures are normally anticipated, particularly during the summer months from October to January.

The summer of 2023 was characterized by isolated cases of extreme heat events, with some areas experiencing temperatures exceeding 40°C. In Chikwawa, for instance, the Ngabu meteorological station recorded temperatures that were 7.2°C and 5.8°C warmer than the long-term average for the months of October and November 2023, respectively.

Hot to very hot temperatures were also recorded at meteorological stations in Mangochi and Blantyre. For example, Chileka in Blantyre recorded 38.6°C on 25th October. Generally, most of the weather stations in Malawi registered very high temperatures in the range of 35.0 to 37.6°C between October and November. Heatwave warnings were issued twice in 2023, in October and December. During

these periods, temperatures exceeded the mean temperature by more than 6°C. On average, the annual maximum temperature was +0.9°C warmer than the long-term average.

The number of very hot days, defined as days with maximum temperatures exceeding 37°C, was 46 in Chikwawa (Ngabu), 29 in Mangochi, 9 in Lilongwe (KIA), and 8 in Nkhatabay. Reports from the Leadership for Environment and Development (LEAD) automatic weather station at Mulunguzi in Zomba, as reported by Prof. Chiotha, indicate that the number of days with maximum temperatures above 30°C was 25 days in December, compared to 9 days in 2022.

Although Malawi generally enjoys a warm tropical climate, there are sporadic cases of extreme cold temperatures experienced from May to August, which are considered the winter months. The lowest temperatures are typically observed in June and July.

During June and July 2023, the minimum temperature of 6°C was recorded at Kamuzu International Airport, Dedza, Mzuzu, and Rumphi. The number of cold nights, defined as nights where temperatures are below 11°C, was 19 in Lilongwe (KIA station), 20 in Mzuzu (Mzuzu Met), and 17 in Zomba (Makoka Met station).

Malawi, unaccustomed to such cold temperatures, faces health challenges as vulnerable groups like children and the elderly struggle to adapt to the drastic changes. Respiratory issues, cold-related illnesses, and discomfort become prevalent, adding strain to an already burdened healthcare system.

Chapter Four

4.0. Major drivers of weather and climate events in Malawi

Weather and climate in Malawi are influenced by a combination of local, regional, and global factors. These factors include topography, the lake effect of Lake Malawi, mean sea level pressure, surface and upper-level winds, and sea surface temperatures in the tropical Pacific, Indian, and Atlantic Oceans.

4.1 Observed Weather and Climate Drivers in 2023

Global factors, particularly sea surface temperatures across the Pacific, Indian, and Atlantic Tropical Oceans, play a significant role in shaping weather and climate events in Malawi. These oceanic temperatures contribute to large-scale atmospheric circulation patterns, such as the El Niño-Southern Oscillation (ENSO) in the Pacific Ocean and the Indian Ocean Dipole (IOD), which can influence rainfall patterns, temperatures, and other meteorological phenomena in Malawi. Additionally, global climate phenomena like the Intertropical Convergence Zone (ITCZ) and the movement of air masses also have a huge impact on weather patterns in Malawi.

4.1.1 The Sea Surface Temperatures (SSTs)

The state and fluctuations of Sea Surface Temperatures (SSTs) in the global oceans play a pivotal role in influencing worldwide weather and climate by modulating the general atmospheric circulation. The conditions of SSTs are instrumental in determining other significant factors that impact weather and climate events, such as El Niño Southern Oscillations (ENSO), Indian Ocean Dipole (IOD), and Madden-Julian Oscillation (MJO). The patterns of SSTs are linked to either increased or decreased rainfall over Malawi.

4.1. 1. 1 El Niño and Southern oscillations (ENSO)

The El Niño-Southern Oscillation (ENSO) is a climate phenomenon characterised by three phases: El Niño, Neutral, and La Niña. El Niño is the warming of the ocean surface, leading to above-average Sea Surface Temperatures (SSTs) in the central and eastern tropical Pacific Ocean. On the other hand, La Niña is the cooling phase, resulting in below-average SSTs in the same region. The Neutral phase signifies conditions that are neither El Niño nor La Niña, and it is mostly linked to SSTs in the Tropical Pacific Ocean that are close to average.

To categorize the ENSO phase, El Niño is declared when the average SST anomalies are greater than 0.5°C, La Niña when they are less than -0.5°C, and Neutral when the anomalies fall between -0.5 and 0.5°C. These thresholds help in identifying and characterizing the prevailing ENSO conditions.

The weather patterns in the year 2023 were influenced by La Niña until September when the ENSO switched to El Niño phase. The La Nina climatic phenomenon is historically known to bring increased rainfall to Southern Africa, including Malawi. The observation of the ENSO for historical data, including the year 2023, is depicted in Figure 17.

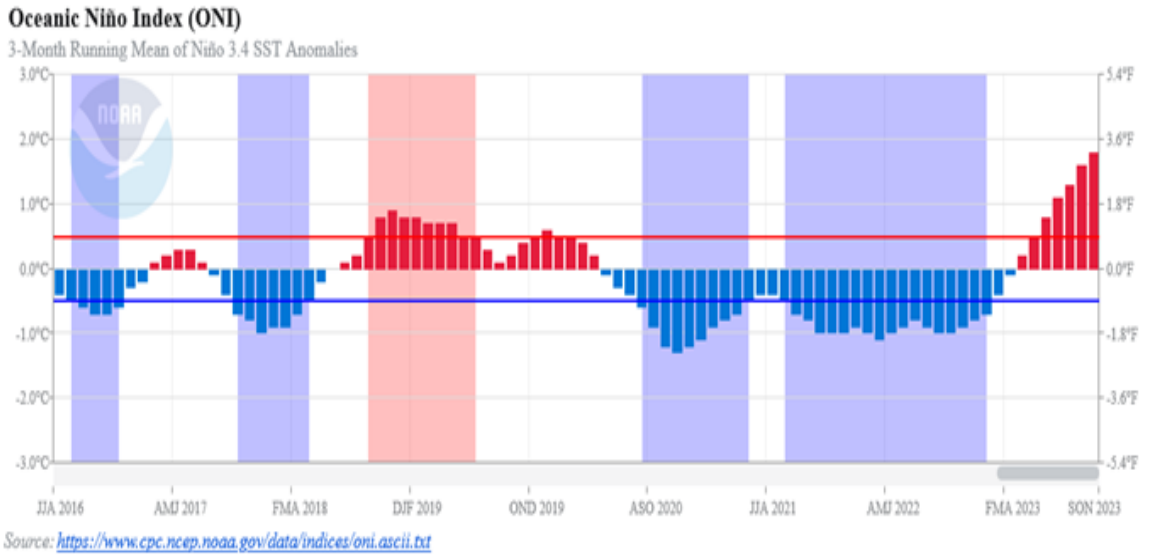


Figure 17: Observed Sea Surface Temperature anomaly for Nino 3.4 from 2016 to 2023 (NOAA, 2023)

4.1.1.2 Indian Ocean Dipole (IOD)

The Indian Ocean Dipole (IOD) is a recognized ocean-atmosphere coupled mode in the Indian Ocean that exerts a significant influence on the surrounding weather and climate events. This phenomenon is characterised by irregular oscillations of Sea Surface Temperature (SST) anomalies, wherein the western Indian Ocean alternately becomes warmer (positive phase) and then colder (negative phase) than the eastern part of the ocean. The IOD is considered negative when the Dipole Mode Index (DMI) is less than -0.4, and is positive when it is greater than +0.4, and Neutral when it falls between -0.4 and 0.4. These thresholds help in identifying and categorizing the different phases of IOD.

The year 2023 was influenced by a negative phase of IOD until September, and then transited to a positive phase until the end of the year as shown in Figure 18

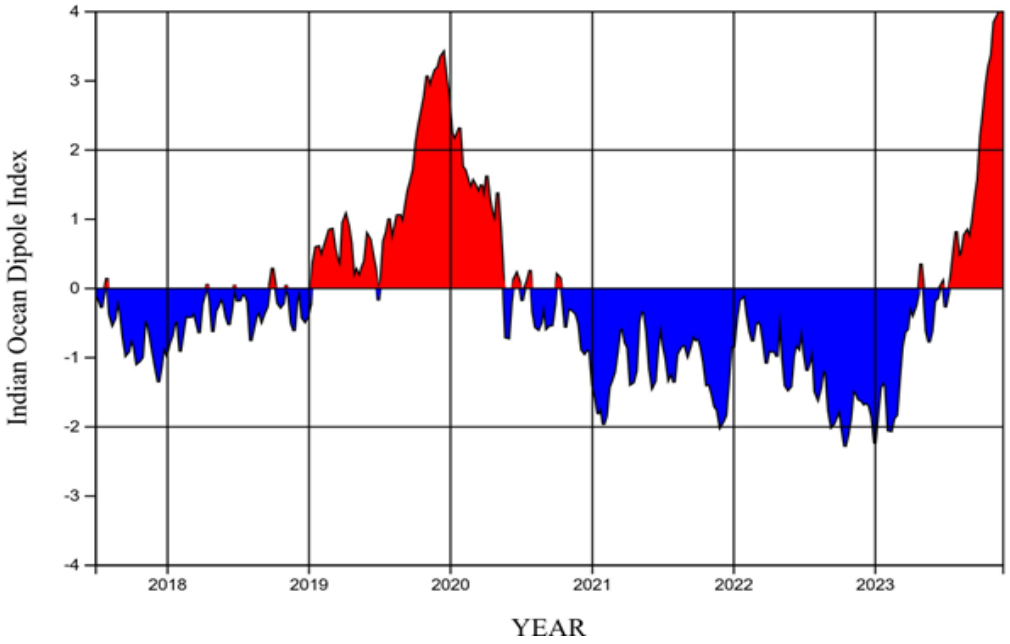


Figure 18: Observed Indian Ocean Dipole Index from 2018 to 2023 (NASA, 2023)

4.1.1.3 Madden-Julian Oscillation (MJO)

The Madden-Julian Oscillation (MJO) is a form of intra-seasonal atmospheric variability observed in tropical oceans. It can be characterized as an eastward-propagating disturbance that spans approximately 30–90 days. The passage of an active phase of the MJO is associated with an increase in tropical disturbances, while the inactive phase tends to suppress such disturbances over a region. Although the MJO is defined in the tropics, its effects extend beyond, reaching both tropical and mid-latitude regions.

