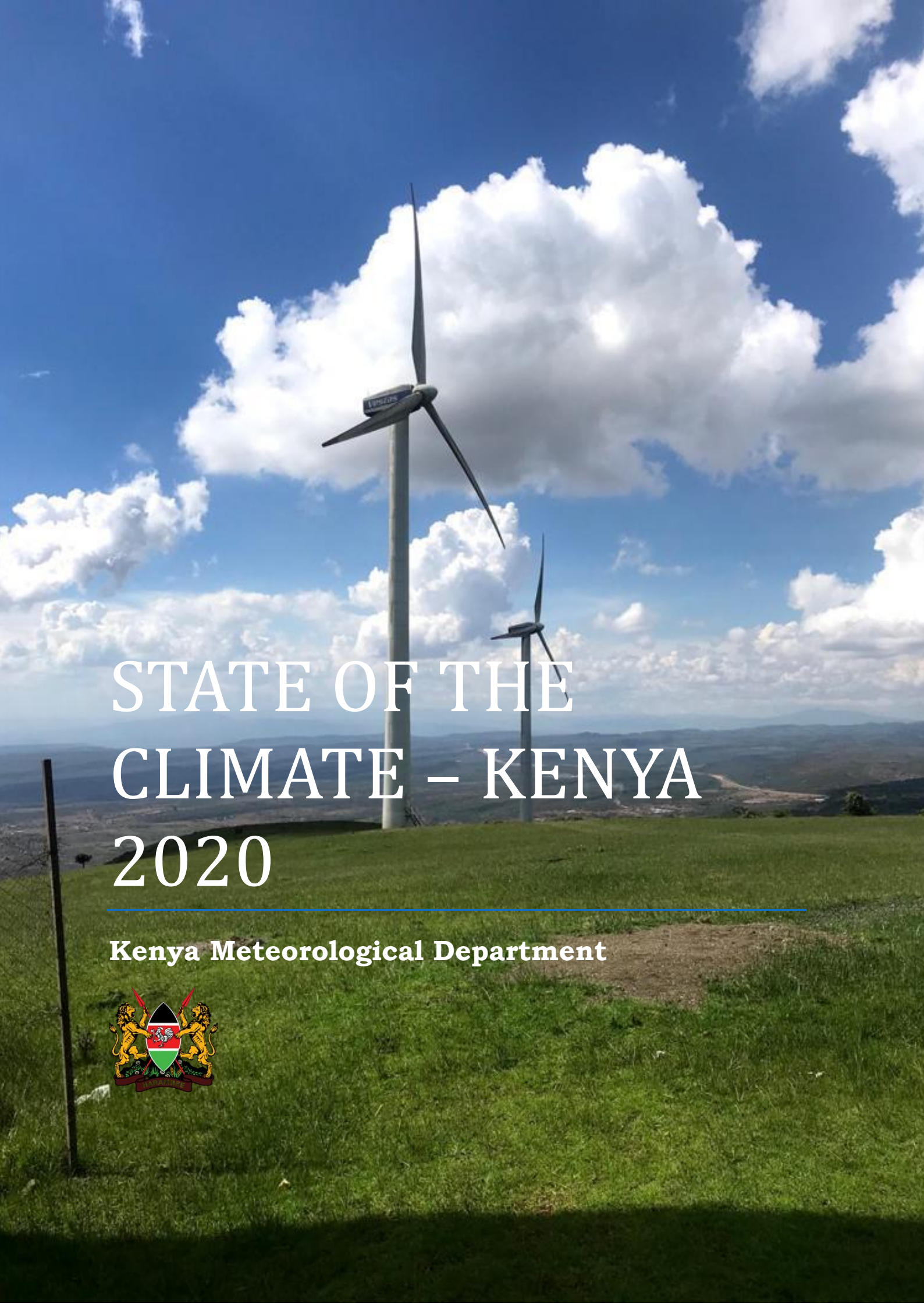

STATE OF THE CLIMATE – KENYA 2020

Kenya Meteorological Department

Published in 2021 by the Kenya Meteorological Department (KMD)

Title: State of the Climate in Kenya 2020.

This Report can be found at www.meteo.go.ke

The complete study should be cited as follows: *KMD. 2020. State of the Climate in Kenya 2020*

Cover Picture: Ngong Hills power generation Windmills Taken by KMD in 2019

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List of Acronyms

AFOLU	Agriculture, Forestry and Other Land Use
CORDEX	Coordinated Regional Climate Downscaling Experiment
ENSO	El Nino Southern Oscillation
HI	Heat Index
IPCC	Intergovernmental Panel on Climate Change
IOD	Indian Ocean Dipole
ITCZ	Inter-Tropical Convergence Zone
JJA	June July August
KMD	Kenya Meteorological Department
LULUCF	Land use and land use change & Forestry
MAM	March April May
OND	October November December
RH	Relative Humidity

Acknowledgements

I would like to express my appreciation to the Ministry of Environment and Forestry for the good leadership that has enabled this work to be carried out.

I would also like to thank the Climate Services and Forecasting branches of Kenya Meteorological Department, for generating this report under the direction of Dr. David Gikungu, Deputy Director Climate Services; Mr. David Adegu, Assistant Director Climate Services; and Mr. Benard Chanzu, Deputy Director Forecasting Services. Special thanks goes to Ms. Patricia Nying'uro, Principal Meteorologist Climate Services, Mr. Chris Kiptum, Principal Meteorologist Forecasting Services and Mr. Zacharia Mwai Principal Meteorologist Hydrometeorological services for compiling this report.

Director
Kenya Meteorological Department

Foreword

Climate Change is unequivocal and its impacts on regions and countries is clearly being felt by all communities. From impacts such as shifts in the onset of seasonal rainfall to increased intensity of short-lived storms, it is undeniable critical role in the socio-economic sectors of any country. The adverse effects of extreme weather and climate have often resulted in loss of lives and livelihoods as well as damage to property and the environment. Timely dissemination of weather and climate ensures key sectors of the economy such as health, agriculture, energy, transport, water and disaster risk management are well informed, thus cushioning the public against climate related adverse effects.

The Meteorological Department has the mandate to provide timely and accurate information to cushion against the effects of these changes. The Department also has the mandate to monitor and document weather and climate data for research purposes as well as to understand how climate and weather systems evolve. It is with this in mind that this report is produced. This document is an important resource for stakeholders and researchers.

On behalf of the Government of Kenya, it is a privilege and a great honour for me to present Kenya's State of Climate Report for the year 2020 to the people of Kenya and the World Meteorological Organization. This report represents the commitment of the Government of Kenya and its people to address global warming as well as a climate variability and change. With this report, Kenya takes an important step towards meeting our national and international obligations and ensuring that weather and climate are mainstreamed into the country's policies and decision-making processes, activities, and investment plans.

It is my hope that this document will provide adequate information for various stakeholders and researchers in their work. It is also my hope that Kenya Meteorological Department will continue to uphold the high visibility profile it has gained in recent years and continue providing more accurate and timely weather forecasts and advisories to inform planning and decision-making for the benefit of all sectors of our economy.

Dr. Chris Kiptoo, CBS
Principal Secretary,
Ministry of Environment and Forestry

Preface

Climate variability and climate change present many risks to populations the world over and more so in developing countries such as Kenya, because of limited adaptation capacity. The impacts of climate change, whose increasing frequency is also notable, include heavier than usual rainfall, leading to floods or drier than normal conditions leading to severe droughts consequently affecting human activities. Observed extreme events during the year included flash floods, floods, rising lake levels and strong winds.

This report on the state of the climate in the year 2020 shows that several stations within the country recorded maximum temperature values exceeding their respective long-term means. Analysis indicates that the minimum temperatures recorded in most stations were also higher than the long-term means. The average annual temperature for the country was higher by just under 1^{o}C.

The year was characterized by enhanced rainfall during the Long rains season (MAM 2020) and depressed rainfall in the Short-rains season (OND 2020). Further, the year had a wetter than normal January and February owing to the strong positive Indian Ocean Dipole index at the time. Compared to the long-term average, the 2020 rainfall was higher for most of the year and mainly during the March-April-May season.

The Department endeavoured to provide advisories and early warnings in keeping with its mandate. Observed impacts of adverse weather included loss of lives, property, livelihoods, destruction of infrastructure (including those submerged or marooned as a result of rising Rift Valley lake levels) and even capsizing of some vessels.

Emerging areas of interest and research by the Department include, among others, the determination of the possible influence of weather parameters on the COVID-19 pandemic.

