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TMA
TANZANIA METEOROLOGICAL AUTHORITY

Statement on the Status of Tanzania Climate in 2020

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(TMA)

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Abbreviations

ENSO	El Niño–Southern Oscillation
IDW	Inverse Distance Weighting
IOD	Indian Ocean Dipole
ITCZ	Inter-Tropical Convergence Zone
JF	January–February
JNIA	Julius Nyerere International Airport
MAM	March to May
MJO	Madden Julian Oscillations
NDJFMA	November to April
OND	October to December
RGoZ	Revolutionary Government of Zanzibar
SSTs	Sea Surface Temperatures
SSTA	Sea Surface Temperature Anomalies
SWFDP	Severe Weather Forecasting Demonstration Project
TMA	Tanzania Meteorological Authority
Tmax	Maximum temperature
Tmean	Mean temperature
Tmin	Minimum temperature

Foreword

Climate change and variability are the global phenomenon, but their impacts are felt at the regional and local levels. Increasing temperatures and sea levels, changing precipitation patterns and frequent extreme weather events are threatening human health and safety, food and water security and socio-economic development. Warmer temperatures and higher rainfall for example may cause damage to infrastructures, increased disruptions to agriculture practices, and even increase the habitat suitability for biting insects and the transmission of vector-borne diseases.

Tanzania like many other developing countries, is vulnerable to the impacts of climate change and variability. The country has continued to experience impacts of extreme weather events such as heavy rainfall, floods, strong winds and high temperatures which have greatly threatened people's livelihoods. The recently extreme rainfall events that occurred in the end of the year 2019 and early 2020 caused large number of socio-economic impacts. Widespread flooding events that were associated with heavy downpour in different parts of the country caused massive destructions, among others on infrastructures, people's settlements, and farm-fields. In addition, injuries, human displacement and loss of lives and properties were reported.

Being aware of the increased challenges posed by climate change and variability, TMA has dedicated efforts and resources to conduct robust and comprehensive climate analysis and then provide an authoritative statement/report on the status of Tanzania climate every year. The statement provides information on the status of climate for a respective year by putting it into historical perspectives with the associated extremes for the purpose of enhancing awareness and understanding of climate variability and change among stakeholders.

The information obtained from this report can be used for effective planning and decision making in various sectors, such as agriculture and food security, water resource management, energy, disaster risks management, and public health among others, but also in informing our actions for achieving various national goals. The report is also useful for researchers and academia, and for enhancing public awareness on climate change and its impacts.

I would like to express my sincere gratitude to all stakeholders for continuous support, constructive comments and ideas, and feedbacks towards improving this series of annual publication on the status of Tanzania climate.

Dr. Agnes L. Kijazi
Director General
Tanzania Meteorological Authority

1. Introduction

Availability of reliable and timely weather and climate information services is very crucial for resilience building, planning for adaptation and in implementing efforts to reduce the increasing negative social, environmental, and economic consequences of the climate change and variability. Continual monitoring of weather and climate, and provision of accurate, timely and reliable climate services including early warning of impending hydrometeorological hazards significantly contribute to reducing and managing climate change and climate variability impacts.

Tanzania Meteorological Authority (TMA) is responsible for provision of weather and climate services in the United Republic of Tanzania. The Authority have continued to monitor and document the state of climate and explore the emerging signals of climate change and variability and prepare the report on the status of Tanzania climate since 2011.

The current report provides a comprehensive summary of the main weather and climate events that occurred in the United Republic of Tanzania from January to December 2020 and their associated impacts by placing them into proper historical perspectives. The major weather and climate events are documented using various weather and climate observations network as well as information obtained from other reliable sources such as newspapers, media and reports from the National Disaster Management Authority (NDMA). In addition, the major drivers of weather and climatic events that have contributed to severe and extreme climate events are included in this report. TMA continues to enhance and sustain close monitoring of climate change and variability and their impacts.

In addition, the report presents summary statistics of temperature and rainfall for the year 2020. All maps and graphs presented in this report characterize the climate status observed in the year 2020 relative to the 1981–2010 baseline climatology.

2. Temperature distribution

In 2020, anomalous warmer temperatures were experienced in most parts of the country in almost all months, but higher temperature anomalies were more pronounced at night (minimum temperature) compared to daytime (maximum temperature). On average January, June and September recorded relatively warmer nights, whereby many parts of the country recorded temperature anomaly between 1°C and 2 °C above long term average (1981-2010). However, in January, March, July, and November many parts of the country recorded anomalous cooler day time temperature in the range between 0 °C and 1 °C.

2.1 Annual Mean, Maximum and Minimum Temperature anomalies

The country annual mean temperature (Tmean) for 2020 was 23.9 °C, which is 0.6 °C above the 1981-2010 long-term average making 2020 being the 15th warmest year in the series of meteorological observation from 1970. The annual mean temperature anomalies across the country (Figure 1) were slight warmer than average, between 0 °C and 1°C except few locations in the Lake Victoria region, and northern coast of the country.

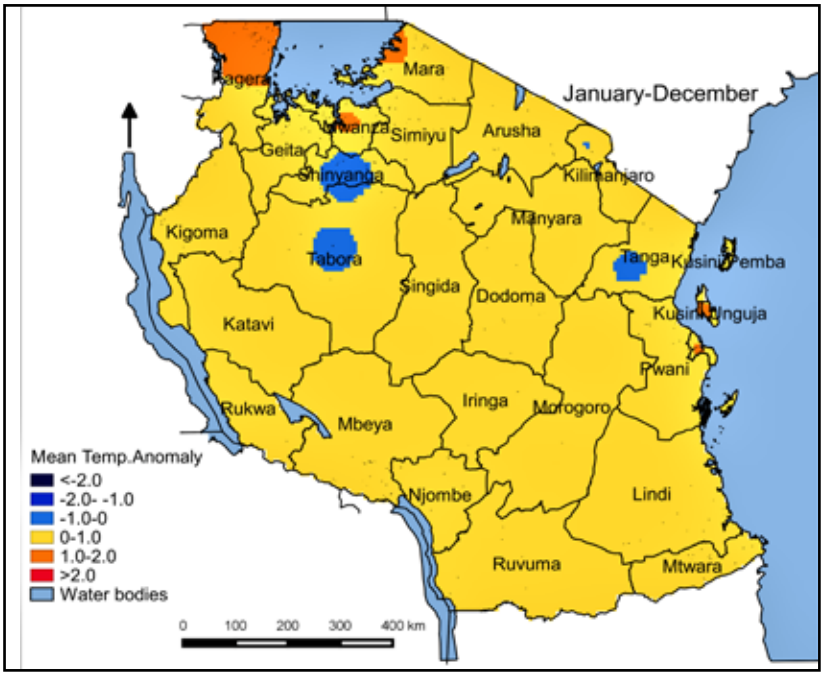

Figure 1: Annual mean temperature departures (°C) for 2020 from long-term average.

The country annual maximum temperature (Tmax) was 28.4 °C which is 0.2 °C higher than long-term average but lower than 2019 by 0.4 °C. The anomalies (Figure 2 right) were above long-term average in the range of 0°C and 1 °C in the southern half of the country, coastal line including Unguja island, and east and western parts of the Lake Victoria. However, central, west, northeastern highlands, Pemba island, and southern parts of Lake Victoria experienced temperature anomaly between 0 °C and 1°C below average.

On the other hand, the country annual minimum temperature (Tmin) was 18.9 °C which is 1 °C warmer than long-term average. The anomalies (Figure 2 left) were above long-term average in the range of 1 °C and 2 °C on areas surrounding Lake Victoria, northeastern highlands extending to Dodoma region, southern Morogoro, eastern parts of Iringa and Njombe, Ruvuma region and coastal areas including Unguja and Pemba islands. but was between 0 °C and 1°C, in the remaining parts of the country.

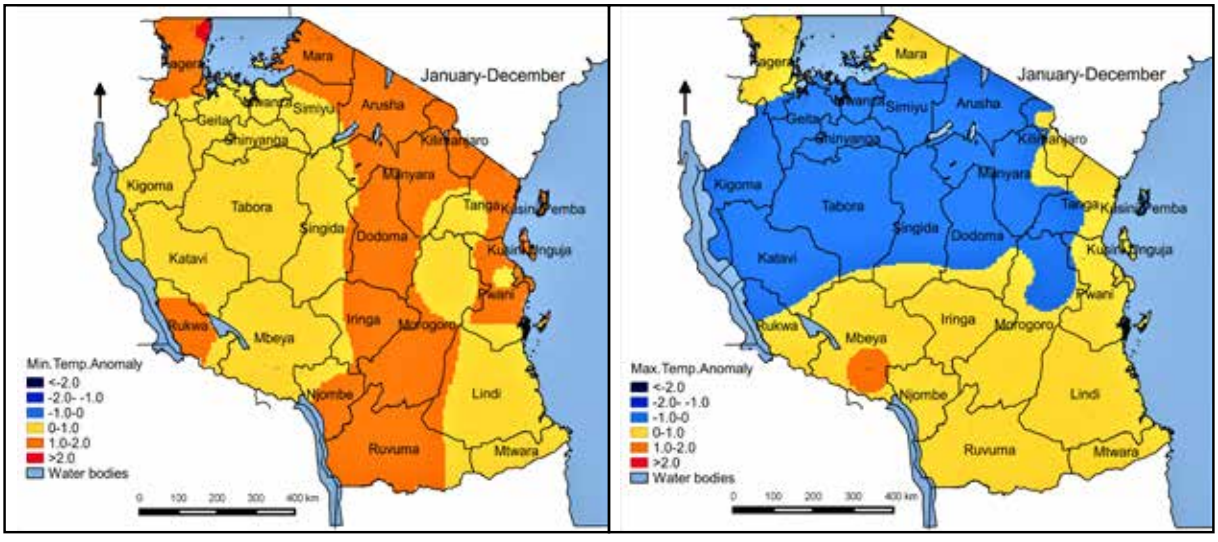

Figure 2: Annual minimum (left panel) and maximum (right panel) temperature departures (°C) from long-term average for 2020.