In Southern Africa, the impacts of the MJO include alterations in the distribution of clouds, rainfall, and wind patterns. The MJO also plays a role in modulating monsoonal rains and enhancing the development of tropical cyclones in the region.

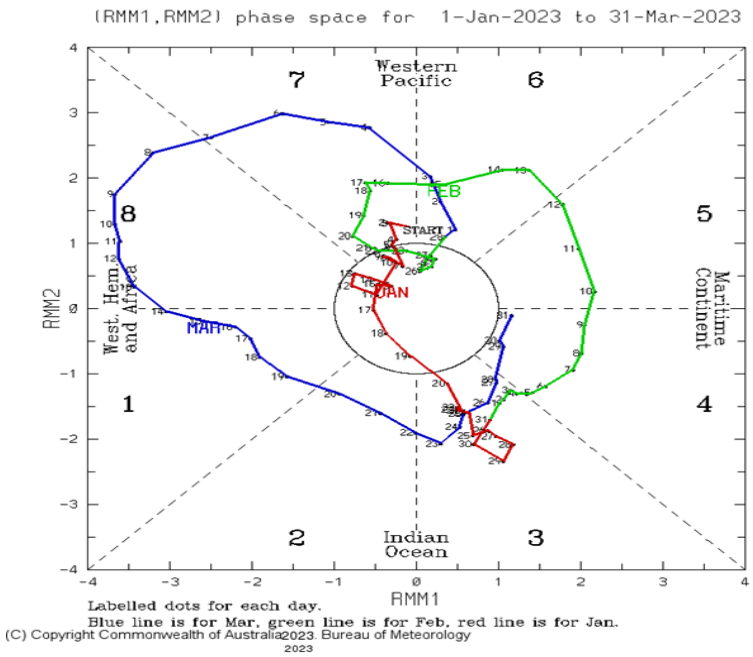


Figure 19: Observed MJO between January and March, 2023 (Australian, 2023)

The Figure 19 shows the Africa region falling under phases 1 and 8. The MJO was active in January and March during the 2023 rainfall season. The activism is indicated by the presence of a blue line for March and red line for January over the region which led Malawi to experience the impacts of Tropical Cyclone Freddy and Cheneso respectively. The MJO's influence on atmospheric conditions contributed to the development and intensity of the tropical cyclones in January and March 2023.

4.2 Observed Rain Bearing Systems and Wind Regimes

The commonly observed rain-bearing systems in Malawi include convergence ahead of pressure rise, the Inter-Tropical Convergence Zone (ITCZ), the Congo air mass, easterly waves, and tropical cyclones.

During the winter season, Malawi experiences distinct weather conditions marked by Mwera winds and Chiperone conditions. The summary of the occurrence in terms of the number of days per month the rain-bearing systems and wind regimes in the 2022-2023 rainfall season are presented in Figure 20.

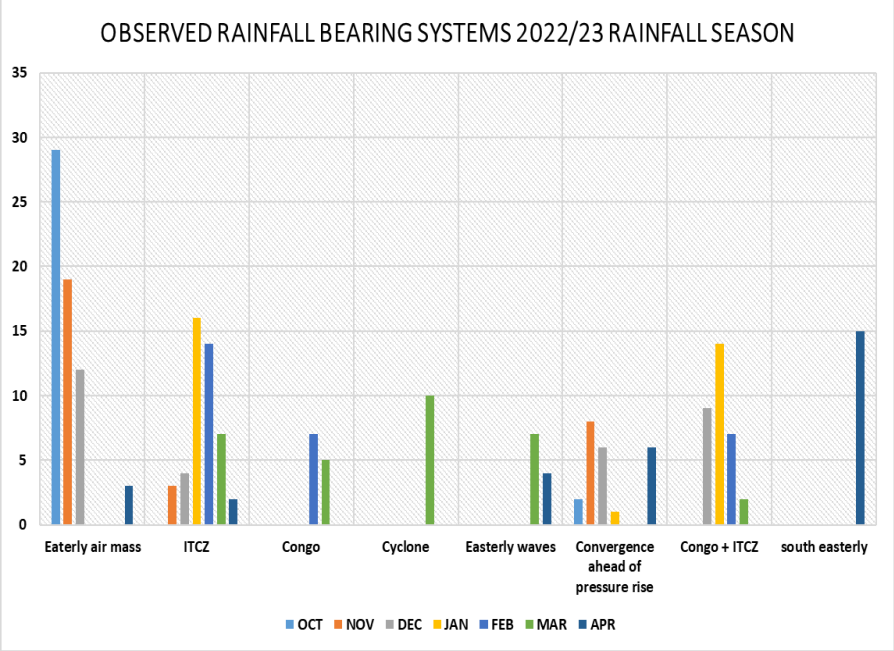


Figure 20: Observed Rain bearing Systems 2022/23 Rainfall Season

4.2.1 Convergence ahead of pressure rise

The convergence ahead of pressure rises occurs when a stronger south-easterly wind meets with easterly winds, typically common at the onset of the rainfall season in October and November. These winds usually originate from the same southern hemisphere. The rainfall resulting from this convergence is often accompanied by lightning, thunderstorms, and strong, gusty winds.

In 2022, this system was observed from the end of October until mid-December, with the highest occurrences in November. The strong winds associated with this system led to the blowing off of roofs, mainly in southern Malawi, as depicted in Figure 20.

4.2.2 Inter-tropical Convergence Zone (ITCZ)

The ITCZ is formed as a result of the convergence of trade winds in areas experiencing maximum solar heating. In these specific regions, the north-easterly

trade winds from the northern hemisphere meet with the south-easterly winds from the southern hemisphere, causing the air to rise into the warm atmosphere and leading to the formation of convective clouds. The ITCZ is essentially a compilation of these convergence zones and is distinguished by frequent thunderstorms and substantial rainfall.

In 2022, the influence of the Inter-Tropical Convergence Zone (ITCZ) over Malawi began in late December and then became dominant in January and February, as depicted in Figure 20. The ITCZ brought heavy rains to the country, resulting in incidents of floods and flash floods in many areas, particularly along the lakeshore.

4.2.3 Congo Air Mass

This refers to air masses originating from the Congo Basin, which carry moisture and leads to rainfall over Malawi when they encounter topographical barriers or interact with other weather systems. The Congo air mass consists of a westerly wind that originates from the Atlantic Ocean, traverses through the tropical forest of the Congo Basin, and brings precipitation to Southern African countries, including Malawi. This air mass is distinguished by intermittent thunderstorms and continuous rainfall that spans a broad geographical area and persists for an extended duration. The convergence area at the surface, where the low-level westerlies from the Congo Basin meet the easterlies from the Indian Ocean trade winds, is referred to as the Congo Air Boundary (CAB).

In 2023, during the month of January, Congo air mass was dominant and at times it was coupled with ITCZ. This led to heavy episodes and intermittent rains over more areas. The remnants of tropical storm Cheneso enhanced Congo air mass towards the end of the month.

4.2.4 Easterly Waves

The end of the rainfall season in Malawi is marked by rains emanating from Easterly waves that originate in the eastern regions of tropical oceans and travel

westward at speeds ranging from 10 to 20 knots. These waves induce rainfall through a disturbance in the typical isobaric pressure pattern, creating a wave-like effect.

In 2023, the presence of Easterly waves was observed from the month of March to the month of April as shown in the Figure 20.

4.2.5 Tropical Cyclones

During the summer season, Malawi's weather is at times influenced by Tropical Cyclones originating from the Southwest Indian Ocean. The impact of Tropical Cyclones varies as they bring either dry spells or wet spells depending on their position and trajectory in the Mozambique Channel. In some instances, these cyclones make landfall over Mozambique and subsequently affect Malawi directly, the consequences of which include loss of life and property, and damage to infrastructure due to fast moving waters, floods and strong winds.

During the period under review, a tropical disturbance developed in the Indian Ocean in January 2023, but it did not have a direct impact on Malawi. The Department of Climate Change and Meteorological Services (DCCMS) began monitoring the system on 19th January 2023. Initially categorized as a tropical storm named Cheneso, it enhanced the Congo air mass over the country. Although it moved westward towards Malawi after making landfall over Madagascar, Cheneso weakened along the way. The remnants of Cheneso, characterized by deep low pressure, led to further enhanced rainfall over the country from Saturday, 21st January, with the highest recorded amount of 86.4 mm from Madisi in Dowa. Cheneso re-intensified on 23rd January, but it still had no direct impact over Malawi, as depicted by its path in Figure 21.

In March, Malawi was struck by Tropical Cyclone Freddy, which influenced weather conditions from 5th to 14th March. The cyclone caused loss of life and damage to infrastructure due to floods and mudslides mainly in the southern districts of Malawi, including Blantyre, Mulanje, Phalombe, Chiradzulu, Thyolo,

Zomba, Neno, Mwanza, Nsanje, and Chikwawa, as depicted by its path in Figure 21.