Stella Aura MBS
Director, Kenya Meteorological Department

Chapter 1: Introduction

The climate of Kenya is complex in time and space. The region, like many other parts of the tropics, is prone to extreme climatic episodes such as frequent floods and recurring droughts (Muhindi et al 2001). Kenya's weather and climate are changing in response to global warming that is currently being experienced world-wide (IPCC, 2013). In response to this, proper adaptation and mitigation measures should be put in place to cushion the population against the current and future negative impacts of climate change. Kenya is located between latitude 5^{o} North and 5^{o} South with the equator almost dividing it into halves, and between longitudes 34^{o} and 42^{o} east. The total area is about 569,137 km^2. Annual rainfall follows a bimodal seasonal pattern with rains, commonly referred to as the "long rains" season occurring in March, April and May (MAM) and the "short rains" season, which occurs in October, November and December (OND). There exists another season from June to August (JJA) over the coastal region and the Highlands west of the Rift Valley. The long rains season is crucial to the agricultural production of the country which is key to Kenya's economy, contributing 26% of the Gross Domestic Product (GDP) and another 27% of GDP indirectly through linkages with other sectors. The sector employs more than 40 per cent of the total population and more than 70 per cent of Kenya's rural population (ASTGS, 2019). Consequently, the MAM rainfall forecast, and its subsequent performance are of great significance to the agricultural sector as well as to the overall performance of the economy. The main driver of weather in Kenya is the annual north and south migration of the sun across the equator. This migration influences the position of the Inter-Tropical Convergence Zone (ITCZ) (Muhindi et al 2001). Figure 1 shows the climatological zones of the country.

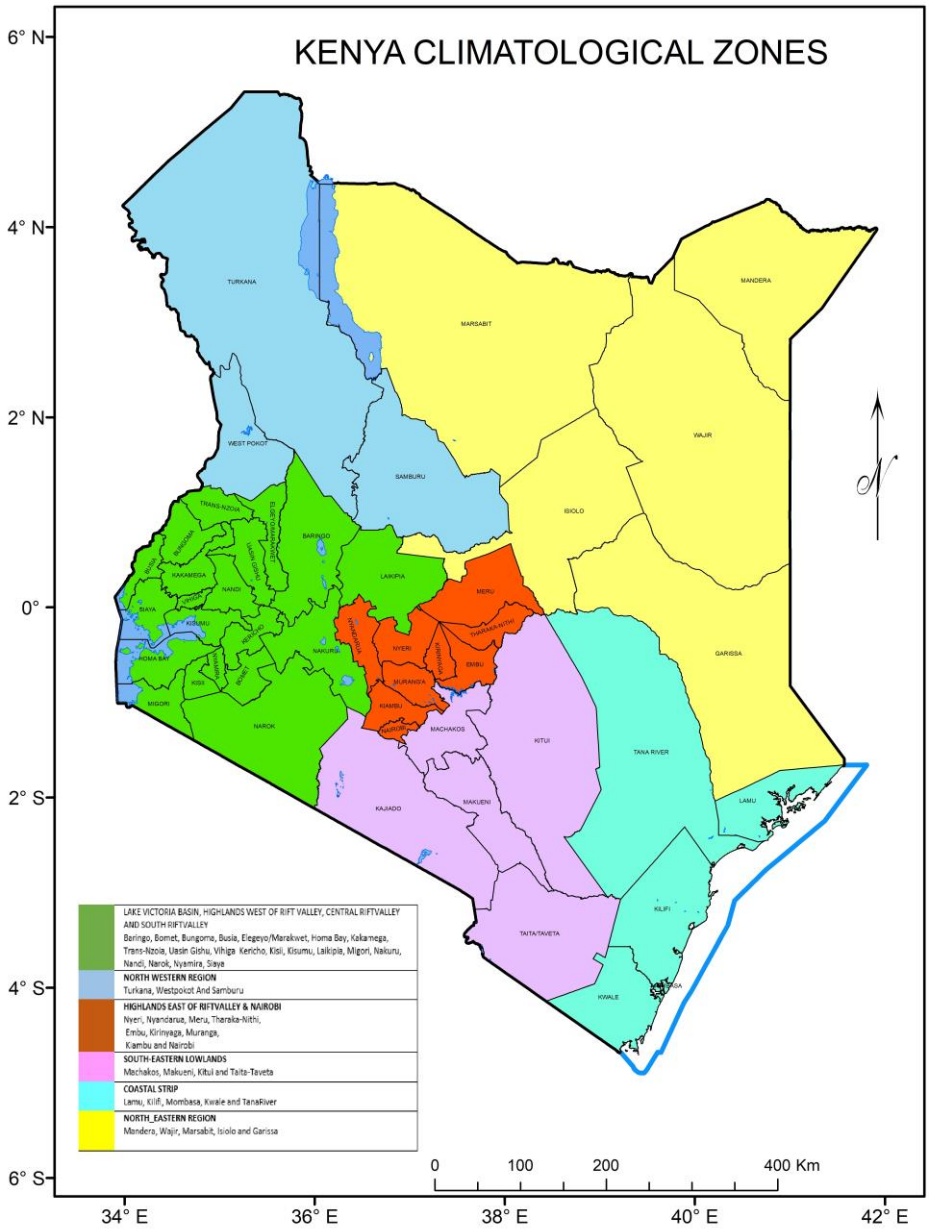

Figure 1: Rainfall Climatological Zones of Kenya

The months of June to August are characterized by cooler temperatures while the highest temperatures are typically experienced during the month of March.

The wind patterns in Kenya are such that the months of May, June, July and August are also characterised by moderate to strong southerly winds especially over the eastern and northern parts of the country. The rest of the year experiences relatively calm wind regimes, bringing in moisture or dry air relative to the season.

Chapter 2: Observed Patterns of key Climatic Parameters during 2020

Solar Radiation

Incoming solar or shortwave radiation is an integral part of the surface energy balance and can often be the largest energy source at the earth's surface. The amount of energy available at the surface plays a central role in determining the partitioning among sensible, latent, and conductive energy fluxes at the surface. Similarly, the hydrologic budget is heavily influenced by solar radiation as evaporation is governed by net radiation (Heck, 2020)

Various stations in the country record solar radiation data even though most records are either incomplete or have large gaps. **Figure 2** shows the variation of yearly radiation at various stations.

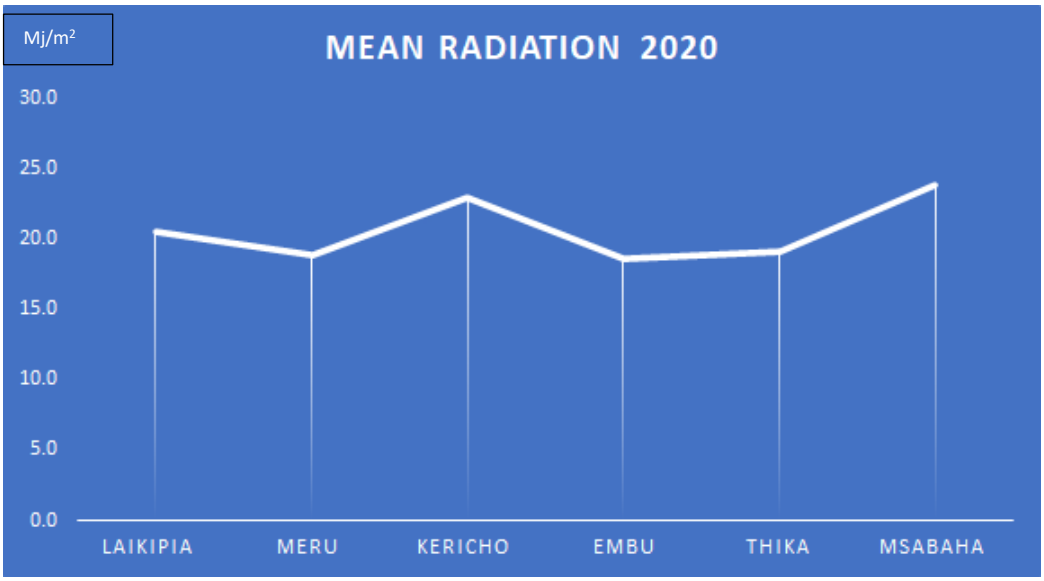

Figure 2: Mean annual radiation for select stations

Temperature

Several stations recorded maximum temperature values exceeding their respective long-term means. These include Marsabit, Mandera, Kisii, Nakuru and Mombasa as can be seen in **Figures 3** and **4.**