2.2 Monthly Mean Temperature anomalies

During 2020, June and October were the warmest months with the country mean temperature anomaly of 0.9 °C above long-term average. The observed warming in June mean temperature is mainly due to anomalously warmer minimum temperatures observed (1.3 °C above average) when compared to maximum temperature anomaly (0.6 °C above average). However, observed warming in October mean temperature is contributed by the anomalous warmer maximum (0.8 °C above average) and minimum temperatures (1.0 °C above average). In addition, historical meteorological observations in the country indicated that June 2020 was the sixth warmest month on record since 1970.

2.3 Monthly Maximum Temperature anomalies

The country monthly maximum temperatures were slightly warmer than average except on January, March, April, July, and November in which large part of the country observed below average temperatures. The highest anomalies of 0.8 °C were observed in June and October while anomaly of 0.6 °C was observed in August. The spatial distribution of temperature anomaly (Figures 3a and 3b) indicates that, temperature departures were between 0 °C and 1.0 °C below average over large part of the country except southern parts and coastal areas during January, March, July, and November. But the cooling was confined over northern parts of the country during February and April, and over central and western parts of the country during May, June, and December. The observed cooling condition in these months especially January and March may partly be linked to reduced incoming solar radiation due to enhanced cloud cover and unusual heavy rainfall events observed in these months.
However, during May, June, August, September, and October, temperatures were between 0 °C and 1.0 °C above average across the country except in few locations in the western and central parts. The highest monthly maximum temperature anomalies of around 2.0 °C were observed over Mbeya region in almost all months except July, November, and December. Specifically, anomalies exceeding 2.0 °C were observed over few locations in Mbeya region during February, April and the lowest anomalies reaching -2 °C were observed over northeastern highlands during January to April but extending to southern parts of Lake Victoria during March.

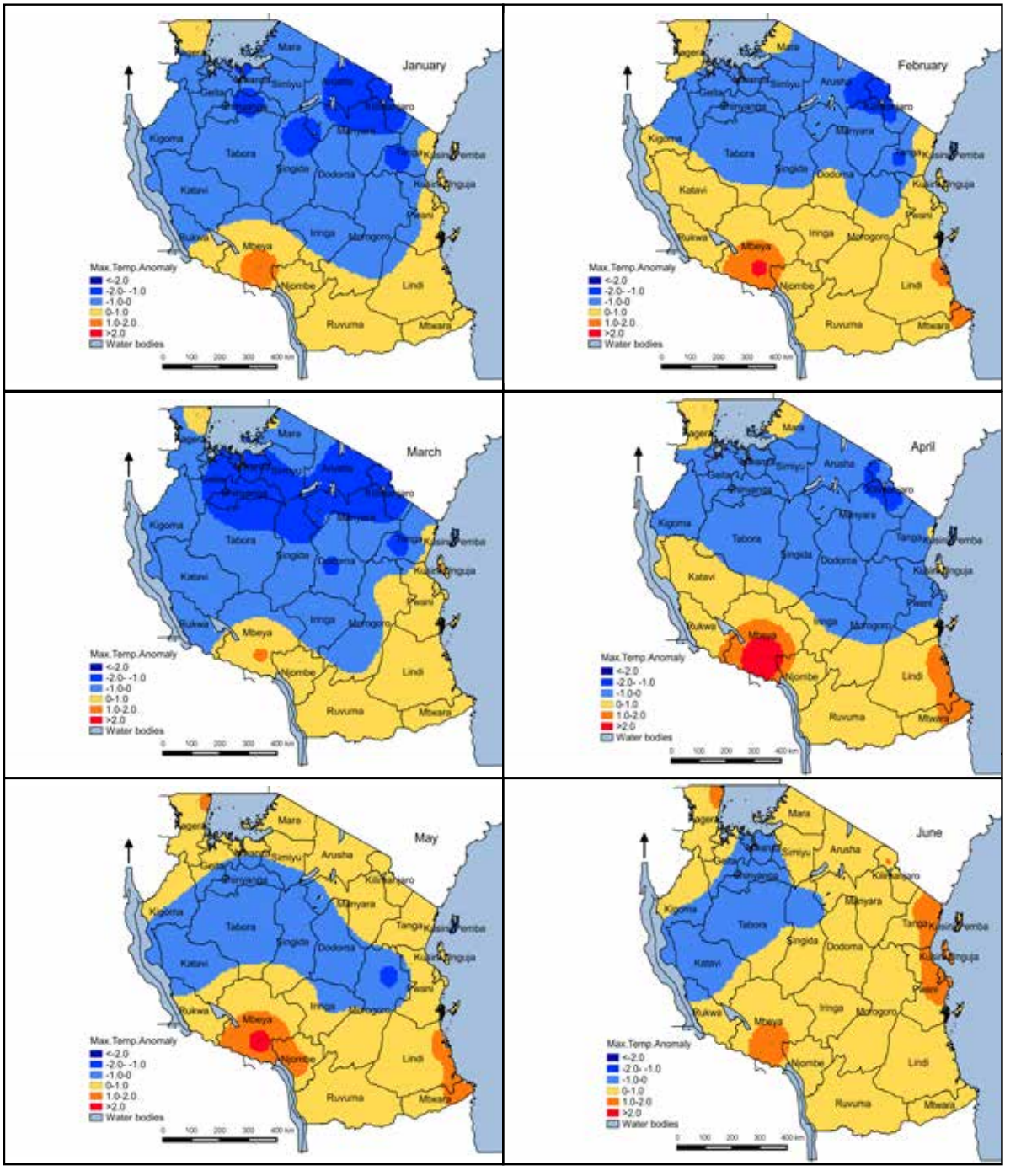

Figure 3a: Monthly maximum temperature departures from long-term average (°C) for January–June 2020.

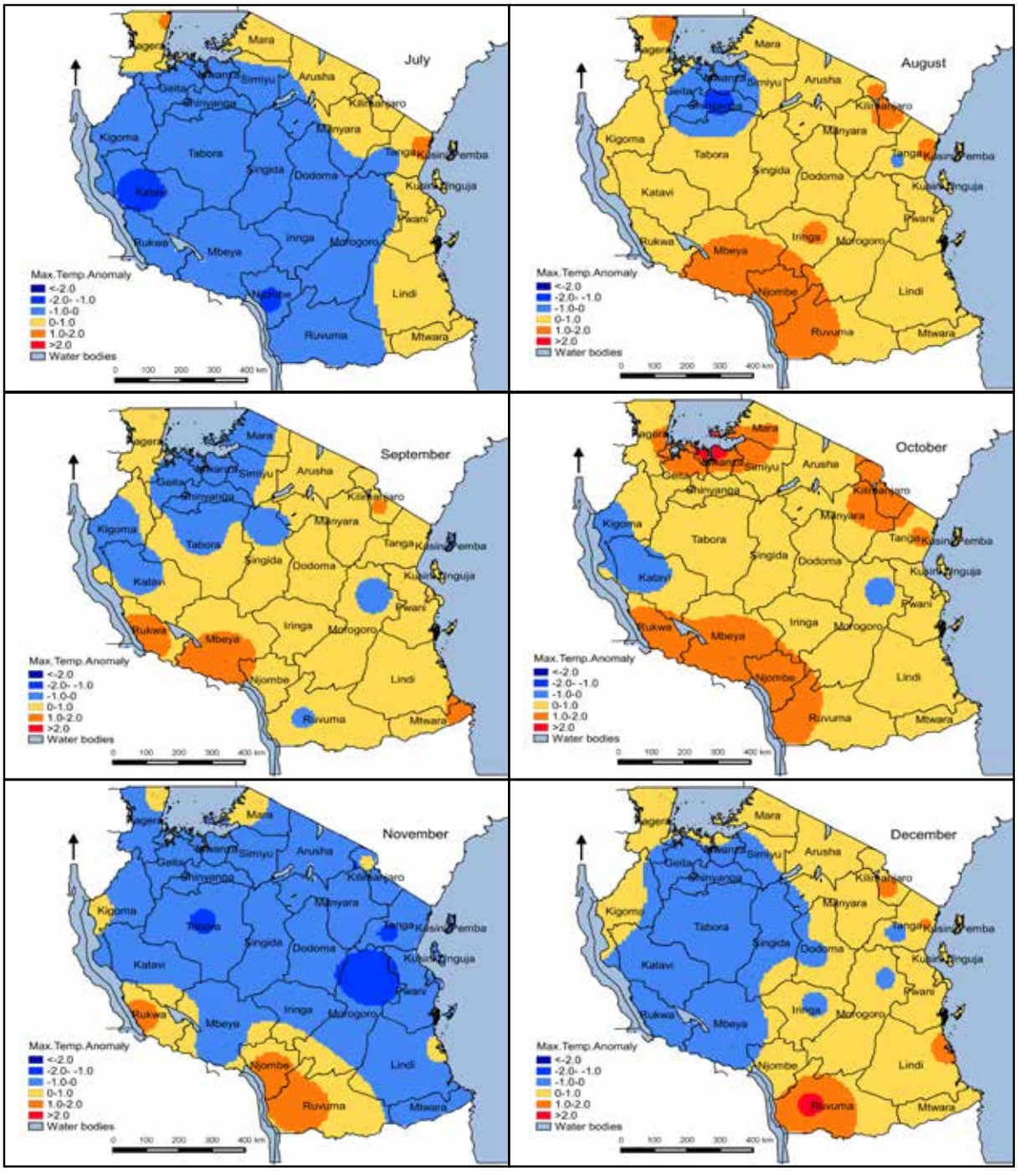

Figure 3b: Monthly maximum temperature departures from long-term average (°C) for July–December 2020.

2.4 Monthly minimum temperature anomalies

The country monthly minimum temperature anomalies (Tmin) were higher than average for all months with higher anomaly of 1.3 °C recorded during June. The spatial distribution of minimum temperature across the country indicates that, warmer than average temperatures between 1°C and 2 °C were recorded over large parts of the country during January, February, March, April, June, July, September, and October. Whereas slight warmer than average temperatures ranging between 0 °C and 1°C were observed over large part of the country during May, August, November, and December (Figures 4a and 4b).