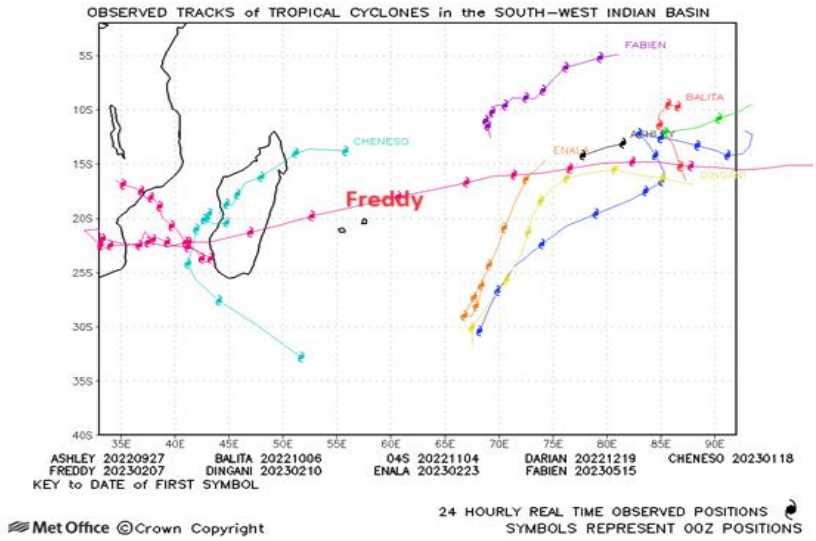


Figure 21: Southwest Indian Ocean Tropical cyclone tracks in 2023 (Met Office, 2023)

4.2.6 Mwera winds and Chiperone

The winter weather patterns are largely influenced by the presence of cool and moist air masses from the southern Indian Ocean, a result of the prevailing high-pressure systems moving from Azore Island to St Helena Island. The robust high-pressure systems situated along the Southern East Coast of South Africa attract a cool and moist south-easterly air mass into Malawi. This phenomenon leads to overcast conditions with local rain drizzles, commonly referred to as "Chiperone," occurring over highland areas. Additionally, Lake Malawi experiences moderate to strong southerly winds, locally known as *Mwera* during this season.

The 2023 winter session had few incidences of high-pressure systems inducing moderate to strong south-easterly (Mwera) winds and cold spells (Chiperone) as shown by the wind rose on the Figure 22.

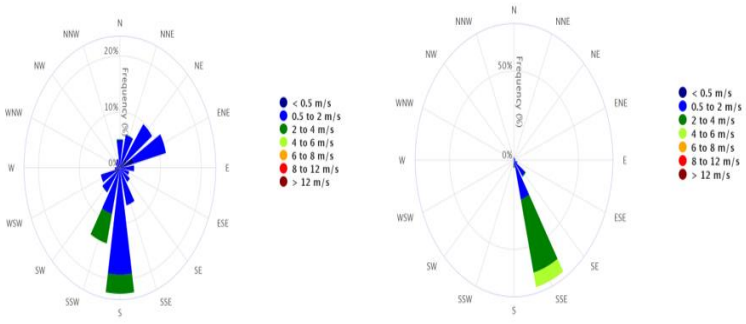


Figure 22: Observed winds from Lake shore areas between May and August in 2023. Image A- Mlowe CDSS in Rumphi and B- Lifuwu Research in Salima.

Chapter Five

5.0 Social-economic impacts of extreme Weather and climate events

Of late, there has been a noticeable increase in the number of extreme weather events, leading to significant social and economic damage in Malawi. In 2023, Malawi tragically lost more than 600 lives due to mudslides caused by Tropical Cyclone Freddy (DoDMA, 2023). Various sectors of the economy were also severely impacted by the cyclone, including agriculture, transport, energy, health, education, water resources, and disaster risk reduction efforts.

5.1 Disaster Risk Management

The Department of Climate Change and Meteorological Services (DCCMS) is tasked with weather monitoring and forecasting in Malawi. It provides weather forecasts and severe weather warnings for various hazardous weather conditions. These hazards vary according to the season of the year. During winter, common hazards include strong south-easterly winds, known as Mwera, which typically affect Lake Malawi, and chilly weather, locally known as Chiperone, bringing cold spells. During summer, Malawi experiences hazards such as flash floods, thunderstorms, and prolonged dry spells.

Meteorologists at DCCMS conduct analysis of weather systems contributing to prevailing weather conditions and predict future weather conditions. Once all weather information, including warnings, is generated, it is packaged in a user-friendly manner for dissemination.

The department issues information on a daily and weekly basis, which is usually translated into local languages such as Chichewa, Yao, and Tumbuka. This ensures that the targeted audience understands and can respond to severe weather warnings effectively.

Currently DCCMS uses the fastest and most convenient modes of communication to send weather warnings to the public such as TVs, emails, radios and social media platforms like WhatsApp, Facebook, Twitter and YouTube.

Due to the increase in weather-related disasters, the department is taking strides to produce and issue impact-based forecasts. These forecasts provide information on the level of risk a hazard poses to a specific area, as shown in Figure 25 and part of Figure 26.

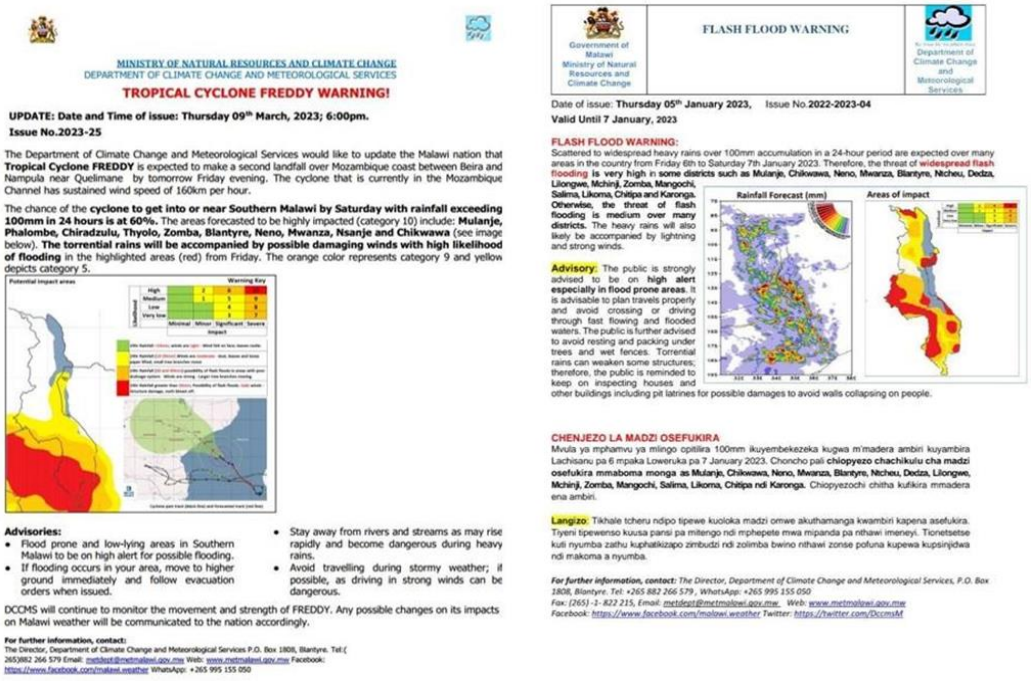
In March 2023, DCCMS forecasted a high likelihood of Tropical Cyclone Freddy impacting southern Malawi. The general public and stakeholders, including government departments such as the Department of Disaster Management Affairs (DoDMA), were warned in good time to allow for preparations and evacuations.

Cyclone Freddy enhanced rains over central and southern areas, while the northernmost parts like Karonga experienced prolonged dry spells, as depicted in Figures 23, 24, 26 (impacts of heavy rains), and 27 (impacts of dry spells).

In summary, a total of MWK147.8 billion is needed to recover and reconstruct the damages and losses caused by tropical cyclone Freddy. At least 2.2 million people were affected of whom 659,278 were displaced (DoDMA 2023) in 14 councils. The highest displaced populations were in Mulanje 131,830 seconded by Phalombe 117,801 people.

Figure 23: Destructive by mudslides in Blantyre, source: www.malawitourism.com

Figure 24: Residential area in Blantyre, Malawi (aerial view) after being struck by a mudslide during Tropical Cyclone Freddy. Photo by Joseph Mizere/Xihua



MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE
DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

TROPICAL CYCLONE FREDDY WARNING!

UPDATE: Date and Time of issue: Thursday 09th March, 2023; 6:00pm.
Issue No.2023-25

The Department of Climate Change and Meteorological Services would like to update the Malawi nation that **Tropical Cyclone FREDDY** is expected to make a second landfall over Mozambique coast between Beira and Nampula near Quelimane by tomorrow Friday evening. The cyclone that is currently in the Mozambique Channel has sustained wind speed of 160km per hour.

The chance of the **cyclone to get into or near Southern Malawi by Saturday with rainfall exceeding 100mm in 24 hours is at 60%.** The areas forecasted to be highly impacted (category 10) include: **Mulanje, Phalombe, Chiradzulu, Thyolo, Zomba, Blantyre, Neno, Mwanza, Nsanje and Chikwawa** (see image below). **The torrential rains will be accompanied by possible damaging winds with high likelihood of flooding** in the highlighted areas (red) from Friday. The orange color represents category 9 and yellow depicts category 5.