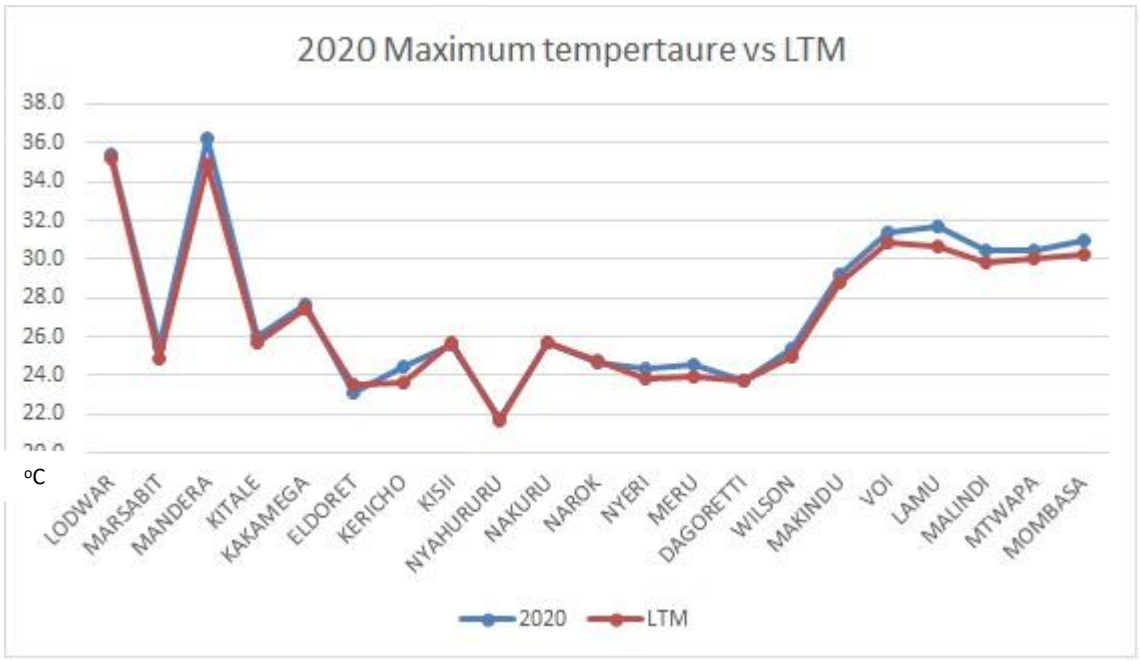

Figure 3: Maximum temperature vs LTM

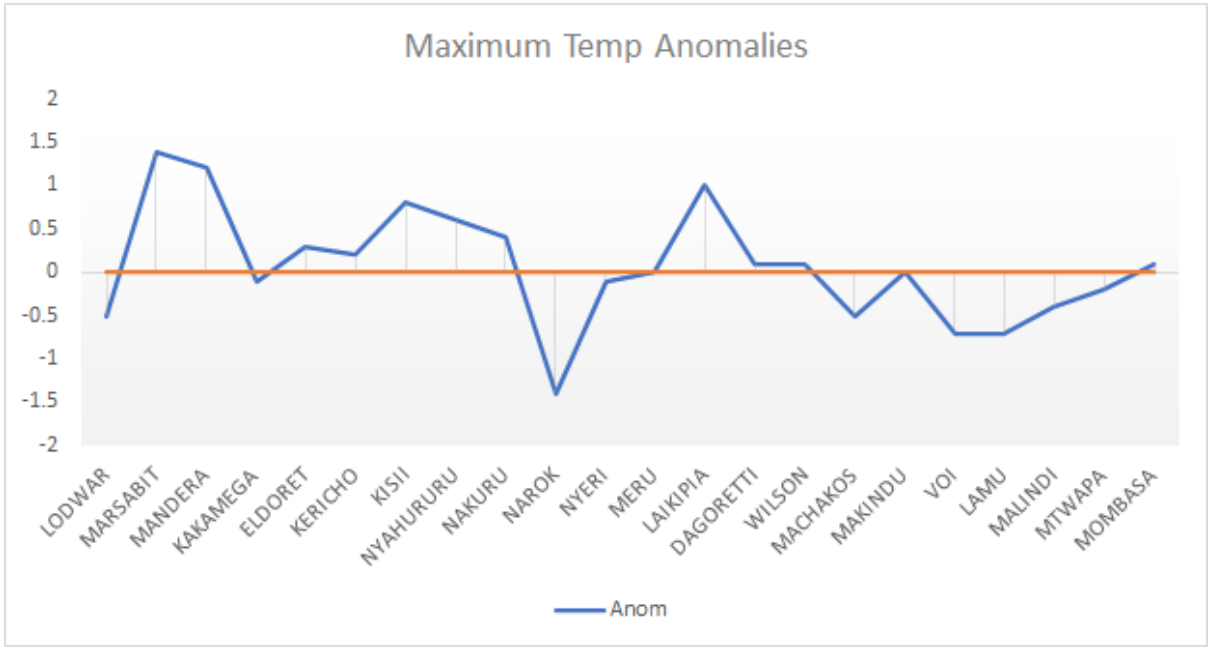

Figure 4: Maximum temperature anomalies

The minimum temperatures observed over most stations in 2020 were higher than the long-term means. This is consistent with the global observation that identifies the year 2020 as one of the hottest years on record. The minimum temperatures and anomalies are respectively illustrated in **Figure 5** and **Figure 6.**

Figure 5: Minimum temperature observed vs long-term mean

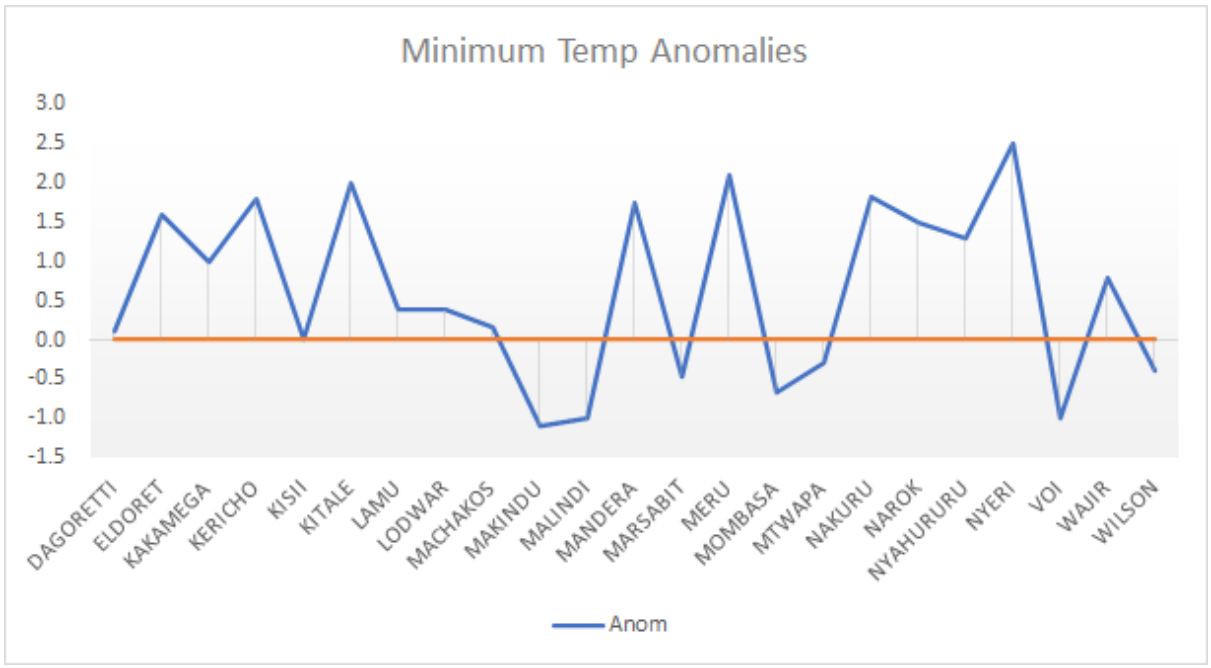

Figure 6: Minimum temperature anomalies

The June to August (JJA) temperatures were generally warmer than average over most of the country. Analysis of the JJA 2020 air temperatures indicate that both the minimum (night-time) and maximum (daytime) temperatures were warmer than average at several stations with generally sunny conditions dominating. Minimum temperatures exhibited a higher variation from the normal as shown in **Figure 7**. However, the daytime temperatures in the Central highlands and Nairobi area occasionally fell below 20°C.