The highest Tmin anomalies exceeding 2 °C were observed over few locations in Kagera region from January to August, over Mbeya region during September and over northern coast including Unguja and Pemba Islands during June, July, September, October, and November. Whereas lowest anomalies of around -1 °C were observed over few locations in west, southwestern and Lake Victoria in the period between January, February, and May and between July and December. For example, the highest monthly Tmin anomaly of 3.5 °C and 3.1°C were recorded over Bukoba and Mbeya meteorological stations during July and September, respectively. On the other hand, the lowest Tmin anomaly of 2.3 °C was observed over Mbeya during February.

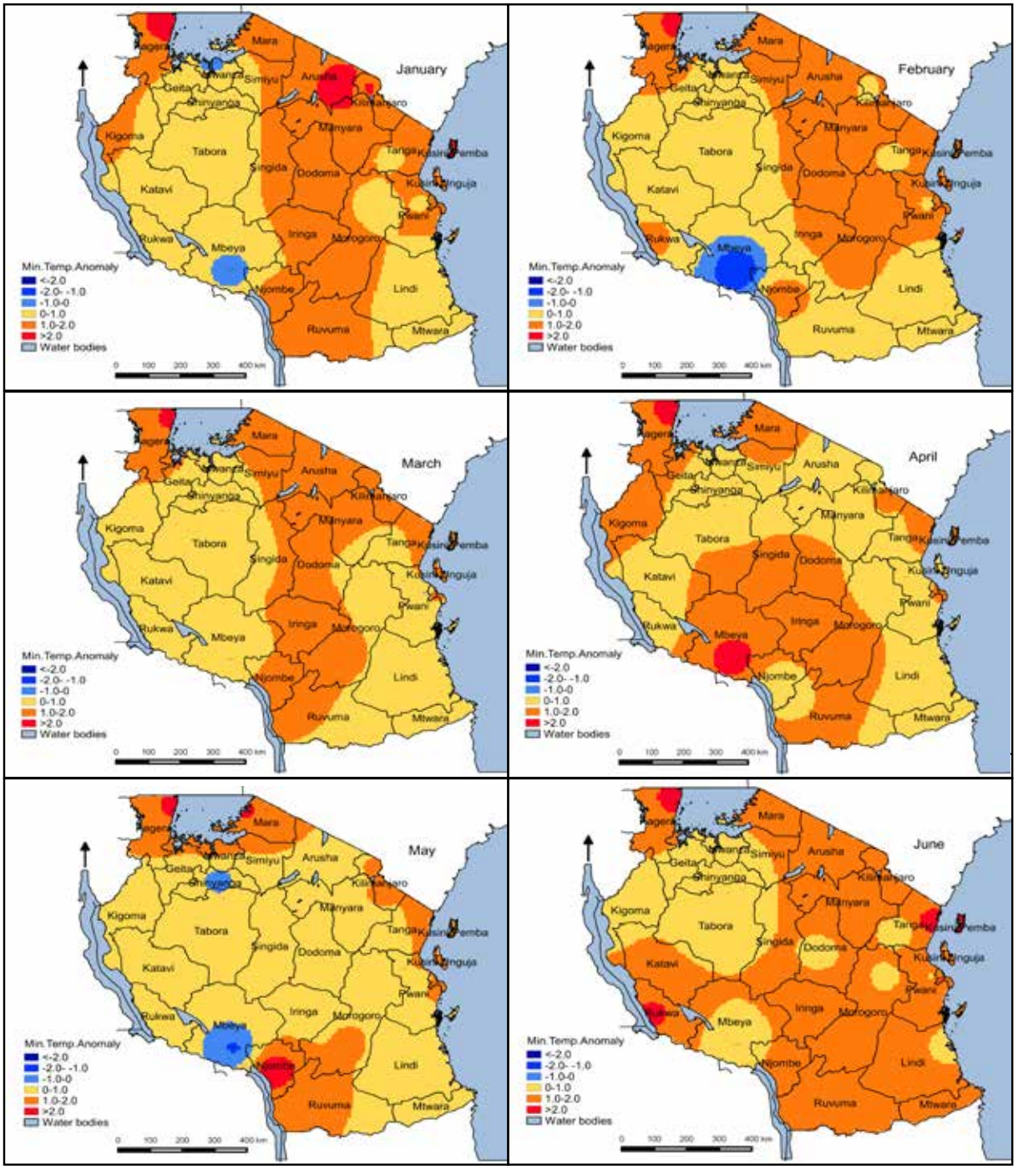

Figure 4a: Monthly minimum temperature departures from long-term average (°C) for January to June 2020.

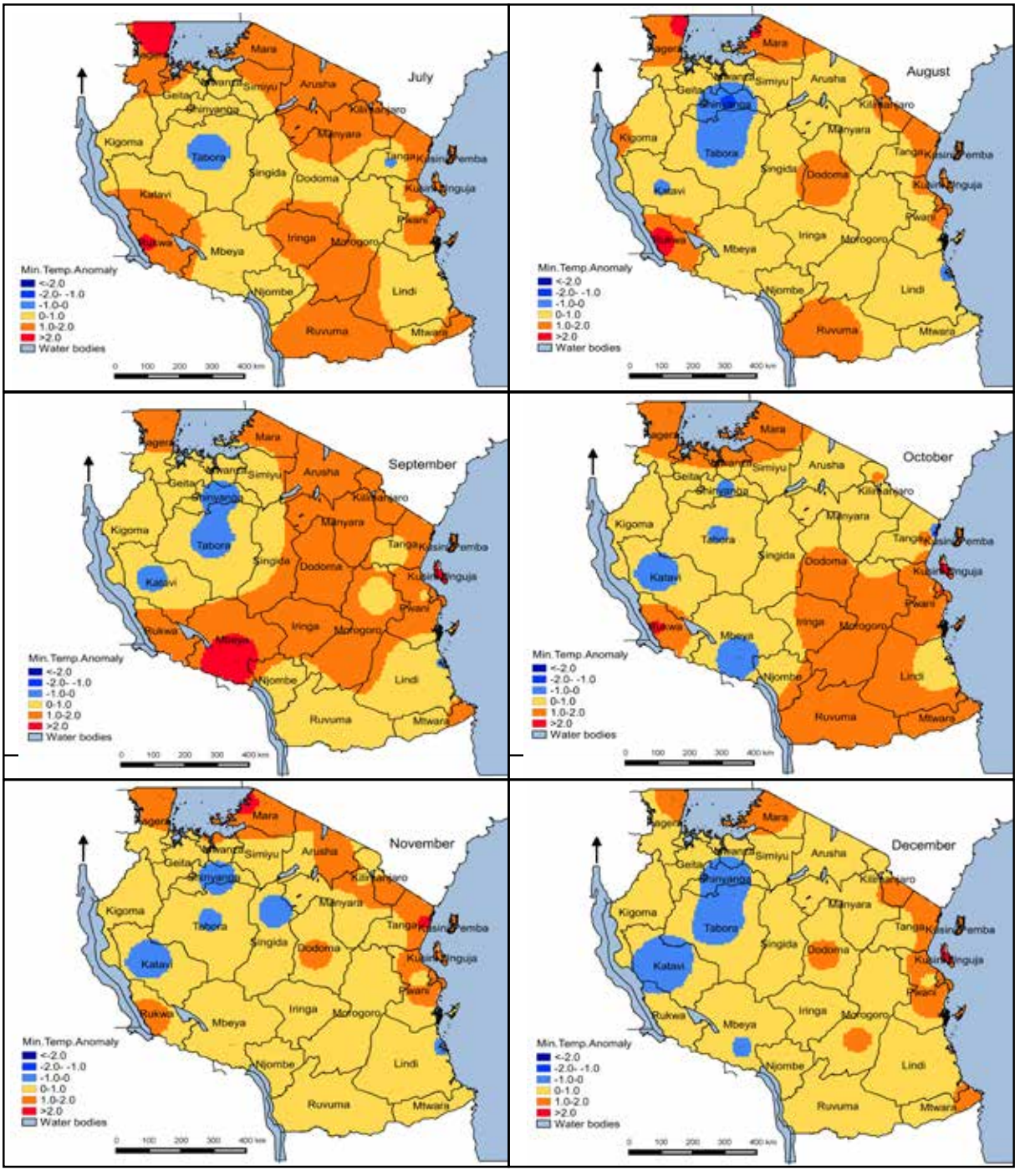

Figure 4b: Monthly minimum temperature departures from long-term average (°C) for July to December 2020.

3. Rainfall distribution

Above normal rainfall was observed over large part of the country during November 2019 to April 2020 (NDJFMA) and MAM rainy seasons, and the rains were associated with the widespread flooding over many areas across the country. However, mainly normal rainfall was observed over the bimodal areas except few locations in northeastern highlands during October–December (OND) rainy season. On average March was the wettest month by recording rainfall exceeding long term average by 100 mm equivalent to 163.6% of the 1981–2010 average while May and December were the driest months especially for bimodal areas. The country rainfall amounts received in these months are lower than long term average by 26.6 mm and 21.2 mm equivalent to 74% and 85% of the long-term average.

3.1 Annual Rainfall distribution

The country total rainfall for 2020 was 1,227 mm, which is 198 mm above the long term (1981–2010) average and equivalent to119.3% of average. This observation makes 2020 to be the fifth wettest year on record since 1970. Most parts of the country received above average rainfall, except for the northern coast, northeastern highlands, and western parts of the Lake Victoria extending to Kigoma region that received normal rainfall. Normal rainfall was also observed over few locations in Njombe, Morogoro, Mtwara, and Rukwa region. The year 2020 was particularly wet across parts of central Tanzania. Notably Dodoma, Singida and Iringa meteorological stations which received 192%, 162 % and 202 % of the long-term average and around 150% at a few individual locations along the coast (Dar es Salaam and Kilwa).

The spatial distribution of rainfall (Figure 5) expressed in percentage of average indicates that, large parts of the of the country received above normal rainfall ranging between 125% and 150% of average, while few locations received normal rainfall in the range of 100% and 125% of long-term average.