Advisories:

- Flood prone and low-lying areas in Southern Malawi to be on high alert for possible flooding.
- If flooding occurs in your area, move to higher ground immediately and follow evacuation orders when issued.
- Stay away from rivers and streams as may rise rapidly and become dangerous during heavy rains.
- Avoid travelling during stormy weather; if possible, as driving in strong winds can be dangerous.

DCCMS will continue to monitor the movement and strength of FREDDY. Any possible changes on its impacts on Malawi weather will be communicated to the nation accordingly.

For further information, contact:
The Director, Department of Climate Change and Meteorological Services P.O. Box 1808, Blantyre. Tel:(265)882 266 579 Email: metdept@metmalawi.gov.mw Web: www.metmalawi.gov.mw Facebook: https://www.facebook.com/malawi.weather WhatsApp: +265 995 155 050

Government of Malawi
Ministry of Natural Resources and Climate Change

FLASH FLOOD WARNING

Department of Climate Change and Meteorological Services

Date of issue: **Thursday 05th January 2023,** Issue No.**2022-2023-04**
Valid Until 7 January, 2023

FLASH FLOOD WARNING:
Scattered to widespread heavy rains over 100mm accumulation in a 24-hour period are expected over many areas in the country from Friday 6th to Saturday 7th January 2023. Therefore, the threat of **widespread flash flooding is very high in some districts such as Mulanje, Chikwawa, Neno, Mwanza, Blantyre, Ntcheu, Dedza, Lilongwe, Mchinji, Zomba, Mangochi, Salima, Likoma, Chitipa and Karonga. Otherwise, the threat of flash flooding is medium over many districts.** The heavy rains will also likely be accompanied by lightning and strong winds.

Advisory: The public is strongly advised to be on **high alert especially in flood prone areas.** It is advisable to plan travels properly and avoid crossing or driving through fast flowing and flooded waters. The public is further advised to avoid resting and packing under trees and wet fences. Torrential rains can weaken some structures; therefore, the public is reminded to keep on inspecting houses and other buildings including pit latrines for possible damages to avoid walls collapsing on people.

Rainfall Forecast (mm)

Areas of impact

CHENJEZO LA MADZI OSEFUKIRA
Mvula ya mphamvu ya mlingo opitilira 100mm ikuyembekezeka kugwa m'madera ambiri kuyambira Lachisanu pa 6 mpaka Loweruka pa 7 January 2023. Choncho pali **chiopyezo chachikulu cha madzi osefukira mmaboma monga as Mulanje, Chikwawa, Neno, Mwanza, Blantyre, Ntcheu, Dedza, Lilongwe, Mchinji, Zomba, Mangochi, Salima, Likoma, Chitipa ndi Karonga.** Chiopyezochi chitha kufikira mmadera ena ambiri.

Langizo: Tikhale tcheru ndipo tipewe kuoloka madzi omwe akuthamanga kwambiri kapena asefukira. Tiyeni tipewenso kuusa pansi pa mitengo ndi mphepete mwa mipanda pa nthawi imeneyi. Tionetsetse kuti nyumba zathu kuphatikizapo zimbudzi ndi zolimba bwino nthawi zonse pofuna kupewa kupsinjidwa ndi makoma a nyumba.

For further information, contact: *The Director, Department of Climate Change and Meteorological Services, P.O. Box 1808, Blantyre. Tel: +265 882 266 579 , WhatsApp: +265 995 155 050*
Fax: (265) -1- 822 215, Email: metdept@metmalawi.gov.mw, Web: www.metmalawi.gov.mw
Facebook: https://www.facebook.com/malawi.weather Twitter: https://twitter.com/DccmsM

Figure 25: Some of Warnings issued by DCCMS in 2023

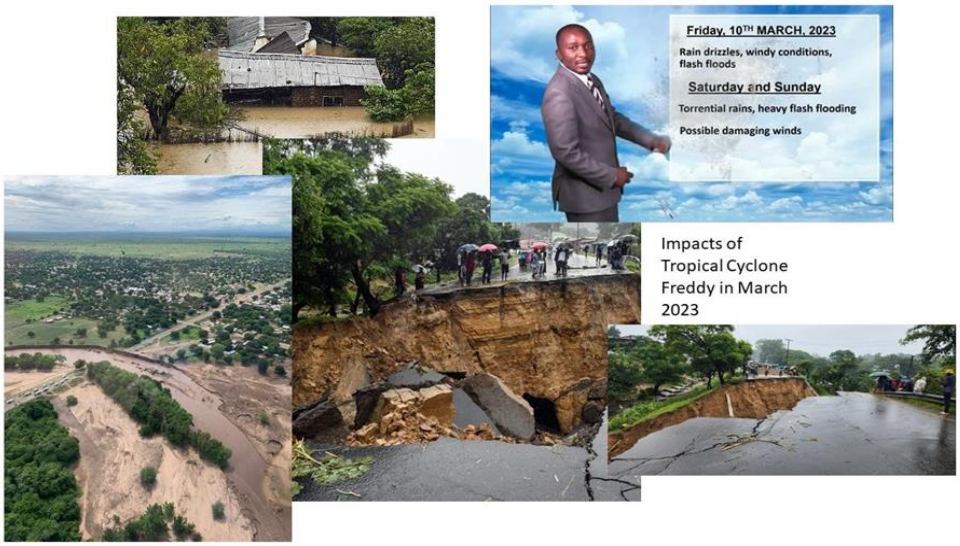


Figure 26: The damages caused by Tropical Cyclone Freddy

Figure 27: Impacts of prolonged dry spell of more than 20 days in Karonga.

During winter of 2023, strong south easterly winds are normally observed mainly over lake Malawi and other large water bodies. DCCMS issues warnings and alerts as shown in Figure 28 in order to reduce the losses and damages that strong winds may cause over lake Malawi and others. Strong winds affect mobility, fishing and also recreation activities.

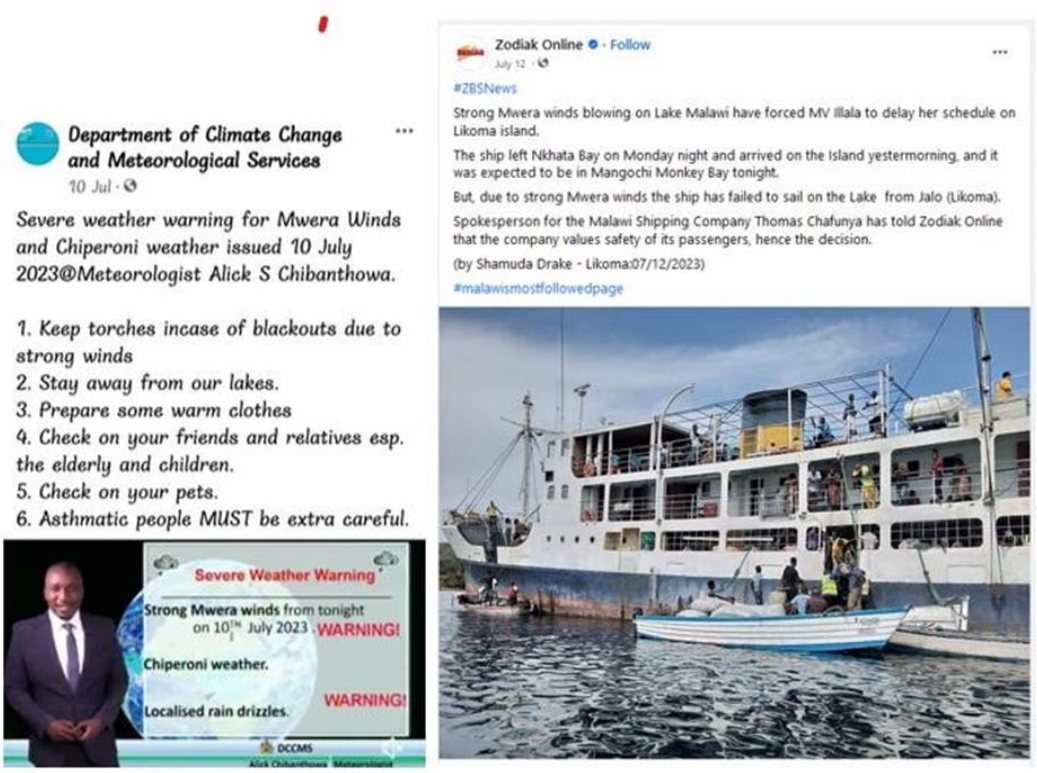


Figure 28: Warning for strong Mwera winds which was issued on 10th July 2023 (A) and the impact when Illala ship failed to sail on 12th July 2023 (B)

Figure 29 Roof blown off by strong winds at Bwengu Primary School in Mzimba District in December 2023.

5.2 Agriculture and food security

The Malawian economy is predominantly agriculture-based, with agriculture accounting for 30% of Gross Domestic Product (GDP) and generating over 80% of national export earnings. Additionally, the agriculture sector employs 64% of Malawi's workforce. (National Agriculture Policy, 2016).

Malawi is extremely vulnerable to weather and climate shocks. During the 2022/2023 rainy season, the country experienced a normal to slightly early seasonal onset particularly over northern areas. The country had evenly distributed rainfall cases over a large part of the season which was favourable for agricultural production. However, during the month of March 2023, the country was hit by Tropical Cyclone Freddy, which resulted in flooding particularly over southern Malawi resulting in crop wash-away, loss of property, livestock death as well as loss of human life. The total number of populations whom their fields were damaged by tropical cyclone Freddy was 1,637,351 where 842,952 were females and 794,399 were males. Approximately 202,095 hectares of cropped land were severely damaged (DoDMA 2023).