Figure 7:2020 JJA minimum temperature vs LTM

Rainfall Performance in 2020

The year was characterized by enhanced rainfall during the Long-rains season (MAM 2020) and depressed rainfall in the Short-rains season (OND 2020). Further, the year had a wetter than normal January and February owing to the strong positive Indian Ocean Dipole index at that time.

January 2020

An analysis of rainfall for January 2020 indicates that the performance of rainfall was significantly above the long-term mean. Most meteorological stations recorded rainfall that was above 200% of their January-long term averages. However, a few stations over the eastern zone (Voi, Mandera and Wajir) recorded below normal rainfall at 66%, 56.2% and 33.5% respectively. The month was characterized by severe storms in different parts of the country. For instance, Kabete recorded 92.5mm on 12th January. On the same day, Wilson Airport reported 91.3mm and Nyahururu 70.0mm. On 14th and 16th January, Ngong reported 57.8mm and Narok 63.4mm respectively. On 25th, 27th and 28th January, Voi Meteorological Station reported 59.7mm, followed

by Kisii with 67.6mm and Matungu with 53.0mm respectively. On 29th January Kitale reported 56.0mm, Eldoret Kapsoya 68.1mm and Eldoret Airport 72.7mm. Dagoretti Corner station recorded the highest monthly rainfall of 242.9.0mm followed by Wilson Airport which recorded 220.1mm. **Figure 8** shows the total rainfall amount recorded in January (Blue bars) in comparison with the January LTMs (Red bars).

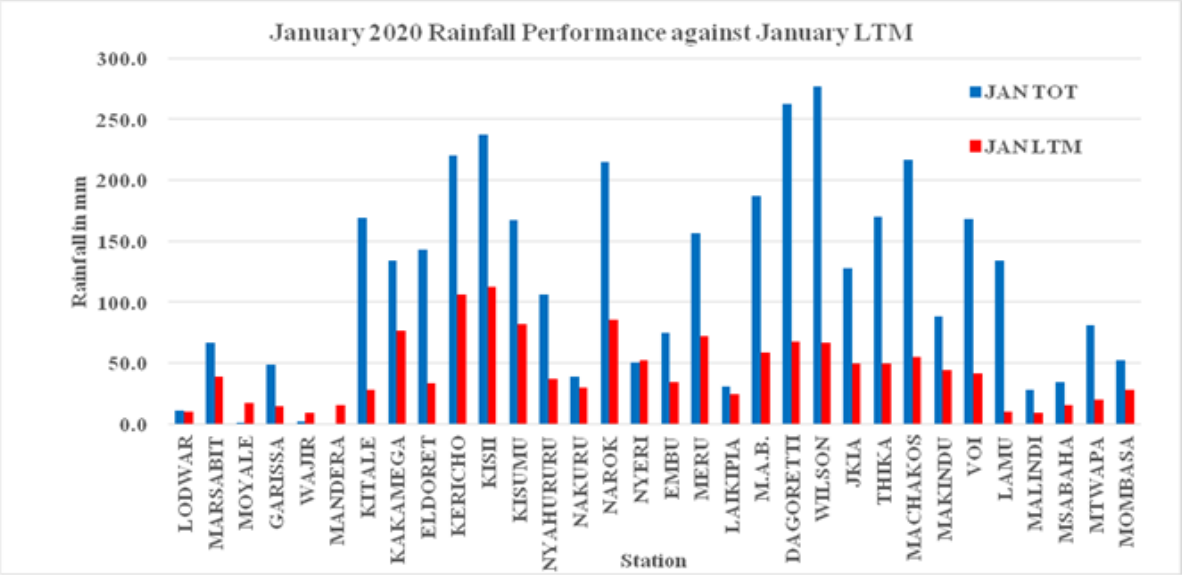

Figure 8: January 2020 Rainfall performance

February 2020

In February 2020, several parts of the country received enhanced rainfall in comparison to the Long Term Means (LTMs) for the respective periods. An analysis of rainfall for February 2020 indicates that the performance of rainfall was above the long-term mean over several parts of the country. Several meteorological stations recorded rainfall that was above 125% of their February long term means. Makindu Meteorological Station recorded 296.1% of its monthly LTM. Other stations that recorded more than 125% are Embu, Laikipia, Nyahururu, Meru, JKIA, Thika, Garissa, Nyeri, Machakos, Marsabit and Kericho. Narok, Kakamega, Msabaha, Lamu, Malindi and Moyale recorded below normal rainfall. Kericho station recorded the highest monthly total rainfall of 109.7mm which is 125.5% of its February Long Term Mean.

The beginning of the month was characterized by a few isolated storms in different parts of the country. For instance, JKIA recorded 41.5mm on 1st February. On the same day, Nyahururu reported 35.6mm, Makindu 29.5mm, Eldoret Airport 29.3mm while Kabete had 23.0mm. Moreover, Kangema reported 48.2mm on 3rd February. Generally sunny and dry weather conditions

prevailed over North-western and North-eastern Kenya where most stations recorded between 0 and 5mm of rainfall. Wajir and Mandera meteorological stations received no rainfall during the month. **Figure 9** shows the total rainfall amount recorded in February 2020 (Green bars) in comparison with the February LTMs (Blue bars).

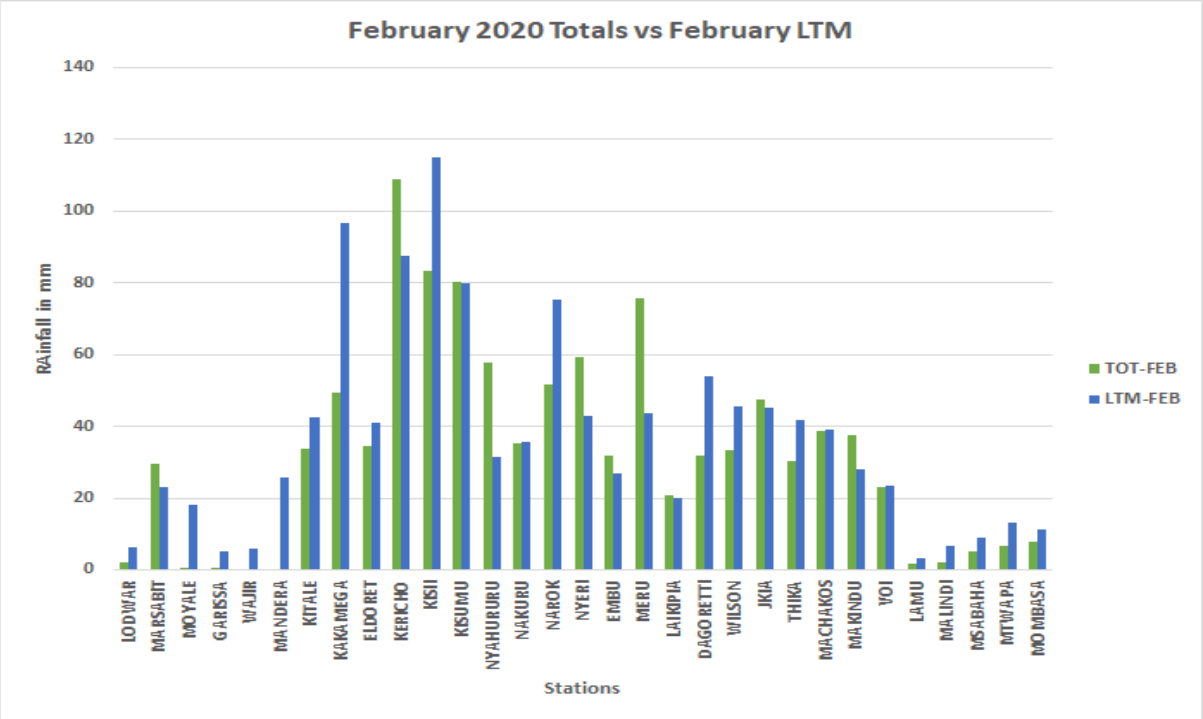

Figure 9: Total rainfall February in comparison to February LTMs

March-April-May 2020 Rainfall Forecast and Performance

An assessment of the rainfall recorded during MAM 2020 indicates that the rainfall performance was far above normal over most parts of the country. Several meteorological stations in the country recorded rainfall that was more than 75% of their seasonal Long-Term Means (LTMs) for the MAM season.