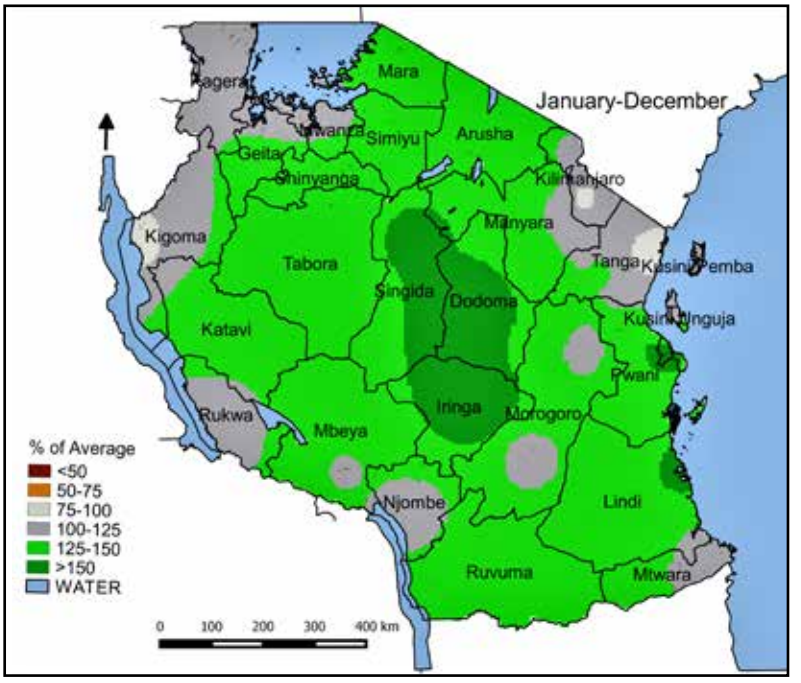

Figure 5: Annual rainfall anomalies for 2020 expressed as a percentage of the long-term average.

3.2 Seasonal Rainfall distribution

Large part of the country recorded above normal rainfall during NDJFMA (2019 - 2020) and MAM 2020 rainfall seasons while mainly normal rainfall was observed over the country during OND rainfall season (Figure 6). Over large part of the country, the observed rainfall amounts were between 150 % and 175 % of average during NDJFMA season but in the range of 125% to 150% of average during MAM season. In both seasons higher rainfall amounts exceeding 175% of long-term average were observed over Dodoma, Singida, and Iringa regions but extended to few locations in northeastern highlands and coastal areas during NDJFMA season as indicate in Figure 6 (top and bottom left panel).

Notably the NDJFMA (2019-2020) rainfall season broke the record of the highest rainfall total since 1970, by receiving around 450 mm of rainfall higher than the long-term average, which is equivalent to 156% of long-term average. This amount of rainfall was contributed by heavy rains that fell during December 2019 through April, 2020 as depicted in Figure 6 (Top left panel) and Figure 7a.

During the transition period January and February 2020 (Figure 6 top right panel), many

parts of the country received above normal rainfall in the range of 150 % and 175 % of the long-term average. However, higher than 175% of average was recorded over the bimodal areas indicating that the areas received off season rainfall.

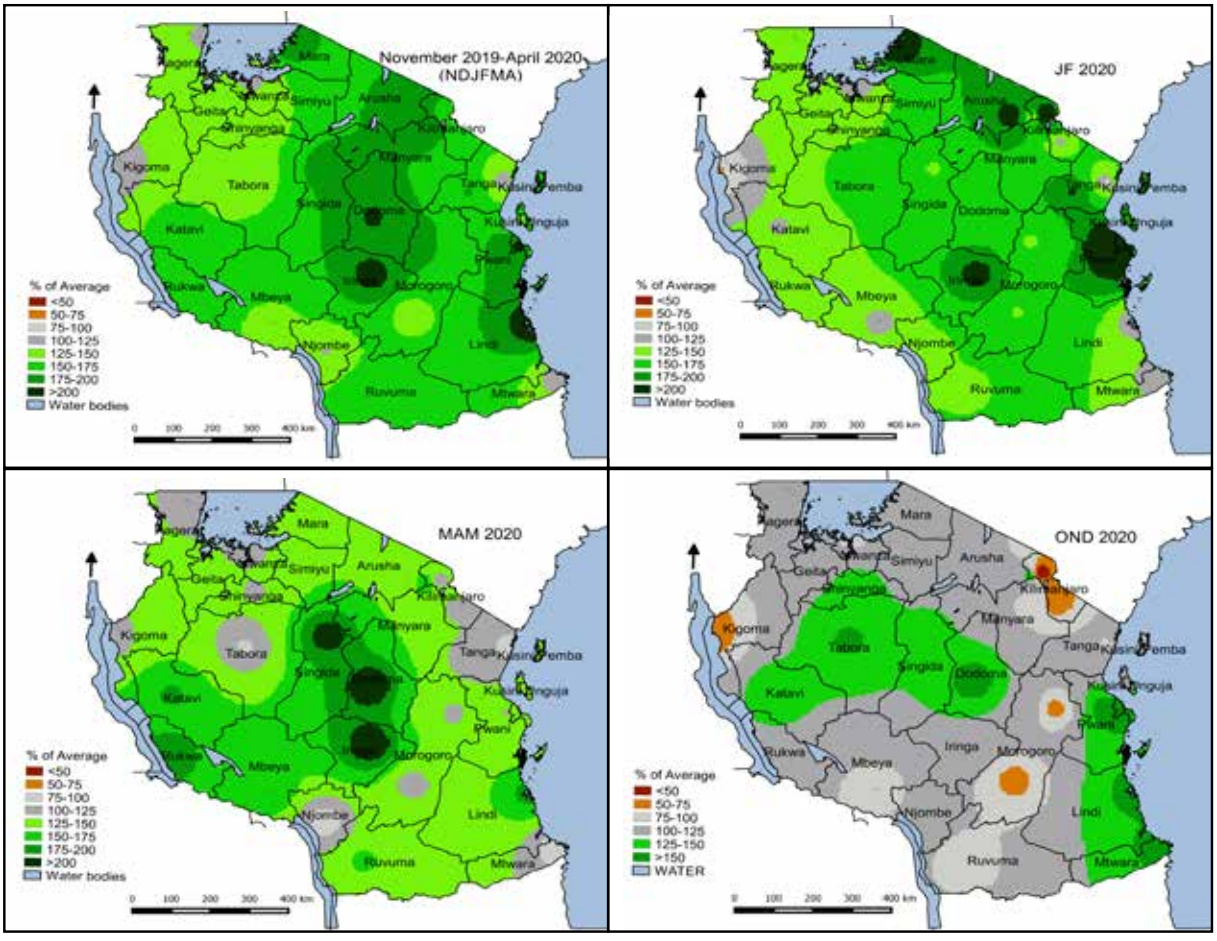

Figure 6: Seasonal rainfall distribution during 2020, expressed as percentage of long-term average for November, 2019 to April, 2020 (top left panel), January and February, 2020 (top right panel), March to May, 2020 (bottom left panel) and October to December, 2020 (bottom right panel).

3.3 Monthly Rainfall distribution

March 2020 was the wettest month by recording rainfall exceeding the long term average by 100 mm which is equivalent to 164%. Other wetter months were January, February, April, and November which had rainfall amounts exceeding 72 mm, 50 mm, and 67 mm equivalent to 150% 146% 134% of the long-term average, respectively. However, May and December were relatively dry months especially over bimodal areas. These areas received lower amount of rainfall with respect to long term average by 26.6 mm and 21.2 mm, equivalent to 74% and 85% of the long-term average, respectively.

The spatial rainfall distribution maps (Figure 7a and 7b) show that in January, March, and November large part of the country received rainfall amounts exceeding 150% of long-term average, but only few locations in Singida, Morogoro, Dodoma, Katavi, Rukwa, Dar es Salaam, and Pwani received this amount during February and April. Higher rainfall amounts exceeding 200% of long-term average were recorded over the northern coast including Unguja and Pemba islands, northeastern highlands and eastern parts of Lake Victoria in January and over northeastern highlands extending to central parts of the country and few locations in the southwestern highlands, and southern coast in February, March, April, and November.

Lower than average rainfall (less than 75 %) was recorded in May and December, and were confined over the north-eastern highlands, northern coast (including Unguja island), eastern part of Lake Victoria, central and southern half of the country. However, well below normal rainfall (below 50% of average) and above normal rainfall (exceeding 200% of average) recorded over most areas of the country during June, July, August, and September (Figures 7a and 7b) should not be translated to be drier or wetter condition, because these months are climatologically dry, although occasional rains do occur.

Noting that, the bimodal areas received off season rainfall that exceeded 200 % of long-term average during January 2020, while unimodal areas especially southern parts and few locations in the western parts of the country received off season rains during October, by recording rainfall amounts exceeding 175 % of the long-term average.