Field Crops			
Crops	2022/23 Third Round Production (MT)	Five-Year Third Round Average Production (MT)	% Change against five-year third round average
Maize	3,509,837	3,634,720	-3.4
Rice	124,344	135,830	-8.5
Wheat	190	522	-63.6
Millet	49,631	41,048	20.9
Sorghum	126,333	116,013	8.9
Groundnuts	468,045	405,243	15.5
Cotton	13,822	29,177	-52.6
Cassava	6195735	5,871,849	5.5
Sweet Potato	7609426	6,592,029	15.4
Potato	1516396	1,196,455	26.7
Pigeon Peas	456,033	418,450	9
Beans	235,089	213,939	9.9
Soya Beans	235,487	246,059	-4.3

Table 1:2022_2023 National Field crops production (APES, 2023)

The majority of Field crops registered a decrease in production during the 2022/2023 farming season as compared to five-year production average with unfavourable weather among the major factors for the decrease. The highest decrease was registered in wheat at 63.6% seconded by cotton at 52.6% with unfavourable weather conditions cited as one of the major contributing factors in the experienced decrease in production as depicted in Table 1 (APES, 2023).

The various related climate shocks also contributed to 15% of the Malawi population facing high acute food insecurity projected to hit 22% during lean season of 2023/2024 according to the Malawi Vulnerability Assessment Committee August 2023 report as depicted in Figure 29 (IPC Malawi, 2023).

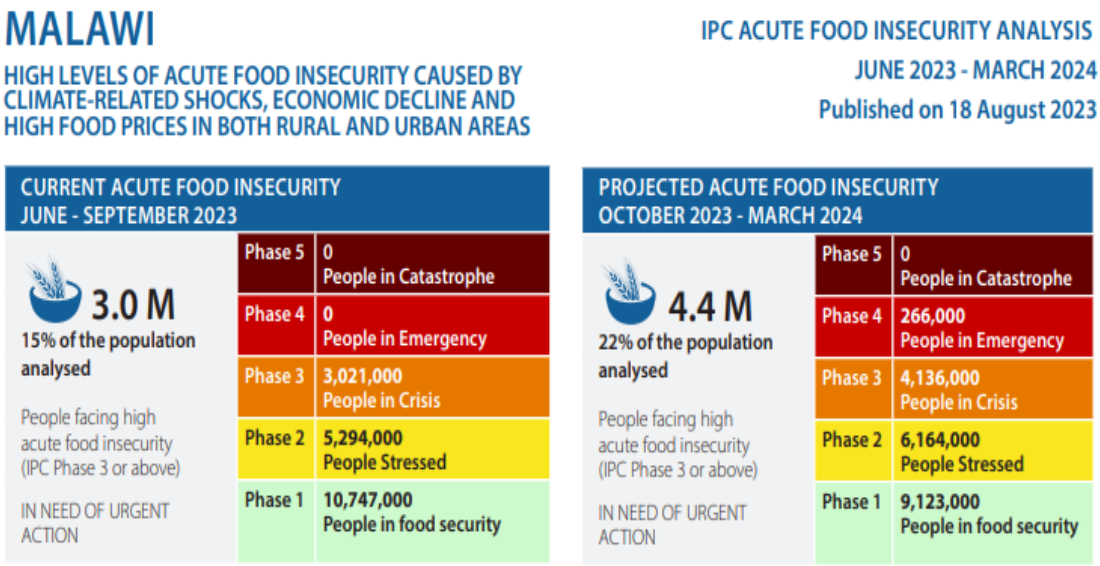


Figure 29: Acute food insecurity situation (IPC Malawi, Malawi: IPC Acute Food Insecurity Analysis, June 2023 - March 2024, 2023)

5.3 Water Resources

Water resources play an important role in sustaining life and supporting economic activities in Malawi. They serve as a lifeline for agriculture, energy production, livelihoods, public health, and environmental sustainability.

Effective management and equitable access to water resources are imperative for fostering resilience, supporting livelihoods, and promoting sustainable development in Malawi across sectors such as agriculture and hydropower

Weather plays a crucial role in determining water availability, with extreme weather events such as heavy rainfall and drought causing significant fluctuations. Heavy rainfall can result in flooding and increased surface runoff, boosting water availability in rivers, lakes, and reservoirs. Conversely, droughts lead to decreased precipitation and reduced water inflow, causing water scarcity and affecting water resources.

These weather extremes highlight the vulnerability of water availability to climatic variability.

5.3.1 Lake Malawi Water Levels

As per the (Environmental Affairs Department, 2010), Lake Malawi holds an average of 90 cubic kilometres of live storage, representing water capable of flowing through the Shire River. The lake encompasses a surface area of 28,760 square kilometres and is estimated to have a total volume of 7,725 x 109 cubic metres at a mean lake level of 474.00 metres above mean sea level (Environmental Affairs Department, 2010).

Over the past five years, there has been a consistent increase in Lake Malawi's water levels, reaching its peak in 2023 to more than 475 metres above sea level as shown in the Figure 30. This can be attributed to the increase in annual precipitation in the catchment area of Lake Malawi. Notably, the lake attains its highest level during the month of May.

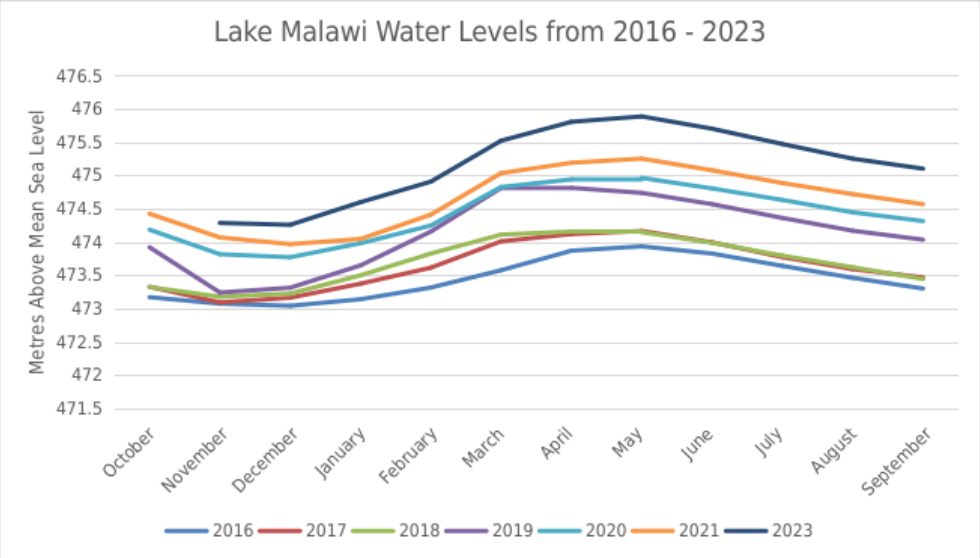


Figure 30: Levels of Lake Malawi from 2016 -2023, Data Source: Department of Water Resources

5.4 Transport

5.4.1 Road Transport

The road sector was also impacted by extreme weather events during the 2023/2024 season. Several roads and bridges were damaged in certain parts of the country. The Post Disaster Needs Assessment report for 2023 indicates that Tropical Cyclone Freddy caused substantial damages estimated at $104.39 million to the transport subsector (Government of Malawi, 2023). The destruction was primarily attributed to heavy rainfall leading to flooding and landslides. Approximately 1,820 km of roads were either partially or fully destroyed as shown in Figure 31. More than 44 roads were damaged of which 16 were major roads, 17 secondary and 10 tertiary roads. Furthermore, the cyclone resulted in the destruction of 58 bridges and the washing away of 117 culverts (Government of Malawi, 2023).

Figure 31:Road washed away by heavy rains in Machinjiri, Blantyre

5.4.2 Air Transport

The influence of adverse weather on air transport can be considerable, frequently leading to flight delays and cancellations. During the reviewed period, Tropical Cyclone Freddy led to the diversion of flights from Chileka International Airport from March 12 to March 14, 2023, owing to poor visibility and heavy rainfall.

5.4.3 Rail Transport

Rail transport was also significantly impacted, particularly in southern Malawi, where certain sections of the railway line were damaged, specifically Blantyre. This disruption hindered the transportation of goods and services.

5.4.4 Marine Transport

Marine transport services, especially on Lake Malawi, are mainly affected by the impact of extreme southerly/southeasterly winds, which typically intensify during

the winter months of May to August. In July 2023, strong Mwera winds blowing on Lake Malawi had forced MV Illala to delay her schedule, it failed to sail on the Lake from Jalo in Likoma.

5.5 Energy

The major hydropower station is situated in the Southern Region, specifically along the Shire River. Challenges in hydropower production typically arise from the accumulation of trash, water, and debris towards intake screens, blocking water entry to the tunnel and consequently reducing power generation, sometimes leading to the shutdown of entire power stations to prevent damages. In severe cases, this accumulation can cause significant damage to dam structures and associated equipment.

During the season under consideration, the energy sector faced severe impacts from Cyclone Freddy. Water levels rose beyond required flows, affecting the tailrace and reducing power generation. The Tedzani dam embankment suffered erosion, while the Nkula dam abutment sustained damage due to excessive water carrying logs and rocks. The Electricity Generation Company Limited (EGENCO) reported an unstable generation system due to Cyclone Freddy, prompting the shutdown of major hydro power stations for observation and protection of infrastructure.

According to EGENCO, during Cyclone Freddy, Kapichira was out of service as its dam was under construction. Nkula and Tedzani experienced zero power generation while waiting for water flow to decrease (ESCOM, 2023). The nation endured a blackout as EGENCO shut down power to prevent further damage to power-generating machines. The hydroelectric power plant, a significant electricity source, became inoperable due to debris.