The most enhanced rainfall was recorded over the Northwest, the Highlands West and East of the Rift Valley, the Northeast and the South-eastern Lowlands. Stations that surpassed their seasonal LTMs include Lodwar (259.9%), Eldoret (207.6%), Narok (185.8%), Nakuru (175.7%), Machakos (172.0%), Nyeri (165.7%) and Meru (164.8%). Kisii Meteorological Station recorded the highest seasonal rainfall total of 878.2mm. The lowest seasonal totals were recorded at Voi 185.0mm and Wajir Meteorological Stations 79.4mm, respectively.

Figure 10 shows the amount of rainfall recorded during the MAM 2020 season (blue bars) as compared to the MAM seasonal LTMs (red bars). **Figure 11**

shows the MAM 2020 seasonal rainfall performance as a percentage of the LTMs.

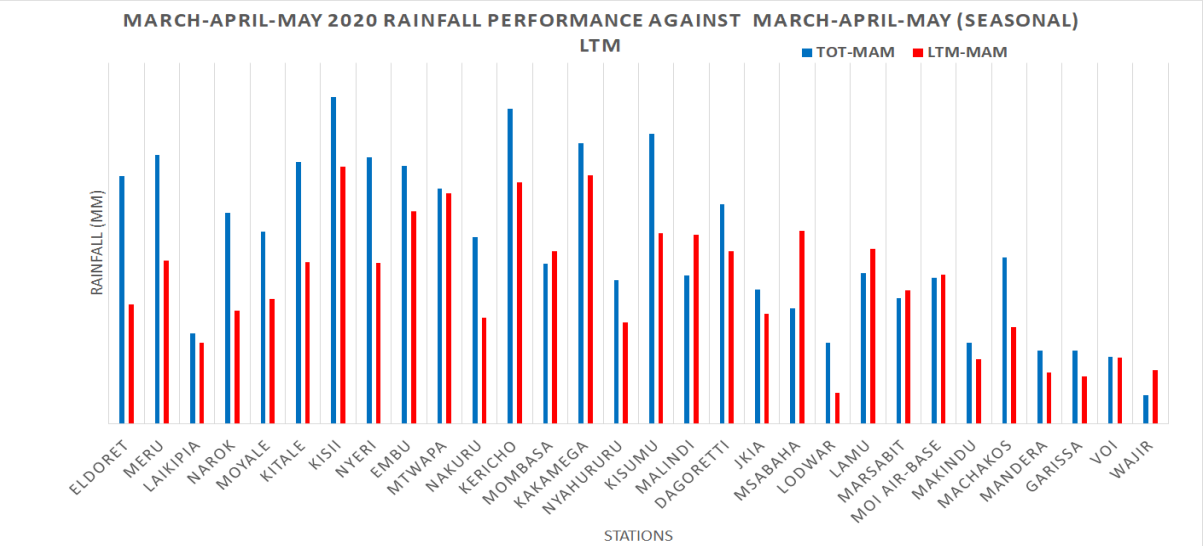

Figure 10: MAM 2020 station rainfall values versus long-term means

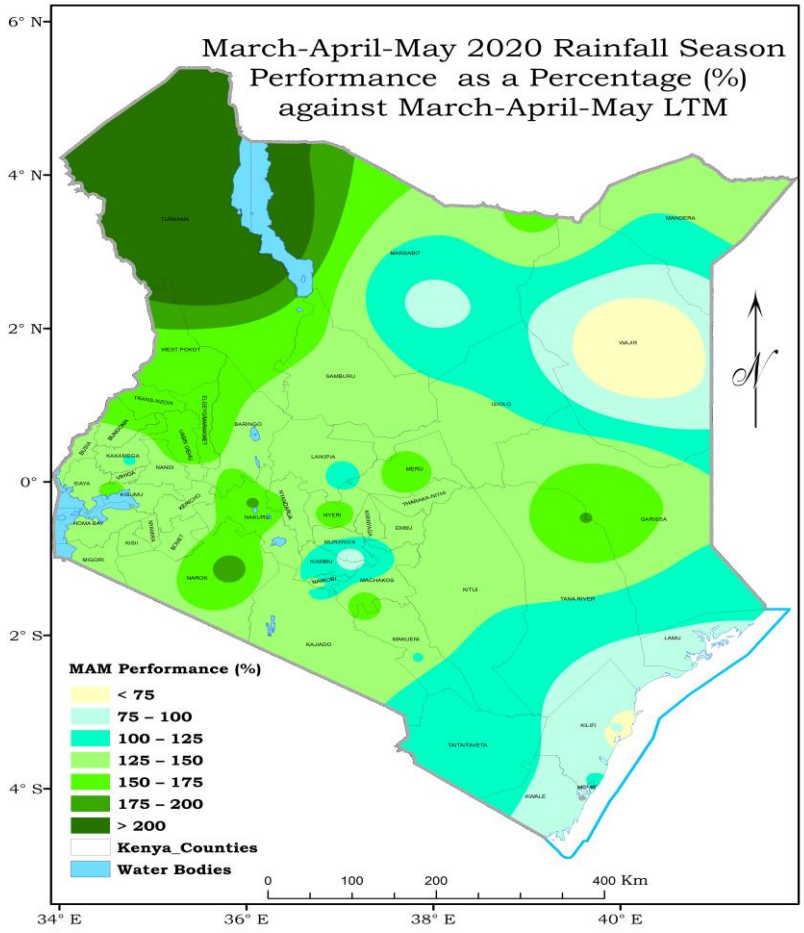

Figure 11: MAM 2020 seasonal rainfall performance as a percentage of the LTMs

June to August 2020 (JJA 2020) Performance

Several parts of the country experienced significant rainfall during the June-July-August (JJA) period. Near-average to above average rainfall was recorded over several parts of Western, Central, Northwestern Kenya as well as parts of the Coastal region. Occasional cool and cloudy conditions were observed over the Central Highlands and Nairobi area during the season.

Several stations in Western, Central Rift Valley, Lake Basin and the Coastal regions recorded significant amounts of rainfall during the season. The rainfall was near-average to above-average (enhanced) in several stations as compared to the JJA LTMs. Kitale recorded the highest amount of 723.8mm (187.4 percent) compared to its LTM of 386.2mm. Other stations that recorded above 200mm include Eldoret– 587.1mm, Kakamega – 517.0mm, Nyahururu - 470.0, Kericho – 468.3mm, Kisii -408.0mm, Nakuru – 405.1mm, Msabaha – 394.5mm, Kisumu – 305.7mm, Malindi - 304.6mm and Lamu – 225.4mm. Nyeri, Laikipia, Mombasa, Mtwapa, Dagoretti, Wilson Airport stations recorded between 100 and 200mm while the rest of the stations recorded less than 100mm as seen in Figure 13. *Figure 14* shows the JJA 2020 Rainfall Totals (in green bars) comparison to JJA LTMs (in red bars).

Generally sunny and dry weather conditions were recorded in the North-eastern, South-eastern and parts of Central Kenya. Most stations in these regions recorded less than 100mm during the three-months period. Some stations like Machakos, Voi, Garissa, Wajir, Makindu and Mandera recorded less than 20mm throughout the period. No rainfall was recorded at Mandera Meteorological station for the entire season.