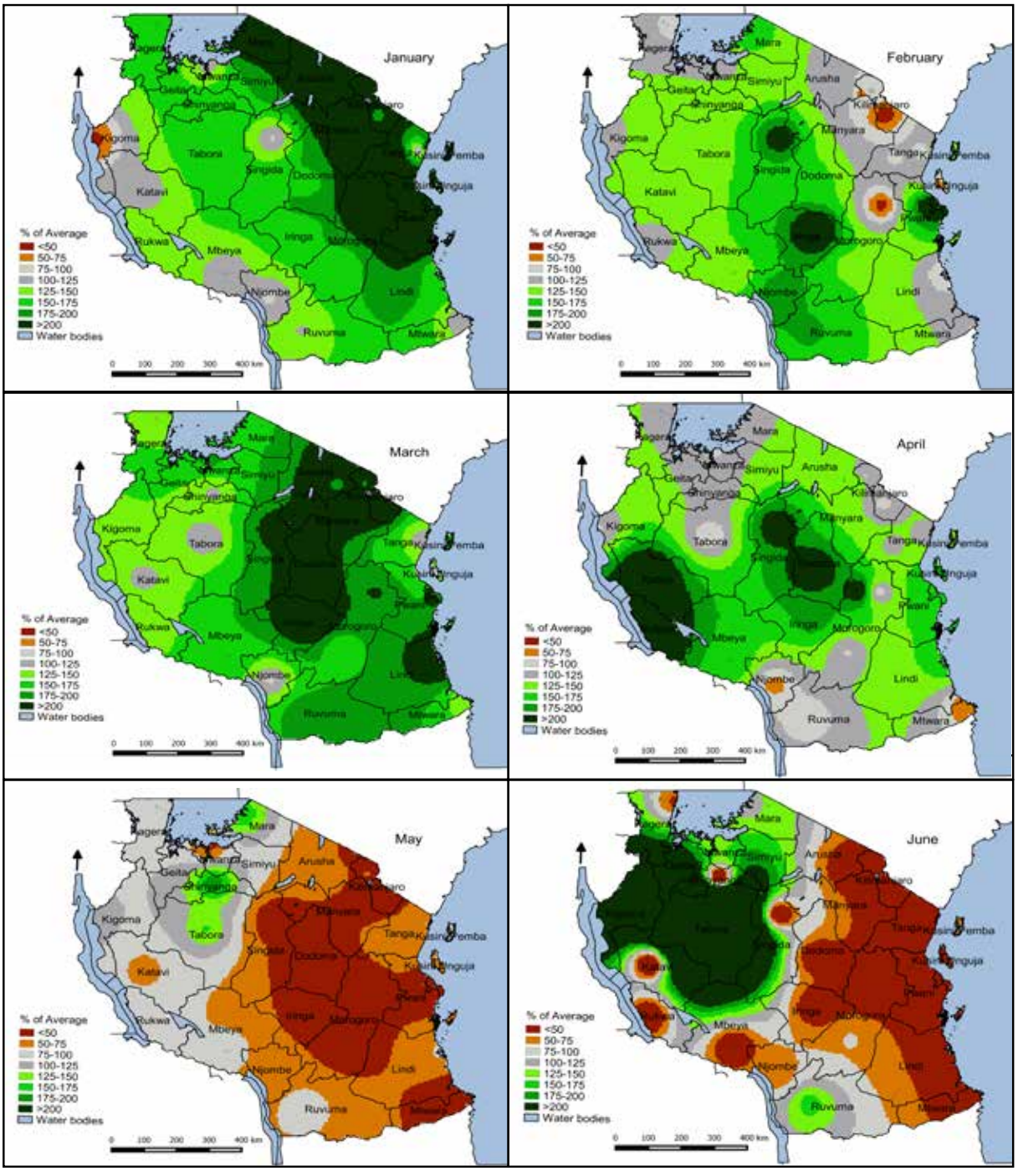

Figure 7a: Monthly rainfall distribution expressed as percentage of long-term average for January to June 2020.

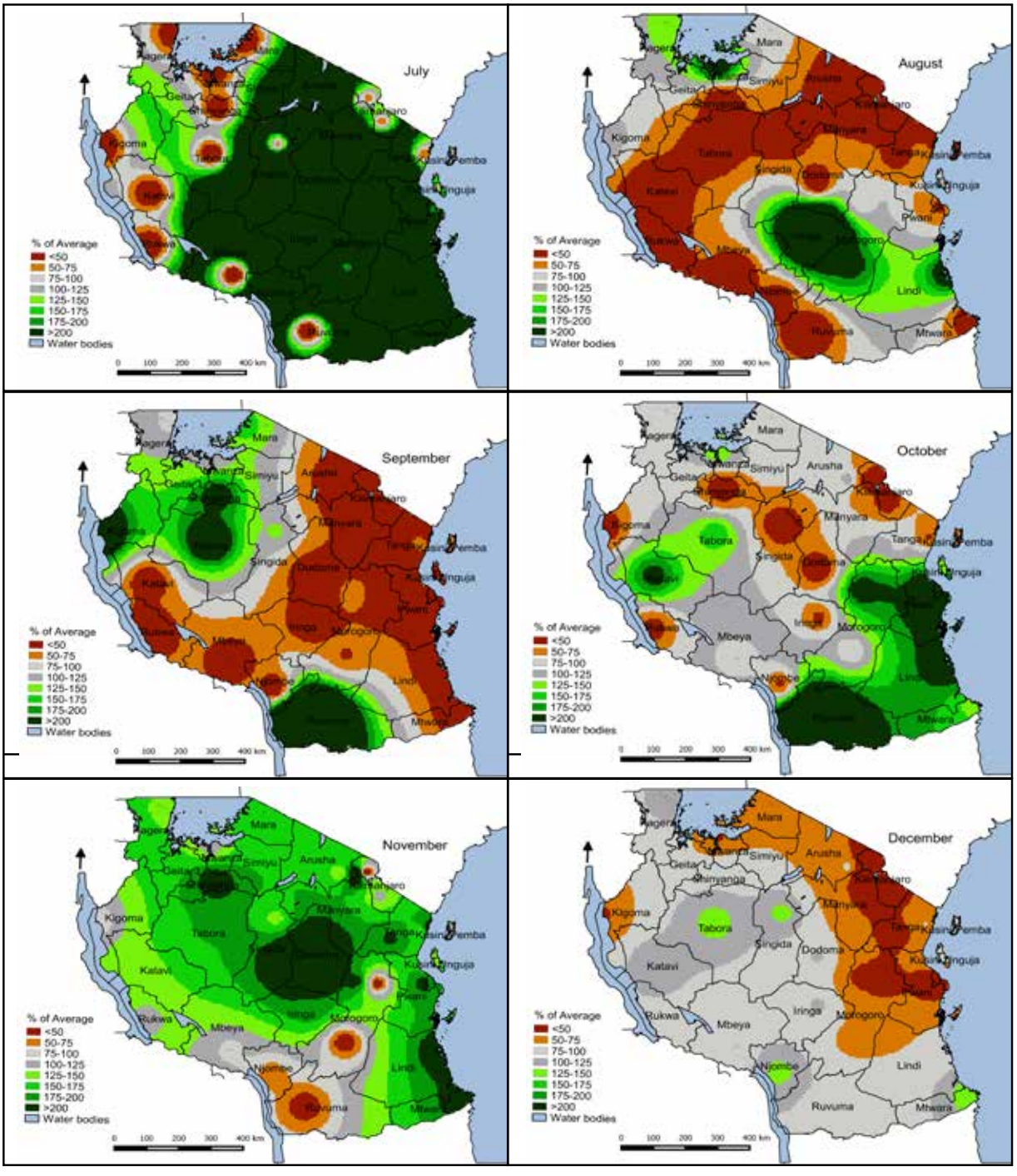

Figure 7b: Monthly rainfall distribution expressed as percentage of long-term average for July to December 2020.

In this report cumulative rainfall analysis is used to characterize observed rainfall performance and trends for different areas in the country. The cumulative rainfall departure from long-term average provides an indication of either insufficient or abundant rainfall during the season. On average, the cumulative rainfall plots for 2020 indicate that most parts of the country received higher rainfall amounts compared to the previous year (2019) as well as the long-term average for NDJFMA and MAM seasons.

During NDJFMA (2019-2020), the seasonal rainfall accumulation for most stations in the unimodal areas (west, central, and southern parts of the country), were above long-term average except Mtwara station that received rainfall total near to long-term average (Figure 8a). Particularly, higher than average seasonal total rainfall amount of at least 600 mm was observed at Songea, Iringa, and Dodoma but also on other stations (not included in the figure) such as Mahenge and Kilwa. This indicates that, sufficient rains were observed over central and southern parts of the country when compared to NDJFMA (2018–2019) rainy season.

In the MAM season, the rainfall accumulation for most stations in the bimodal areas (Morogoro, Arusha, Musoma, Shinyanga, Moshi and Zanzibar (Unguja and Pemba islands) were above the long-term average. However, rainfall for stations like Tanga, Bukoba, Mwanza, Shinyanga (Figure 8b) were nearly comparable to long-term average. Higher than average seasonal total rainfall was recorded over few locations in the northern coast. For example, Dar es Salaam (JNIA) and Zanzibar airport meteorological stations recorded rainfall amounts approximated to 250 mm higher than long term average. In addition, the temporal evolution of rainfall during the season indicates that, the rainfall events remained above average throughout the season.