Figure 32: A toppled electric pole in Blantyre as a result of heavy rainfall during Tropical Cyclone Freddy

EGENCO stated that power generation capacity was unstable, experiencing total system shutdowns twice on Monday, 14th March 2023. To protect against damage, major hydro power stations were shut down, leading to blackouts in some areas for two weeks due to damaged infrastructure. As of March 28, 2023, EGENCO successfully stabilized the generation system, making all machines at Nkula and Tedzani Power Stations available. However, challenges persisted in running Tedzani II and Nkula A machines due to excessive trash, debris, silt, and rocks clogging water intakes (ESCOM, 2023). Additionally, Tropical Cyclone Freddy damaged power transmission lines (132KV and 66KV) and distribution infrastructure, including poles, broken jumpers, and conductors, as shown in Figure 33. Repairs to the damaged power infrastructure were generally delayed due to poor road access, which inhibited the movement of supplies (DoDMA, 2023).

Figure 33: ESCOM Engineers working as part of Post Tropical Cyclone Freddy recovery (16 march 2023) (ESCOM, 2023)

5.6 Health

The impact of Tropical Cyclone Freddy in March 2023 extended to the health sector in Malawi, affecting nearly 16 districts in the southern region. The estimated damage to this sector was $4.14 million, with losses incurred totalling $3.99 million (DoDMA, 2023). This highlights the significant impact of weather on human health and well-being, whether directly or indirectly (Kalkstein & Valimont, 1987).

As a result of Cyclone Freddy, a total of 313 health facilities, including infrastructure and health equipment, were destroyed. Additionally, 92 health workers were displaced, creating staff shortage problems in the 16 affected local authorities.

Furthermore, in terms of nutrition, 340,267 children under five years old, 181,098 pregnant women, and 2,385 chronically ill people were also affected by the aftermath of Cyclone Freddy. The cyclone also left 944,784 people without WASH services increasing the risk of waterborne diseases including cholera (DoDMA, 2023).

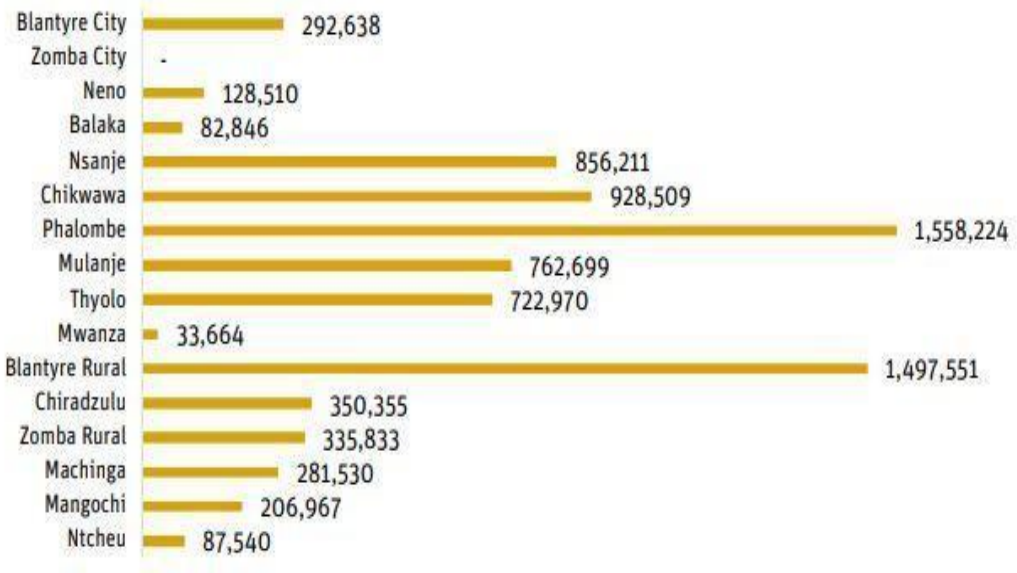


Figure 34: Total damages of Tropical Cyclone Freddy on Health and Nutrition sub sector across the affected local authorities in US Dollars (Government of Malawi, 2023).

5.7 Education

The education sector is not spared when it comes to the effects of climate impacts and extreme weather events. Effects of cyclones and heat waves on education range from physical damage to infrastructure, institutional and administrative challenges and psychosocial impact. These effects are worse in communities where climate extreme events are not common, as they are ill prepared to cope.
In March 2023, Tropical Cyclone Freddy brought torrential rains to southern areas of Malawi. These rains persisted for more than three days, causing havoc with flash floods, landslides, and the disruption of essential services such as education, health, roads, electricity, and agriculture.

The education sector was hit hard, resulting in disruption of classes, child protection, school feeding programs, and loss of school days due to the closure of schools in the affected districts. Over 400 schools were occupied by internally displaced persons. Figure 35 shows the damage of Chingoli primary school in

Mulanje, (Siula, 2023) while Figure 36 depicts Kapeni Primary School in Blantyre which was used as a camp for cyclone survivors (McBrams, 2023).

At least 624 schools, 423 teacher houses and 542 toilets experienced damages. Additionally, the damage of the cyclone Freddy amplified the already critical shortages of classrooms, desks, and toilets as well as teaching and learning materials (Government of Malawi, 2023).

Some universities were also affected such as Malawi University of Business and Applied Sciences (MUBAS), Malawi University of Science and Technology (MUST), and the University of Malawi (UNIMA), that experienced leakage in their library, hostels, houses, and teaching areas.

Figure 35: Chingoli Primary School In Mulanje was affected by tropical cyclone Freddy on 12th March 2023 (Siula, 2023)

Figure 36: Kapeni Primary School in Blantyre used as a camp for Cyclone Survivors (McBrams, 2023)

Over 724,800 learners, including 368,313 girls, were unable to access learning due to the cyclone (UNICEF, 2023).

The sector was also affected by heat waves. During the period under review, some parts of southern and lakeshore areas experienced a heat wave, with maximum temperatures ranging from above 39.6 to 43.2°C. These temperatures were warmer by 5.2 to 7.3°C compared to the 1991-2020 maximum average temperature range.

Chapter Six

6.0 Conclusion

In the 2022/2023 rainy season, Malawi experienced cumulatively normal to above-normal rainfall conditions with below-normal rainfall in parts of Chitipa and Karonga. However, the October-November-December (OND) sub season was characterized by mainly dry weather conditions, with substantial rains occurring only in December. Unlike the OND period, the January-February-March (JFM) period was characterized by very wet conditions.

Rainfall onset was generally normal for most of southern and central areas of the country, with a slightly early onset for northern areas. The rainfall cessation was also normal in most parts of the country.

In terms of temperatures, most areas in southern and central Malawi had experienced warmer temperatures than their normal average. However, few areas in northern and south-eastern parts of Malawi experienced cooler temperatures. Extreme temperatures were also experienced in some areas during October (Heat waves) and June (Cold spells).

The 2022/2023 season was also characterized by occurrences of extreme weather events, including droughts, heavy rains, floods, tropical cyclones, strong winds, and extreme temperatures. For instance, Tropical Cyclone Freddy, one of the most destructive cyclones to ever hit the country, impacted over ten districts in the southern and eastern regions. The cyclone lasted for three to four days, resulting in extensive damage and widespread suffering. On the contrast, Karonga and Chitipa experienced drought conditions during the same period of Cyclone Freddy.

The extreme weather events that occurred during the 2022/2023 season negatively affected most social economic sectors such as agriculture, water resources, disaster risk management, education, transport, health and energy.
For Instance, the agriculture sector experienced a decrease in crop production due to the impact of Cyclone Freddy. Fields, crops, and livestock were washed away as a result of flooding. In the transport sector, several roads and bridges were damaged in certain parts of the country. Travel and service delivery was disrupted as a result of damages from Cyclone Freddy.

The energy sector was similarly affected, with power transmission lines being destroyed, resulting in power outages in some areas lasting up to two weeks.
The education sector was also adversely affected, with schools being utilized as camps for survivors or individuals displaced from their homes due to disasters.
Cyclone Freddy also disrupted health service delivery. At least 313 health facilities were destroyed and 92 health workers were displaced.

In conclusion, the 2022/2023 season in Malawi witnessed a range of weather conditions, spanning from normal to extreme. Notably, Tropical Cyclone Freddy emerged as one of the most devastating events, leaving a profound impact on the nation. The repercussions of these weather phenomena were felt across multiple sectors, emphasizing the critical need for resilience and preparedness in addressing climate-related challenges. Moving forward, concerted efforts across sectors will be essential to mitigate future risks and foster the development of a more resilient society.

The year 2023 will be remembered for the significant losses and damages inflicted upon various sectors of the Malawian economy by Tropical Cyclone Freddy.

7.0 Annexe 1- Summary Poster

Facts and Figures
Climate Change in Malawi

Weather and climate observations in Malawi commenced in the 1890s, with records maintained by administrators at the BOMAS, missionaries, farmers, and individuals. Recent climate analyses indicate a consistent increase in average temperatures, aligning with the global temperature rise.