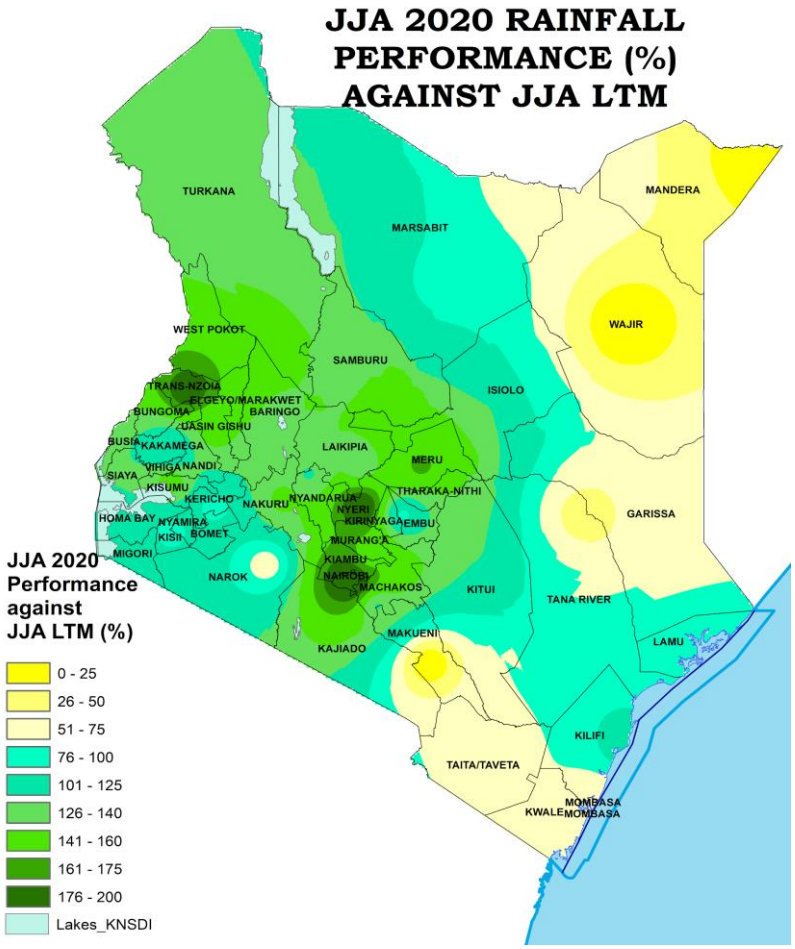

Figure 12:JJA rainfall as percentage of LTM

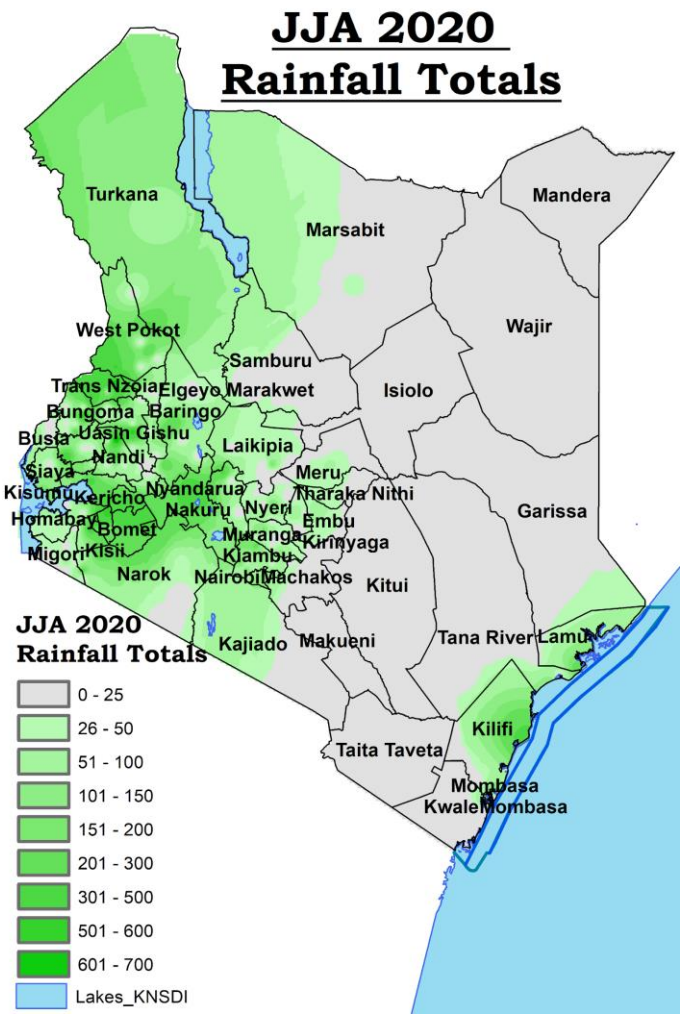

Figure 13:JJA Rainfall totals

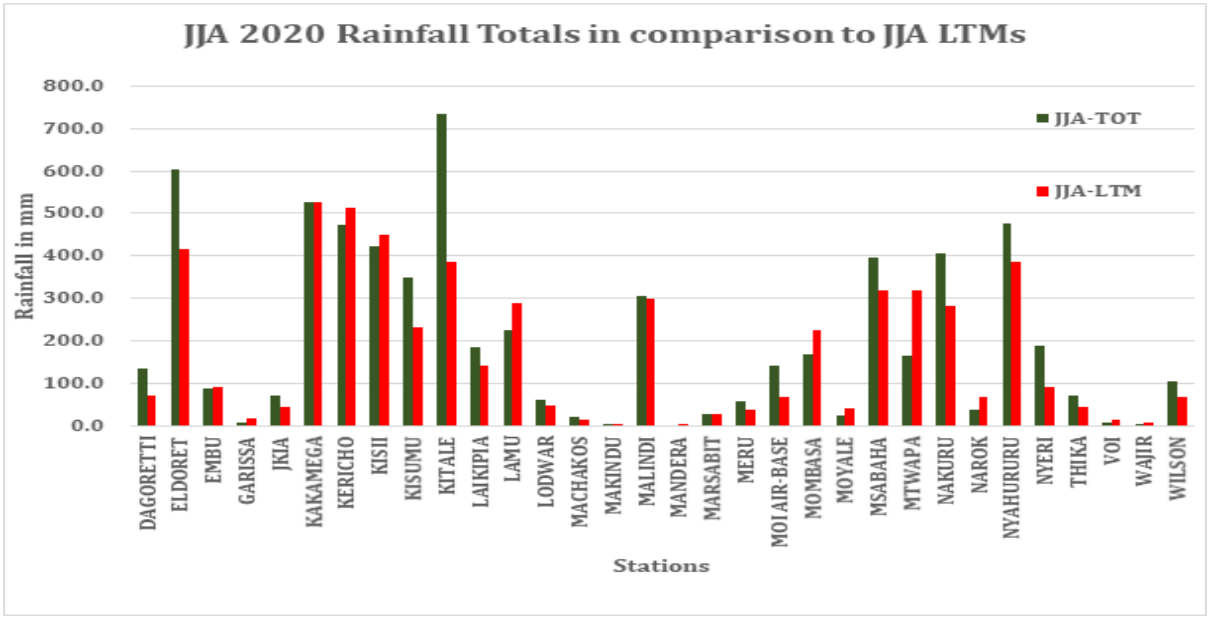

Figure 14: Comparison of June to August rainfall to LTMs

October to December Short rains season performance.

The October to December 2020 analysis indicates that depressed rainfall was recorded over several parts of the country. The start of the seasonal rains (onset) was also delayed over most places apart from the Highlands West of the Rift Valley, North-western as well as the Lake Victoria Basin region where rainfall continued from September 2020 as had been predicted. The rainfall distribution both in time and space was poor throughout the country.

The seasonal rainfall analysis shows that depressed rainfall was recorded in North-western, North-eastern, and South-eastern parts of central Kenya including Nairobi as well as the Coastal region. Several stations recorded below 100% of their LTM for the season. Kisumu meteorological station recorded 183.2% of its seasonal LTM of 328.5mm. Other stations that recorded more than 125% of their LTMs include Lodwar (173%), Kisii (151.8%), Voi (129.1%) and Marsabit (126.4%).

The highest seasonal total rainfall amount of 760.3mm was recorded at Kisii Meteorological station. Other stations that recorded significant amounts of rainfall are Meru (633.5mm), Kisumu (602.0mm), Embu (599.1mm), Kericho (415.9mm), Kakamega (416.9mm), Voi (373.5mm), Thika (360.4mm), Marsabit (347.6mm) and Nyeri (316.4mm). The other stations recorded between 100-300mm with the exception of Wajir, Lodwar, Garissa, Lamu and Mandera.

Figure 15 shows the OND 2020 rainfall performance (%) while Figure **16 shows** total rainfall amount recorded in OND 2020 (**Blue bars**) in comparison to the OND LTMs (**Red bars**)

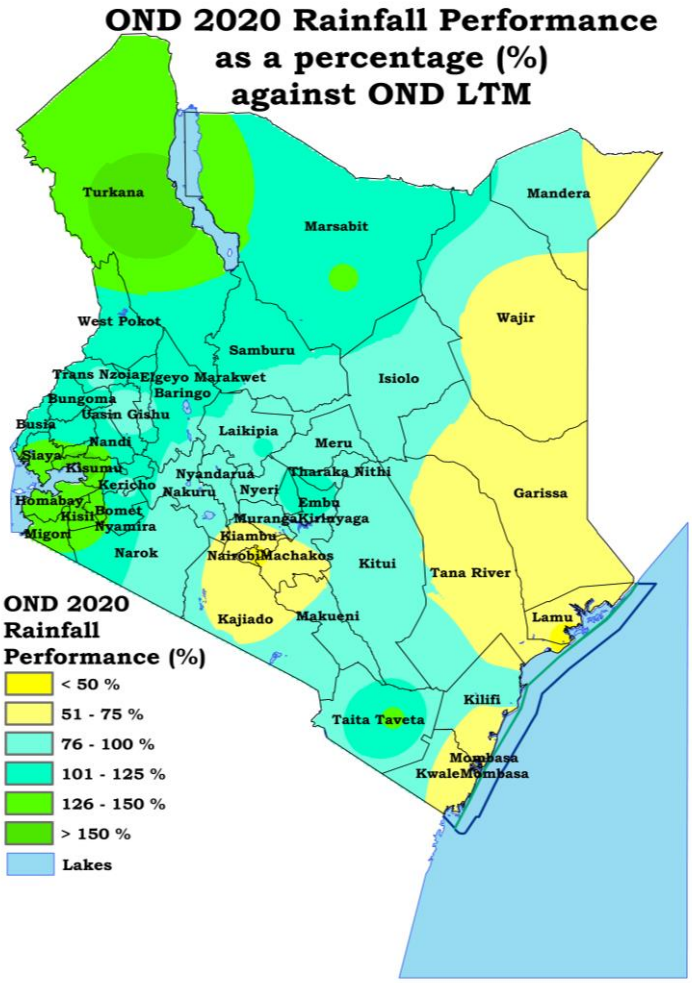

Figure 15: October-December 2020 Seasonal Rainfall Performance (%) against OND LTM