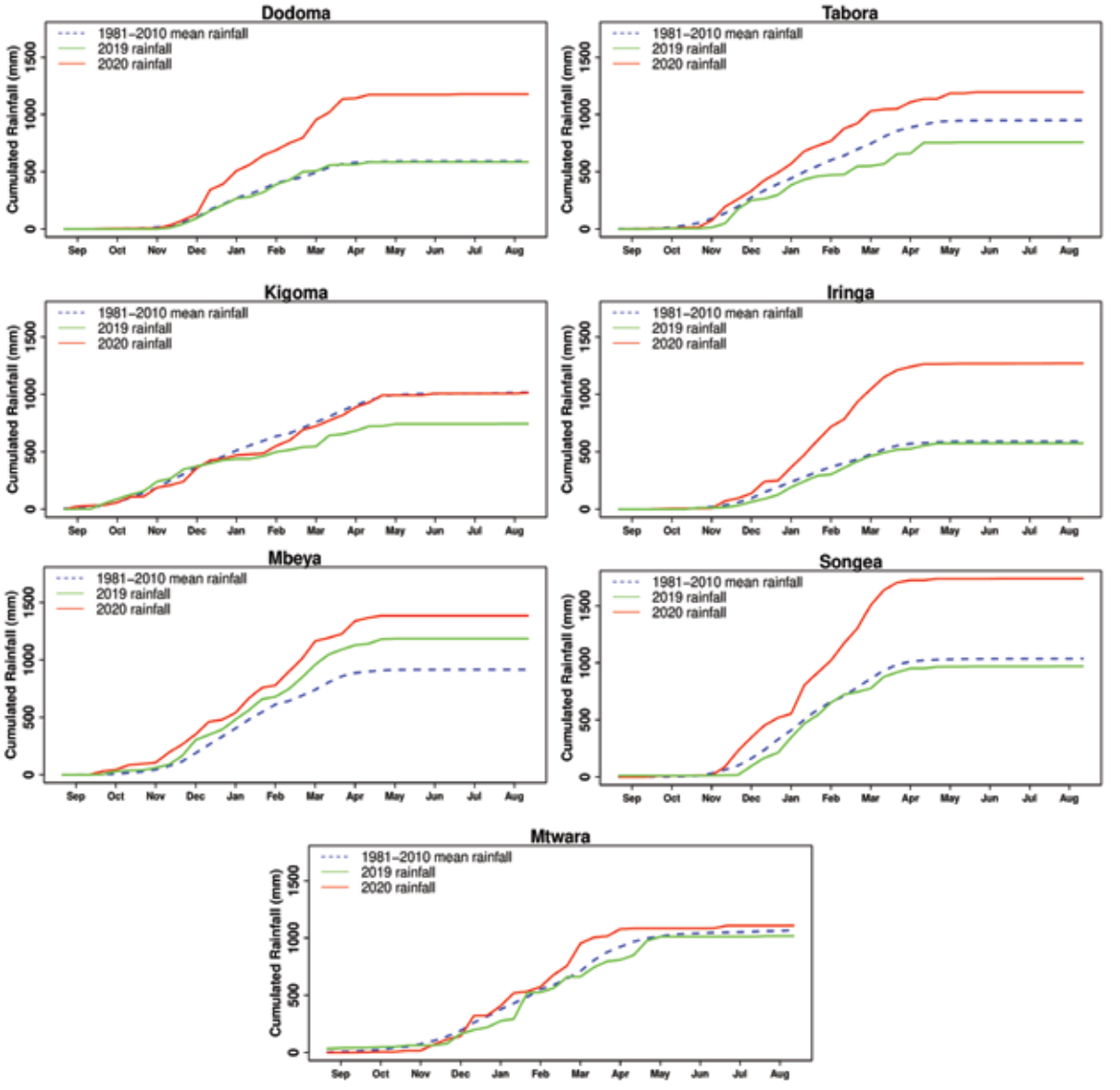

Figure 8a: Cumulative rainfall plots for NDJFMA season for Dodoma, Tabora, Kigoma, Iringa, Mtwara, Mbeya and Songea meteorological stations presented as accumulation of dekadal rainfall totals for each month starting from September 2019 to August 2020.

In contrast, during OND season most stations in the bimodal areas (Zanzibar, Arusha, Morogoro, Mwanza, Bukoba, Tanga and Musoma) received near average seasonal total rainfall except Kibaha, Dar es Salaam, and Shinyanga which recorded above long-term average rainfall (Figure 8c). On average, the OND 2020 total rainfall across many stations was lower than that of 2019 except for Kibaha and Dar es Salaam meteorological stations that received nearly equal amount of rainfall in both years especially during October and November.

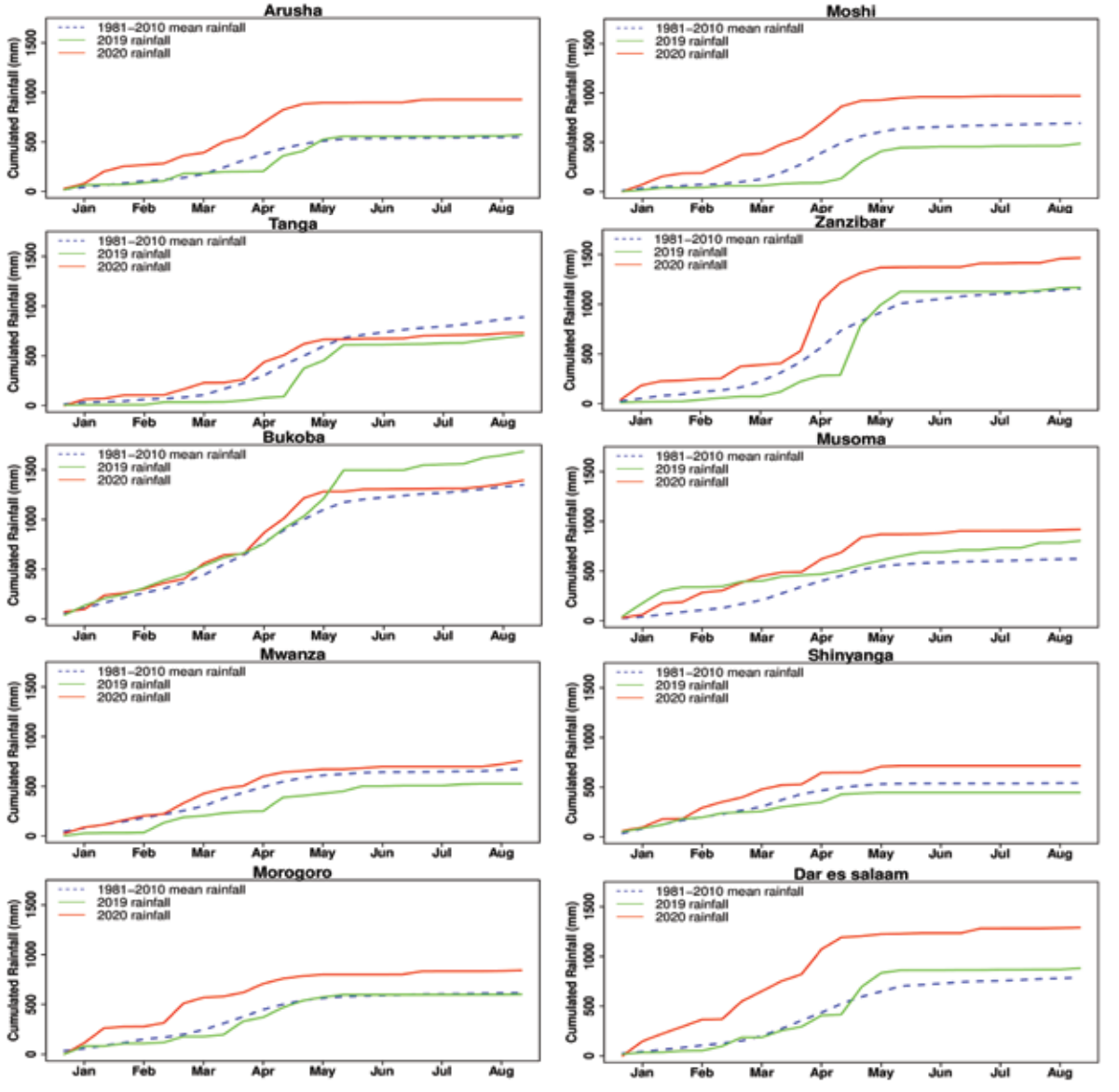

Figure 8b: Cumulative rainfall plots for MAM season for Bukoba, Mwanza, Musoma, Shinyanga, Dar es Salaam, Morogoro, Tanga, Zanzibar, Arusha and Moshi meteorological stations presented as accumulation of dekadal rainfall totals for each month starting from January to August 2020

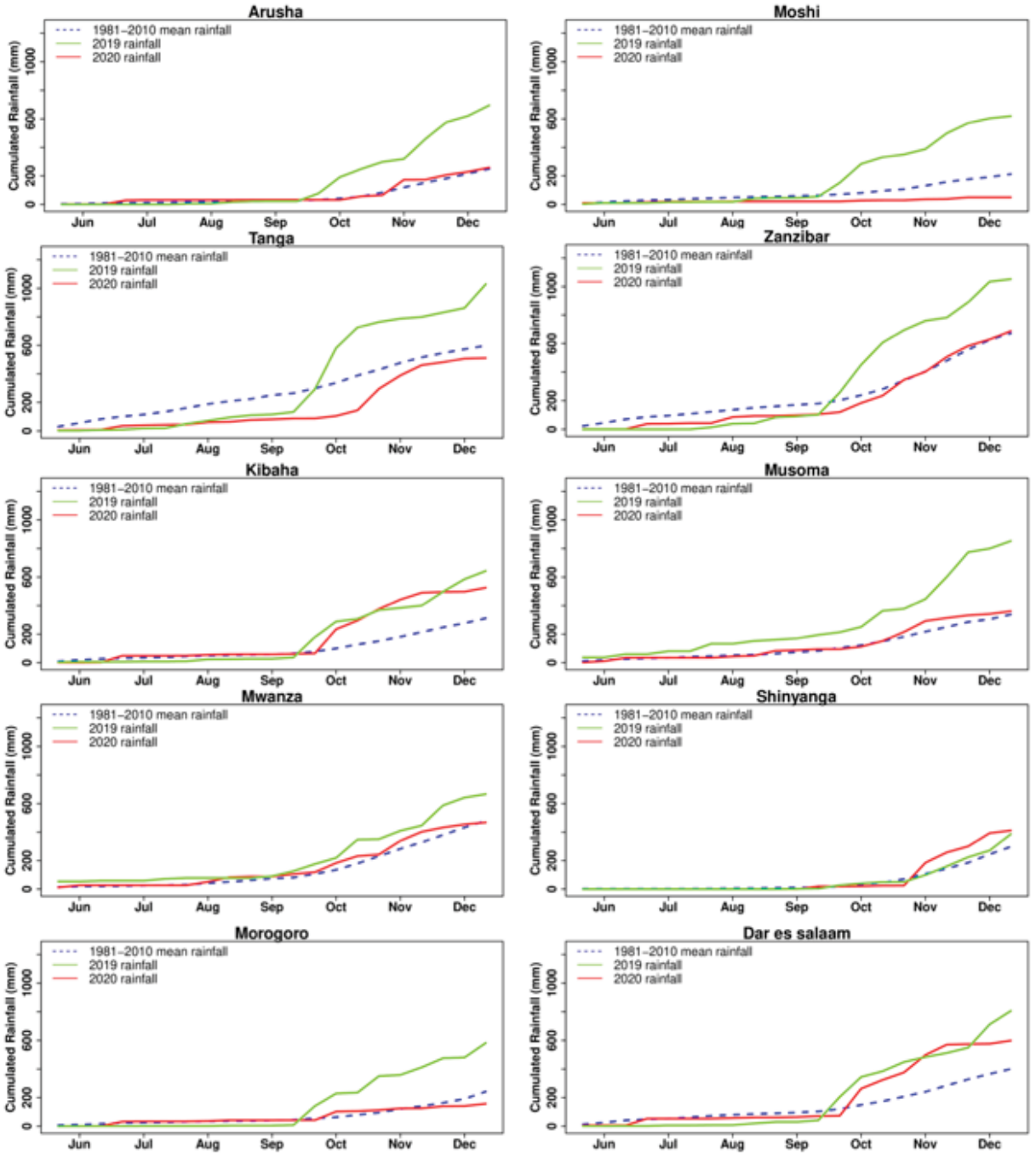

Figure 8c: Cumulative rainfall plots for OND season for Bukoba, Mwanza, Musoma, Shinyanga, Dar es Salaam, Morogoro, Tanga, Zanzibar, Arusha, and Moshi meteorological stations presented as accumulation of dekadal rainfall totals for each month starting from June to December 2020.