THE HIGHEST RECORD FOR 2023

43.9°C

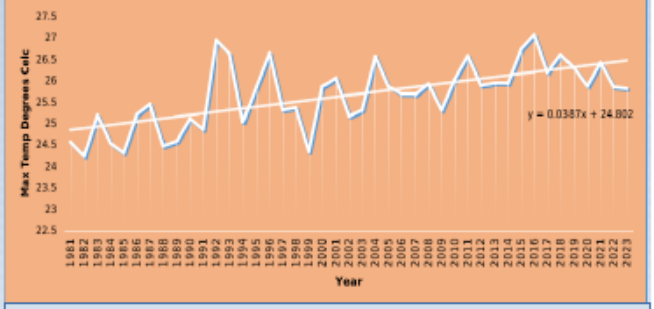
Ngabu Chikwawa 25th October

THE HIGHEST RECORD FOR 2023

458.6mm

Nkhulambe Phalombe 13 March

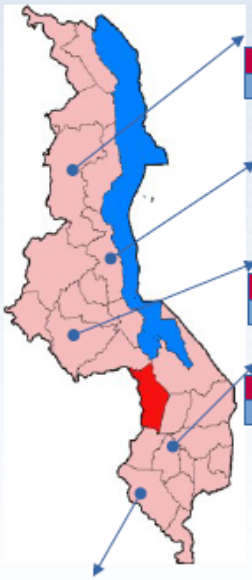
BLANTYRE MAXIMUM TEMPERATURE FROM 1981 -2023



ANNUAL AVERAGE TEMPERATURE

On average, the mean maximum temperature in Malawi is 28 degrees Celsius. There is an average rise of +0.02 annual in most districts. Notably (graph above), the mean maximum temperature is increasing by +0.38 in Blantyre possibly due to urbanization. However, the mean maximum temperature is expected to increase by +0.3 on average based on SSP2.45 and +0.7 based on SSP5.85 during the 2040s.

TEMPERATURE RECORDS FROM 5 DISTRICTS



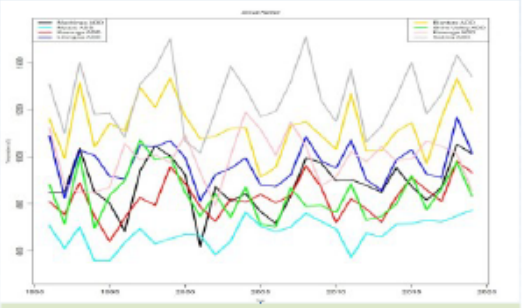
Mzimba
Max Temp 36.3°C 15/11/1995
Min Temp 3.5°C 14/07/1994

Nkhotakota
Max Temp 38.5°C 17/10/2018
Min Temp 11.4°C 17/10/2018

Lilongwe
Max Temp 35.8°C 28/11/1995
Min Temp 1.6°C 02/07/1996

Blantyre
Max Temp 37.0°C 17/10/2018
Min Temp 6.7°C 02/07/1996

Chikwawa
Max Temp 45.0°C 24/11/1994
Min Temp 8.8°C 12/07/1996



ANNUAL RAINFALL IN ADDs

The Northern Mzuzu ADD has the lowest rainfall amounts which are around 600 mm, while the highest is around 1300 mm in Salima ADD. The trend is generally positive in many ADDs except the southernmost ones of Blantyre and Shire Valley ADD which have negative trend.

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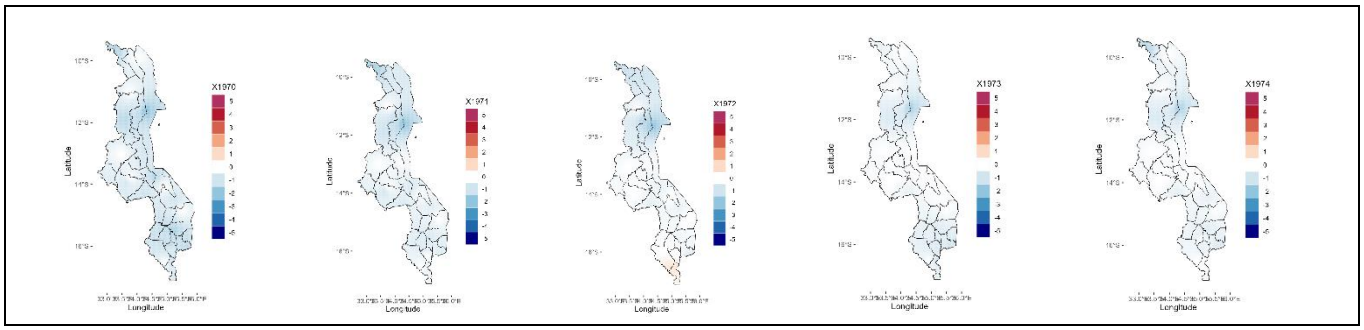
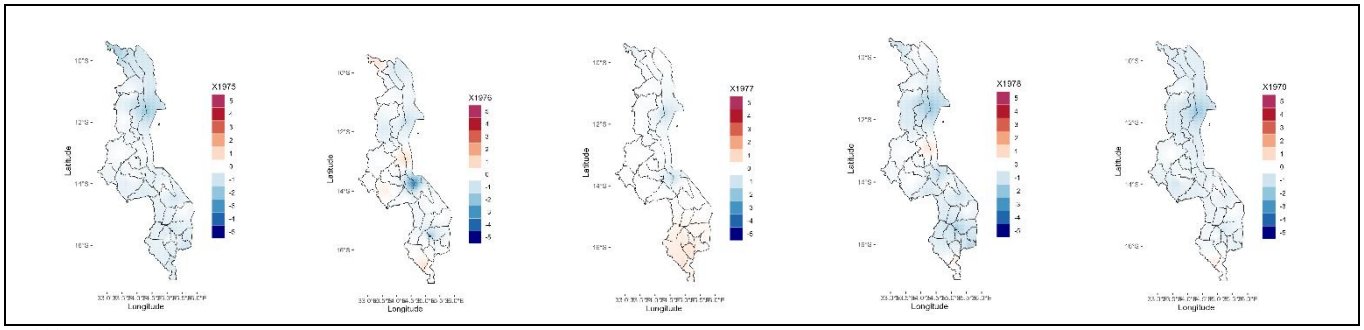
Twitter: https://twitter.com/DccmsM