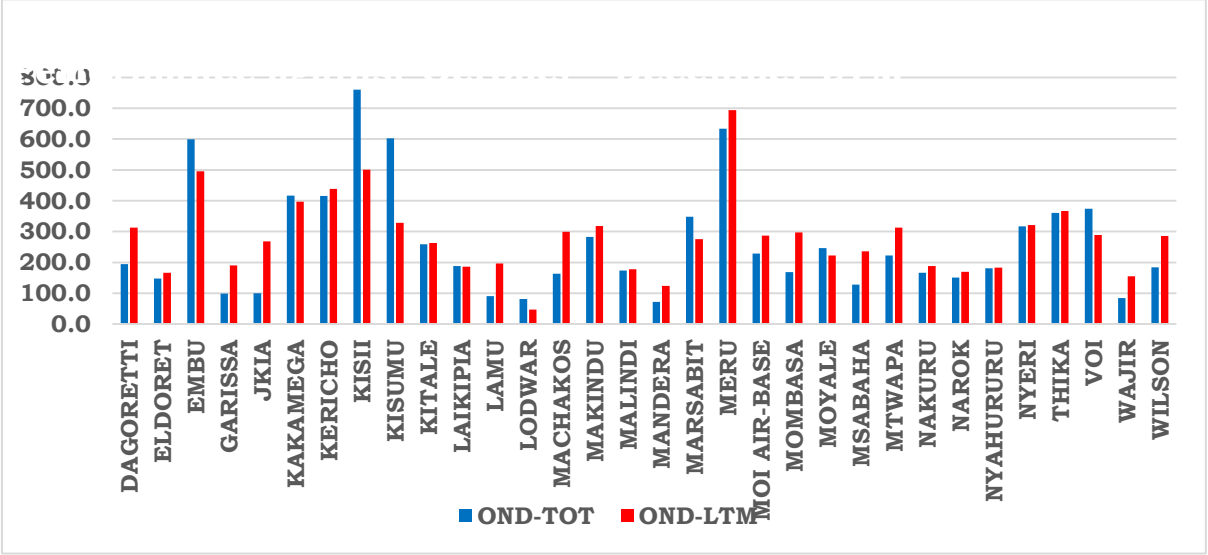

Figure 16: October-December 2020 Seasonal Rainfall Totals against OND LTM

Annual Rainfall performance in 2020

Figures 17 to 19 highlight the annual rainfall performance in the country. It is evident that the rainfall received over most parts of the country exceeded the annual long-term means.

From analysis in the previous sections the long rains season contributed the most to the exceedance of the long-term mean during this year.

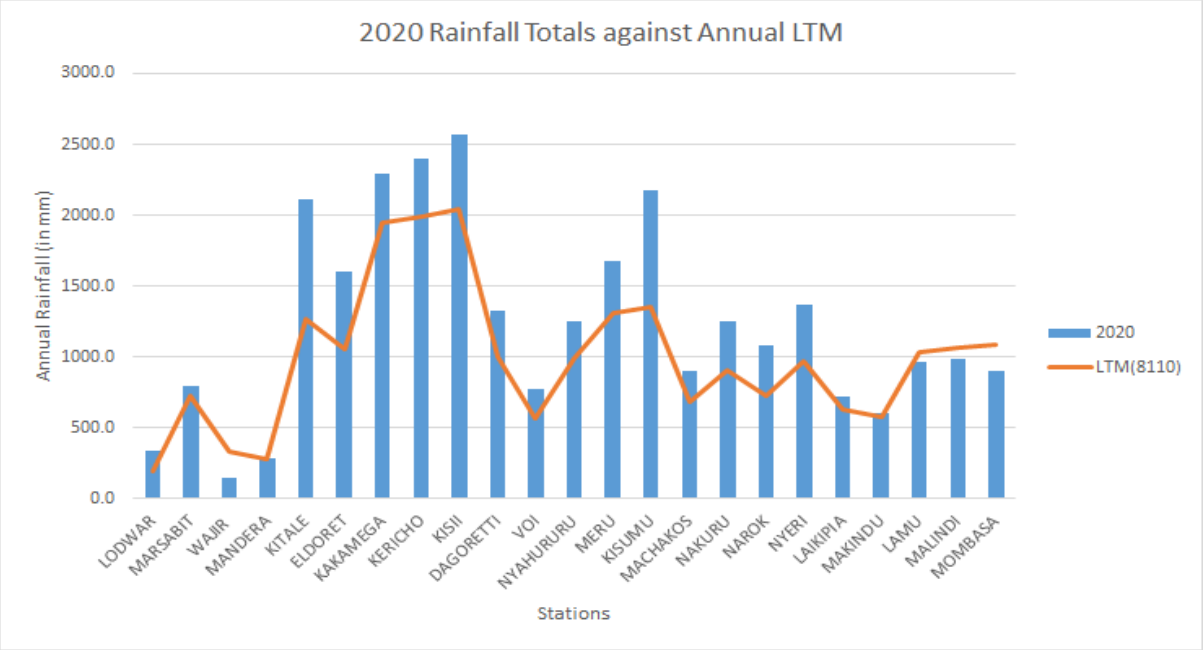

Figure 17: October, November and December (OND) 2020-rainfall performance against LTMs