4. Extreme Weather and Climatic events

The year 2020 was characterized by highly destructive extreme weather events particularly heavy rains associated with significant flooding. Heavy rains that persisted over many parts of the country during OND 2019 rainy season continued through the first four months of the year 2020. Widespread floods were observed over many parts of the country even when less amounts of rainfall were observed. This could be associated to saturation of soil or other factors.

4.1 Extreme Rainfall and Flood events

Between 23rd January and 13th February 2020, a series of heavy rainfall events were observed over most parts of the southern and southwestern Tanzania. Unusual and widespread flood events with severe socio-economic impacts were reported in different parts of the country. In many affected areas, floods were mainly associated with flooded rivers crossing those areas and due to saturation of the soil by receiving excess water.
Heavy rainfall of 106.6 mm was recorded in Songea (Ruvuma region) on 23rd January 2020, this amount is the third highest for January but fourth on record since 1956 when the station was established. Moreover, heavy rainfall amounts reaching 93.6 mm and 92.7 mm were recorded over Mahenge and Naliendele meteorological stations on 5th and 25th February 2020, respectively.

During March 2020, several cases of extreme rainfall events occurred in 24 hours were reported in different parts of the country. For instance, 138.8 mm was recorded at Mahenge meteorological station on 1st March 2020, which was the third highest amount recorded for March but twelfth on record since the station started operations in 1993. In addition, 122.5 mm was recorded on 23rd March 2020 at Kilwa meteorological station, this amount was the highest on record for March, but second highest on record since the station was established in 2005. Furthermore, on 22nd March 2020, a total of 103.9 mm being the fifth on record since 1956 was recorded at Songea meteorological station. Generally, there were about 40 extreme or heavy rainfall events (rainfall amount greater than 50 mm) that were observed in March 2020.

In April, extreme rainfall events were mainly confined in the northern parts of the country (bimodal areas), about 42 extreme rainfall events with rainfall amount exceeding 50 mm were recorded in this month. Few events indicated nearly record break. For example, on 17th April 2020, a total of 202.6 mm of rainfall was reported at Zanzibar meteorological station, being the 5th highest for April but 6th on overall record since the station was established in 1952. On the same date, 17th April 2020, a total of 121.3 mm of rainfall was recorded in Dar es Salaam (JNIA), this amount is the 4th highest for April but 11th on overall record since the station was established in 1949.

Moreover, high rainfall amounts of 132.7 mm and 134.8 mm were recorded within 24 hours over Lyamungo agrometeorological station (northeastern highlands) on 19th and 21st April 2020, respectively. These amounts are ranked number 13th and 10th on record for April but 23rd and 19th on overall record respectively, since the station was established in 1937.

In the northern coast, a total of 124.2 mm of rainfall was recorded on 11th April 2020, at Pemba meteorological station. This is the 10th highest amount for April but ranked 34th on record since the station was established in 1974. Likewise, on 29th April 2020, a total of 156.6 mm of rainfall was recorded at Dar es Salaam port meteorological station, which is the 3rd highest for April but 4th highest on overall record since the station was established in 1982.

Although October and December 2020 were relatively dry especially for bimodal areas, still heavy rainfall amounts reaching 108.4 mm, 107.0 mm, and 109.8 mm in 24 hours were recorded at JNIA, Dar es Salaam Port, and Kibaha meteorological stations on 13th October 2020, respectively. Likewise, 128.8 mm of rainfall was recorded at Mtwara meteorological station on 27th December 2020. Generally, four events with rainfall amount exceeding 50 mm were reported in October, 10 in November, and seven in December.

4.2 Extreme Temperature events

In the year 2020, the number of higher daily maximum temperature (Tmax) events exceeding 35 °C were minimal compared to 2019 due to continuous heavy rainfall that was observed over many parts of the country during hot months (January, February, and March). Generally, 7 events of higher temperatures exceeding 35°C occurred during January (compared to 22 in 2019), 22 in February (compared to 76 events in 2019), 11 in March (compared to 159 events in 2019) and 1 in April (compared to18 events in 2019) and were confined over the northern parts of the country especially the northeastern highlands and the northern coast.

The highest value of day temperature was 37.1 °C observed over Zanzibar meteorological station on 27th February 2020. This temperature is ranked fourth on record since the station was established in 1952, but the highest in this decade. The third, second and first on records are 37.4°C, 38.2°C, and 39.4°C that were recorded in 1992, 2006, and 2007, respectively.

The southwestern highlands region was the coolest part of the country during May, June, July, and August 2020 but not as cool as 2019. Large number of cooler nights (with temperature lower than 5 °C) occurred during July (15 events compared to 32 in 2019), followed by August (13 events compared to 12 events in 2019) and June (3 events compared to 22 events in 2019). These observations indicate that, June 2020 was slightly warmer than July and August. However, the lowest temperature in 2020 was 3 °C observed at Igeri agrometeorological station on 17th July 2020.

Higher night temperatures exceeding 25 °C were observed in January through April and in December 2020 for some stations, especially those situated along the coastal strip. Specifically, higher number of warmer nights (54 events) were observed in January followed by December 2020 (47 events).

5. Major Drivers of Weather and Climate events in 2020

There are two main factors that describe the observed weather and climatic events in 2020, which are the El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). The two-oceanic condition are normally associated with above or below average rainfall condition over East Africa including Tanzania. Other factors occurring at regional scale and even local scale also contributed to the observed climate, severe weather, and extreme climatic events in different parts of the country.

The climate dynamics in the year 2020 was largely dominated by neutral to negative ENSO conditions. Neutral ENSO conditions persisted from January to July, but the sea surface temperatures anomalies (SSTA) over the central Pacific shown in Figure 9 were positive (yellow to red colour) from January to April then turned to negative (blue colour) from May to July. From August 2020, the central Pacific Ocean cooled further down, signifying the beginning of La Niña condition, which persisted through December 2020 as shown in Figure 9 (right). However, the influence of ENSO condition to rainfall in 2020 was minimal, because rainfall activities were mainly dominated by the Indian Ocean behaviors, whereby many parts of the country received normal to above normal rainfall.

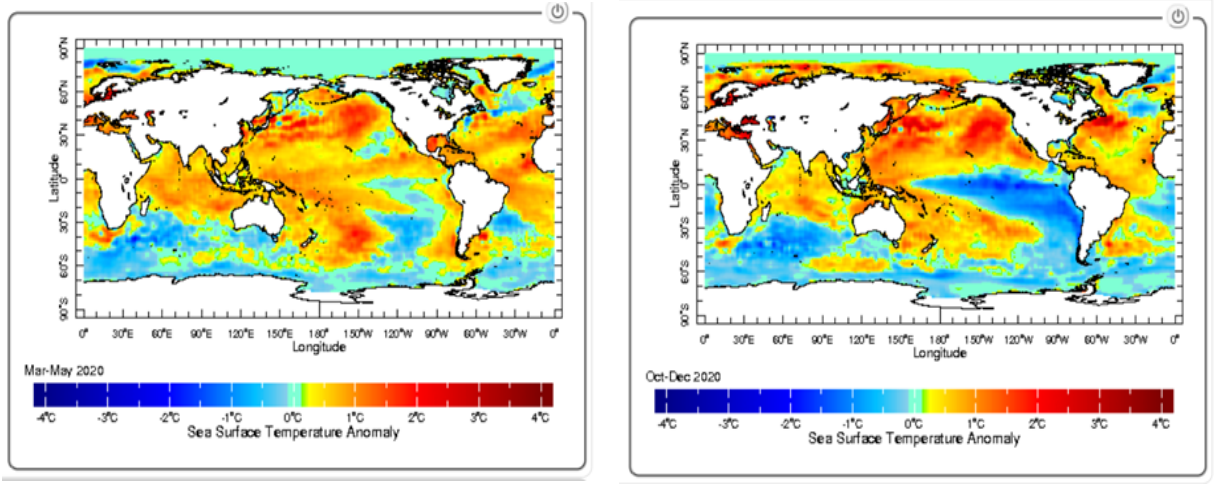

Figure 9: Sea surface temperature anomalies for March-May (left) and October-December (right) 2020, showing Indian ocean basin (red circled) and central Pacific basin (black circled).

Over the Indian Ocean, the positive phase of IOD that peaked in October 2019 switched to neutral phase in February 2020 and persisted through May before it changed back to positive phase in June and back to neutral in July through December 2020. Apart from the fluctuation of the IOD phase across the year, the basin-wide SST warming persisted in the tropical Indian Ocean throughout the year (Figure 9) resulted into the observed off seasonal rainfall during January and February over the bimodal areas. Moreover, this condition favored observed anomalous westerlies in the lower levels especially over the southern part of the country that was seen to prevail throughout the OND season. This in turn allowed westerlies from Congo basin to reach the southern part of the country in addition to moisture influx from the Indian Ocean. As a result, above normal rainfall was observed over the southern coast extending to Dar es Salaam and Pwani regions.