5.0 Annexe 2- observed maximum temperature anomaly from 1970 to 2023 (October to December)

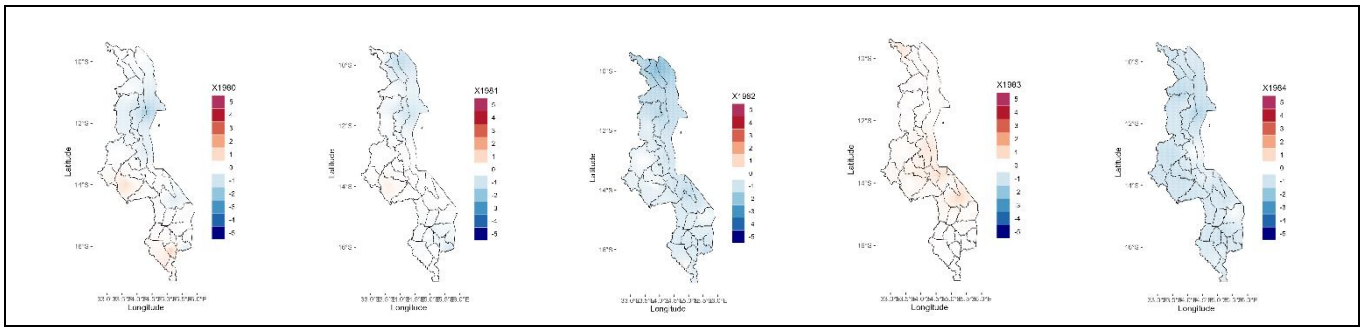
1970 to 1974



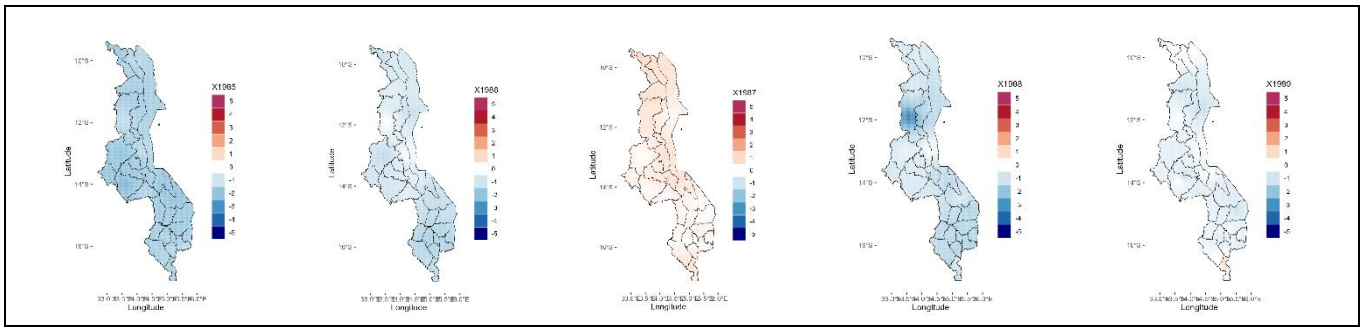
1975 to 1979



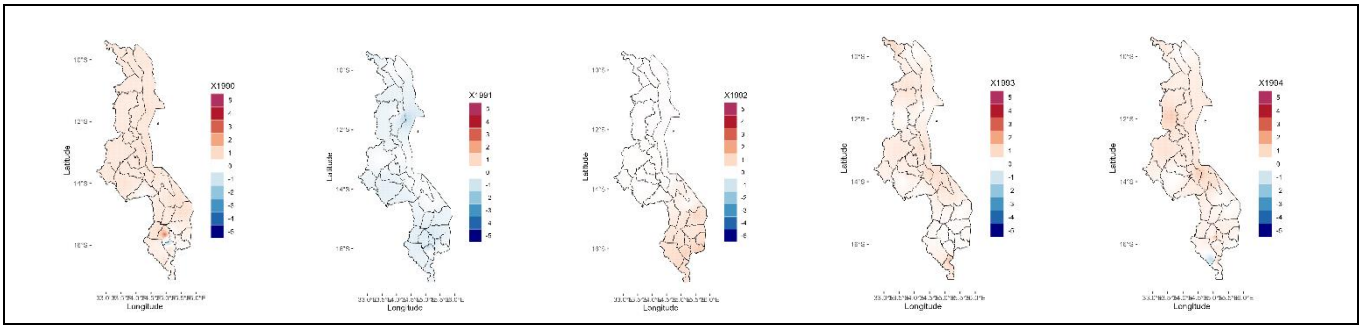
1980to 1984



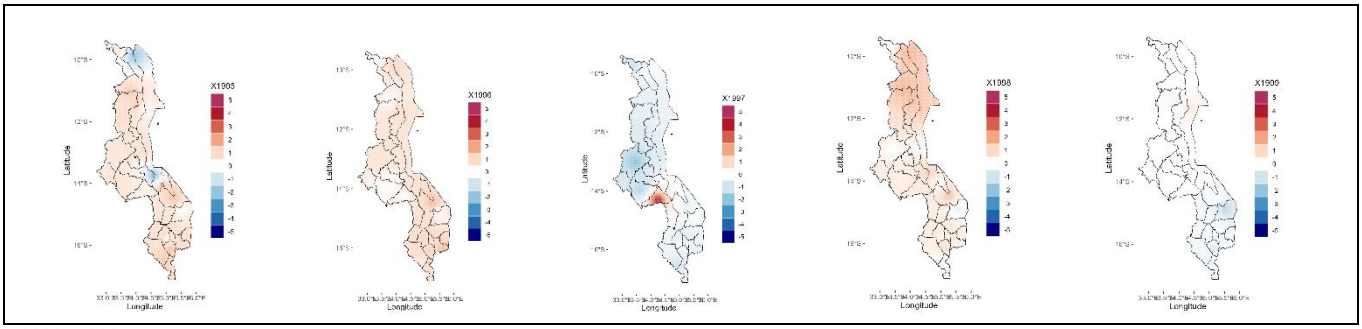
1985 to 1989



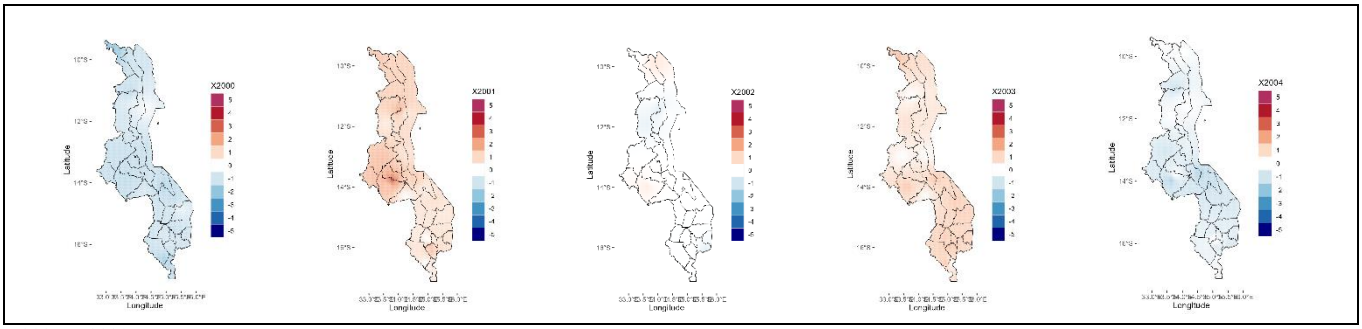
1990 to 1994



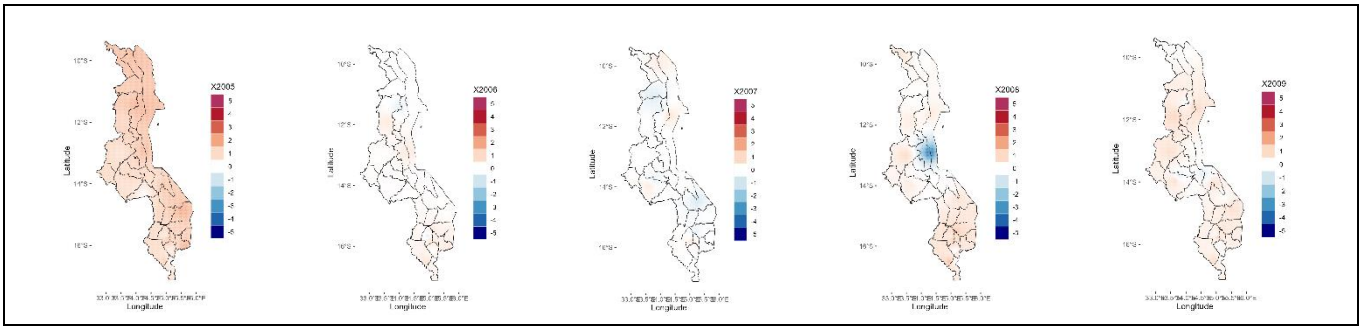
1995 to 1999



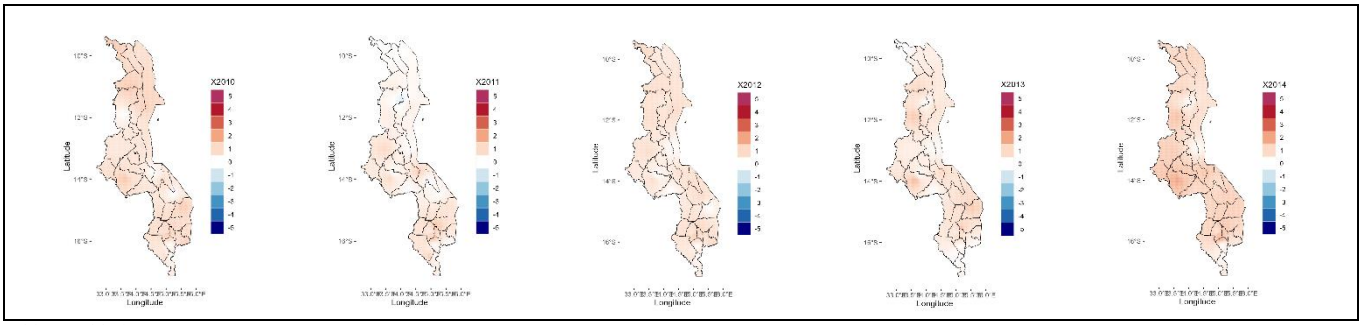
2000 to 2004



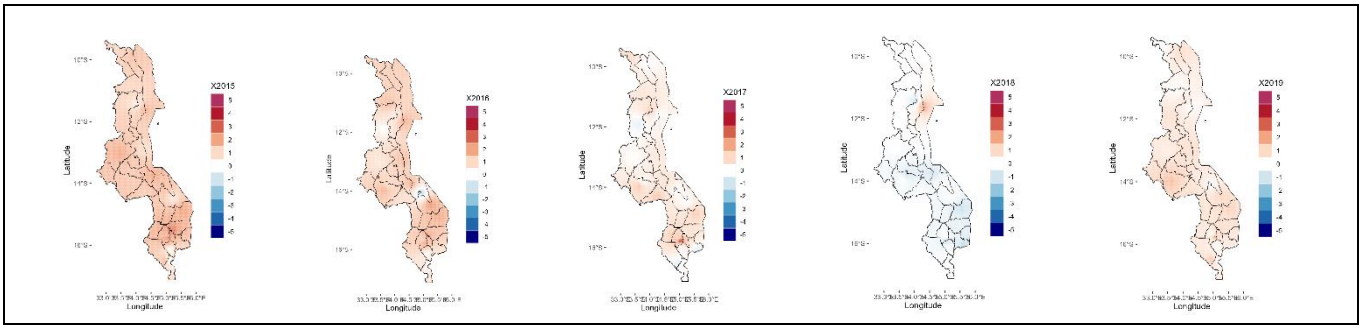
2005 to 2009



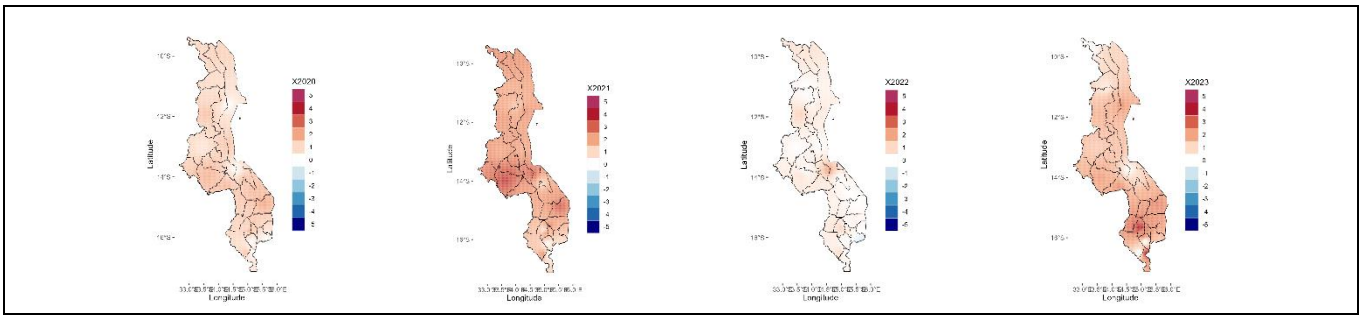
2010 to 2014



2015 to 2019



2020 to 2023



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