Other drivers such as tropical cyclones in the Indian ocean, the Madden Julian Oscillations (MJO), easterly waves over the Indian Ocean, near equatorial trough in combination with Inter Tropical Convergence Zone (ITCZ) brought significant heavy rainfall over different parts of the country. Apart from global and regional factors the existence of quasi-stationary systems near or within the country are responsible for the occurrence of individual severe events (heavy rainfall) that occurred during 2020.

6. Weather and Climate related impacts

Extensive flood events caused by persisted heavy rainfall were observed over several places of the country in 2020. Noteworthy, events related to heavy rainfall or continuous rainfall occurred in the areas of Lake Victoria, northeastern highlands, Kilwa, northern coast including Unguja and Pemba islands, central, western, and southern parts of the country during January through April and during November and December. Nearly all dams that supply hydroelectric power in the country were flooded beyond their water holding capacity such that they were forced to discharge. This also caused more flood events in the low-lying areas. Likewise, the water level of all major lakes surrounding the country (Lake Victoria and Tanganyika) were observed to increase beyond their normal levels. As a result, many activities undertaken near the lake shores such as fish markets, parks and beaches were affected, and of all many settlements near the lake shores were submerged (Figure 10).

Figure 10: Submerged areas near the Lake Victoria shores (Chato, Geita) (Source: Dr. Sarah E. Osima, February 2020)

In addition, the floods caused major damage to infrastructures (roads and bridges), livelihoods, personal properties, and schools. For example, over 80% of bridges, 1500 houses and 400 acres of farmlands in Iringa district were destroyed by floods. Likewise, at least 20 deaths were attributed to heavy rainfall in Lindi region during January and February 2020. Furthermore, in Zanzibar, MAM 2020 rainy season led to a death toll of 10 people, great number of road culvert were washed away, about 3600 houses were flooded and about 800 houses were damaged leading to significant number of people homeless (RGoZ, Department of Disaster Management, June 2020).

Several infrastructures have been damaged, among them were Kiyegeya bridge at Morogoro which broke down due to heavy rainfall. This caused chaos to passengers and vehicles which were shuttling between Dar es Salaam and Dodoma (Figure 11).

Figure 11: Kiyageya bridge damaged because of heavy rainfall on 2nd March 2020. (source: TANROAD)

Mudslides from the Mount Meru slopes down to the Malula village occurred on 23rd April 2020, because of heavy downpour in Arumeru District in Arusha Region. Two (2) deaths were reported, and fifty (50) houses were severely damaged. In addition, at least five (5) deaths were reported in Kilimanjaro region and more than 100 people lost their home due to flooding on 25th April 2020 (Figure 12).

Figure 12: The impact of heavy rainfall at Arumeru which lead to 2 deaths and damage to 50 houses (Source: Nipashe newspaper on 24th April 2020)

On 13th October 2020, in Dar es Salaam at least 12 people found dead, 800 houses affected, and 107 houses were washed away by floods caused by heavy rainfall events which occurred on that day (Figure 13).

Figure 13: Impacts of heavy rainfall caused floods at Mandela road part of Mfugale flyover on 13th October 2020 (Source: Habari Leo, 14th October 2020).

7. Summary and Conclusion

In 2020, the country was generally wet across all rainy seasons i.e NDJFMA (Msimu), MAM (Masika) and OND (Vuli). The annual rainfall records show that 2020 was the fifth wettest year on record since 1970. During this year areas which normally receive little rainfall recorded above normal rainfall especially over central parts of Tanzania (Dodoma and Singida regions).

Above normal rainfall was observed over large part of the country during NDJFMA (2019-2020), and MAM rainy seasons, and the rains were associated with widespread flooding over many areas across the country. In particular, the NDJFMA (2019-2020) rainfall season broke the record for the highest NDJFMA rainfall total since 1970. However, bimodal areas were observed to have normal rainfall except over few locations in northeastern highlands during OND. Particularly, higher than average seasonal total rainfall amounts of at least 600 mm was observed over Songea, Kilwa, Iringa, and Dodoma but also on other stations in the southern parts of the country during NDJFMA rainy season. On average March was the wettest month while May and December recorded widespread below normal rainfall especially for bimodal areas.

In terms of temperature the country was relatively cooler in 2020 during warm months (January, February, March, and April) and was slightly warmer during cool months (June, July and August) than 2019. Warmer temperatures were experienced in most parts of the country in all months, with higher temperature anomalies being depicted in minimum temperatures compared to maximum temperature. On average the country recorded relatively higher warmer nights in January, June, and September, but relatively cooler day time temperature in January, March, July, and November. Large number of events with higher daily temperatures exceeding 35 °C were mainly observed in February and March especially over northern coast and northeastern highlands, whereas large number of cooler nights with temperature lower than 5 °C occurred during July and August mainly over southwestern highlands.

Observed extreme weather events especially heavy rainfall resulted into widespread floods and rising of lake levels posed significant impacts to socio-economic activities. The impacts include loss of lives and properties, damage to infrastructures, destruction of farm fields and settlements that has not been experienced in recent years.

The observed extreme weather impacts and risks could be much reduced if weather forecasts and warnings issued by TMA were closely followed and mainstreamed by the public and government sectors in their day-to-day planning of socio-economic activities.

8. Appendix

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 14.4 °C to 26.4 °C. Regions with the highest temperatures are along the coast and western parts of the country. The season with high temperatures starts from October, continuing through February or March, whilst the cold season is from May to August. The annual minimum air temperature (Tmin) and maximum air temperature (Tmax) across the stations ranges from 9.6 °C to 22 °C and 19.1 °C to 30.7 °C respectively.

8.1.2 Rainfall distribution

The rainfall distribution and variability are driven by multiple factors including East African Monsoon, El-Niño Southern Oscillation (ENSO), and westerlies from Congo, tropical cyclones, and Inter-Tropical Convergence Zone (ITCZ). The migration of ITCZ north and south across the equator are among the main factors affecting distribution and variability of rainfall in Tanzania and the entire East Africa. The migration of ITCZ lags the overhead sun by 3-4 weeks over the region. The ITCZ migrate to southern regions of Tanzania in October to December, reaching southern part of the country in January-February and reverses northwards in March, April and May. Due to this movement, some areas experience single and double passages of the ITCZ. The areas that coincide with single passage are known as unimodal areas. These include the southern, southwestern, central, and western parts of the country, which receive rainfall from November to April or May (NDJFMA, also known as Msimu). Areas that experience double passage are known as bimodal, and include northern coast, northeastern highlands, Lake Victoria basin, and the Islands of Zanzibar (Unguja and Pemba). These regions receive two distinct rainfall seasons. The long rain season (also known as Masika), which starts mainly in March and continues through May (MAM) and the short rainfall season (also called Vuli) which starts in October and continues through December (OND). January and February are the transition period (relatively dry) for bimodal areas while June, July, August, and September are dry months for the entire country.

8.2 Percentage Rainfall

Percentage rainfall is obtained by taking the ratio of the (monthly/seasonal/annual) rainfall to long-term average (period between 1981-2010) of monthly/seasonal/annual rainfall multiplied by 100. The percentage value greater than 125 is regarded as above normal rainfall and that between 75 and 125 is normal rainfall. The percentage value less than 75 is below normal.

8.3 Temperature anomaly

Temperature anomaly is calculated by taking the difference between the observed values (monthly/seasonal/annual) and the long-term mean. Anomalies are computed with respect to the 1981-2010 base period means.

8.4 Cumulative Rainfall analysis

Cumulative rainfall is defined as the rainfall that has accumulated in a prescribed period (e.g. 10 day or monthly interval). Cumulative rainfall analysis is used to characterize observed rainfall performance and trends for different areas in the country. The cumulative rainfall departure from long-term average is a concept used to evaluate the temporal correlation of the seasonal rainfall with the long-term average rainfall. Cumulative rainfall is used to see how much rain has fallen in the region within the prescribed period such as previous week, month or year. The concept has hydrological meaning in the short term as a generalized evaluation of either insufficient or abundant rainfall. In addition, the cumulated rainfall saves as a tool to detect the start and end of the seasons and the presence of wet or dry spells in the season.
In this report, cumulative rainfall is an accumulation of observed dekadal rainfall from a selected reference point. Dekadal rainfall for 2020 was calculated by observing the following procedures:

- for unimodal areas, rainfall from September 2019 to August 2020 was accumulated, because rainfall season over these areas starts from November in the previous year to April in the following year (NDJFMA). While,
- for bimodal areas accumulated rainfall from January to August 2020 was used to characterize rainfall for MAM season and rainfall from June to December 2020 was used to characterize rainfall for OND seasons
- dekadal baseline climatology from 1981-2010 was calculated by following same procedure as it is done in calculating dekadal values for individual season.

8.5 Spatial analysis for Temperature and Rainfall distribution

Temperature and rainfall were analyzed as point data for the selected stations across the country. 31 stations were used for rainfall analysis and 27 stations for temperature analysis. They were analyzed by the Inverse Distance Weighting (IDW) interpolation method in Quantum GIS to generate spatial distribution maps. The IDW interpolator assumes each input point has local influence that diminishes with distance. It weights the points closer to the processing cell greater than those far away. The IDW algorithm is a moving average interpolator that is usually applied to highly variable data.

8.6 Severe Weather

Severe weather is defined as any aspect of the weather that poses risks to life, property or requires the intervention of authorities. Types of severe weather phenomena vary, depending on the latitude, altitude, topography, and atmospheric conditions. Strong winds, hail, excessive precipitation, and wildfires are forms and effects of severe weather. According to WMO, severe weather can be categorized in to two groups; general severe weather (e.g. windstorms and its accompanied phenomena), and localized severe weather (e.g. downbursts and tornadoes). Extreme weather is described as unusual weather events that are at the extreme of historical distribution for a given area.

Rainfall threshold in this statement adopted those prescribed by Severe Weather Forecasting Demonstration Project (SWFDP) in East and Southern Africa which is 50 mm or more recorded in 24 hours. However, extreme weather and climatic events can also be described by other statistical terms such as percentiles and on the magnitude of impact caused even if it does not reach the prescribed threshold.