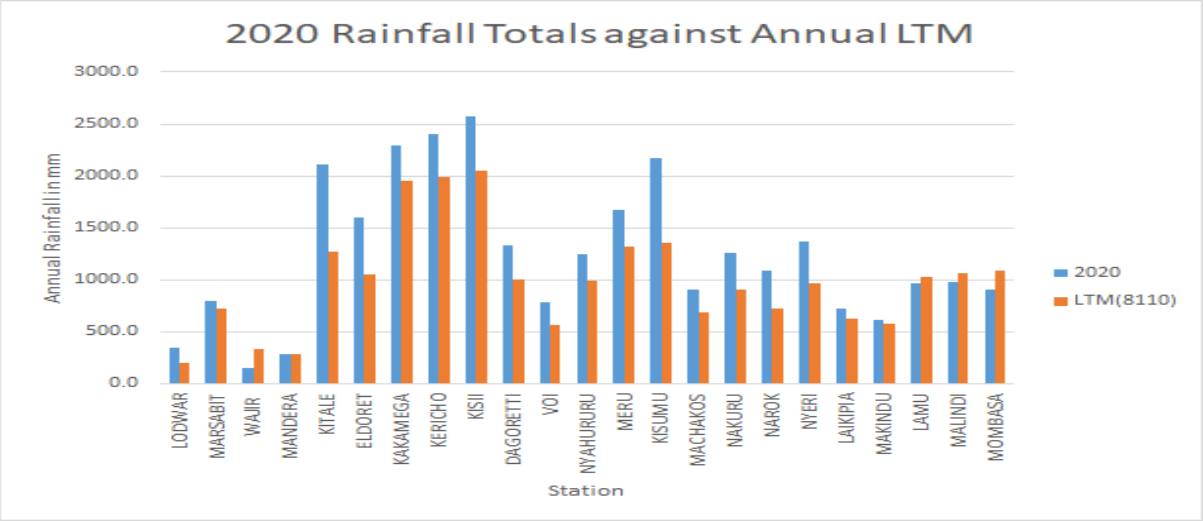

Figure 18: Bar graph of 2020 station values against their LTMs

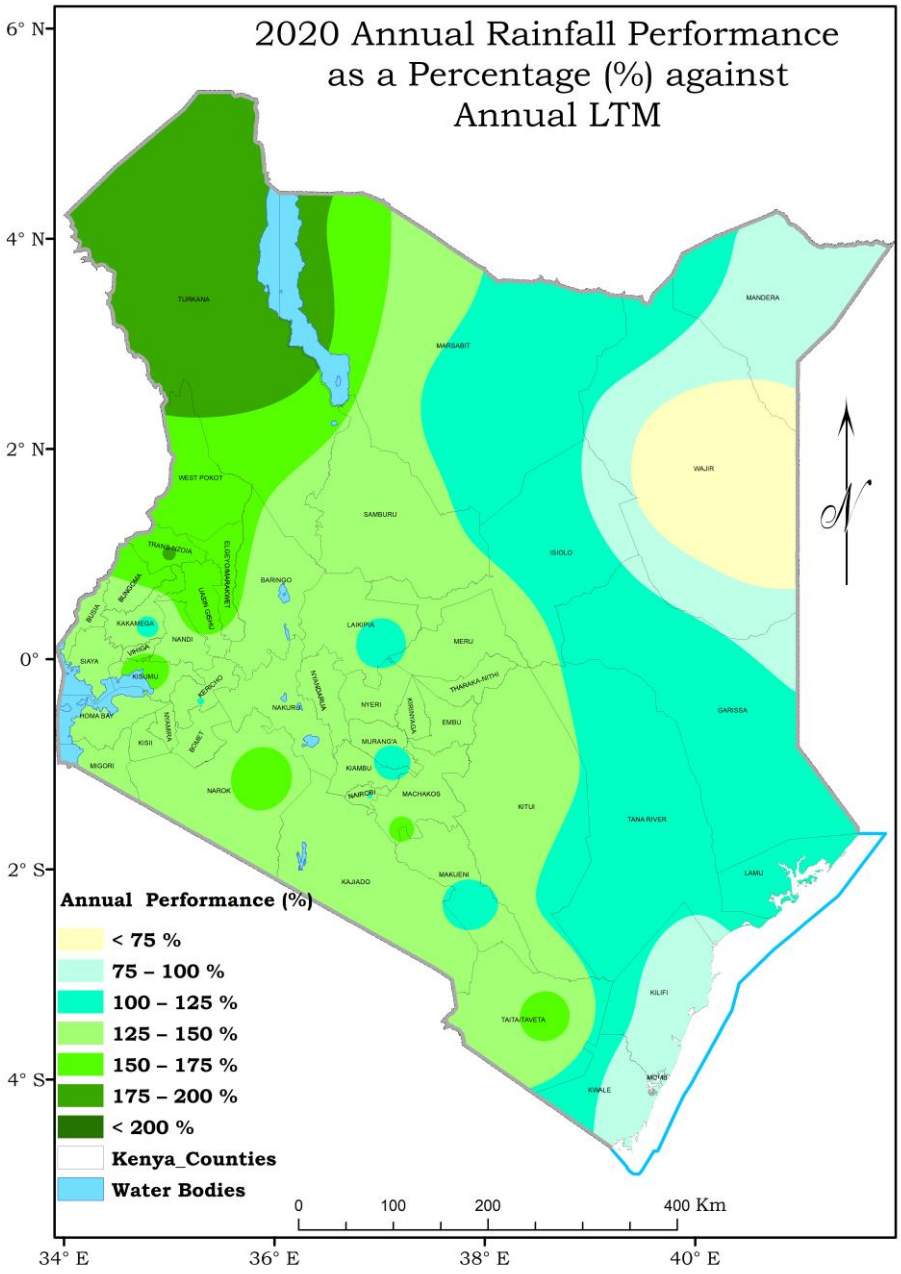

Figure 19: 2020 annual rainfall performance as a percentage of annual LTM

Chapter 3: Observed Changes of Climate Pattern for 2020 (Current year minus Long-term mean

Precipitation including Trends

January 2020 was uncharacteristically wet throughout the country, with total values exceeding the long-term mean by up to 2500mm. February rainfall was almost similar to the long-term mean values. Thereafter, the Long Rains season of March to May was quite wet with the total country values exceeding the LTM values by up to 2000mm. The values recorded for the rest of the year were close to the LTM values. December had less rainfall by up to >1000mm. May and November had less than normal rainfall for the country by up to about approximately -400mm. **Figures 20** and **21** illustrate the observed variation during the year in comparison to the LTM.

Figure 20: Comparison of 2020 total rainfall with the long-term mean.

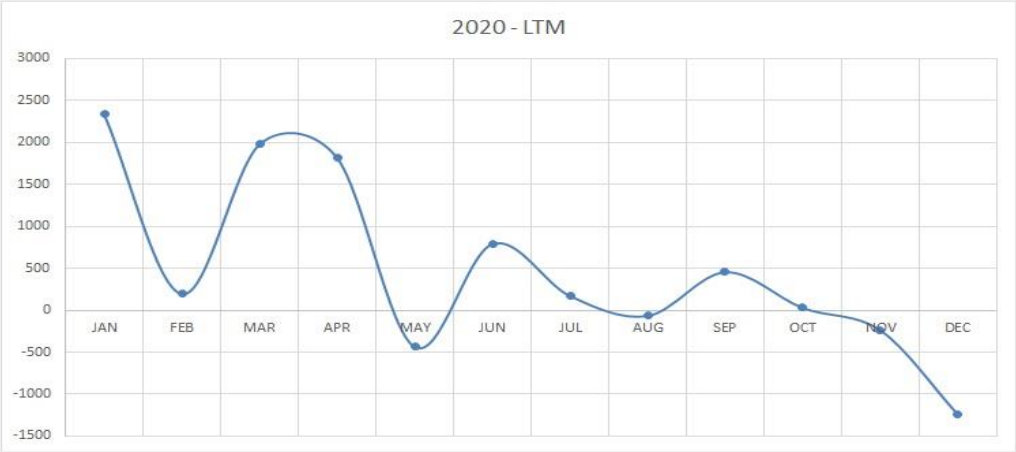

Figure 21: Total rainfall minus the long-term mean total

Temperature (Mean, Maximum and Minimum) including Trends

Temperature values recorded during 2020 were higher than the average temperature for the 1981 to 2012 period (which was used as base period). The highest deviation was by 1°C during August 2020 while the lowest was about 0.35°C in April. It is quite noteworthy that the cold season for Kenya (June to August) had the greatest deviation from normal compared to the other months of the year. **Figures 22** and **23** illustrate these variations.

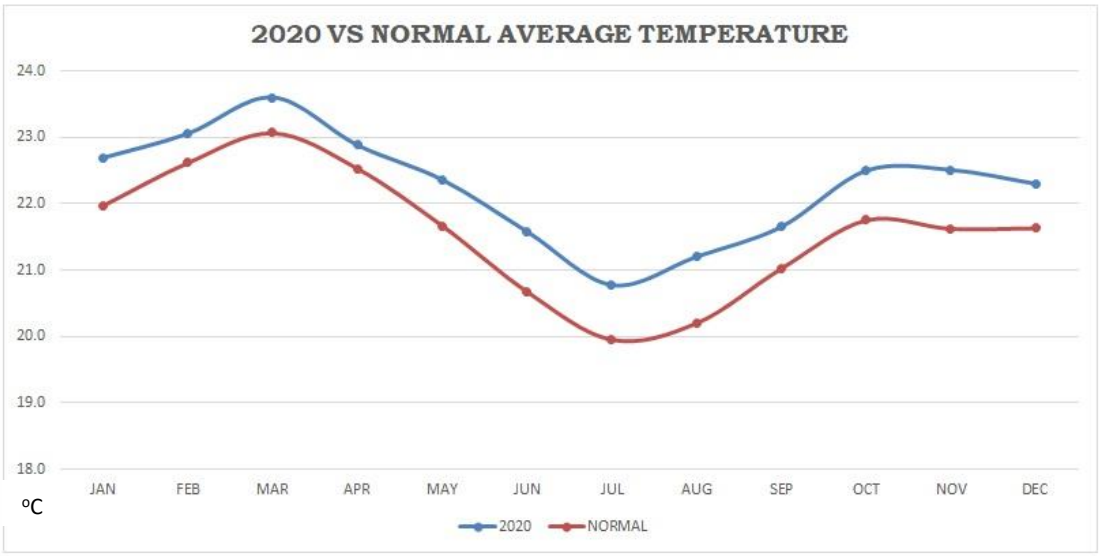

Figure 22: Comparison of 2020 average temperature with the LTM (1981 – 2010)

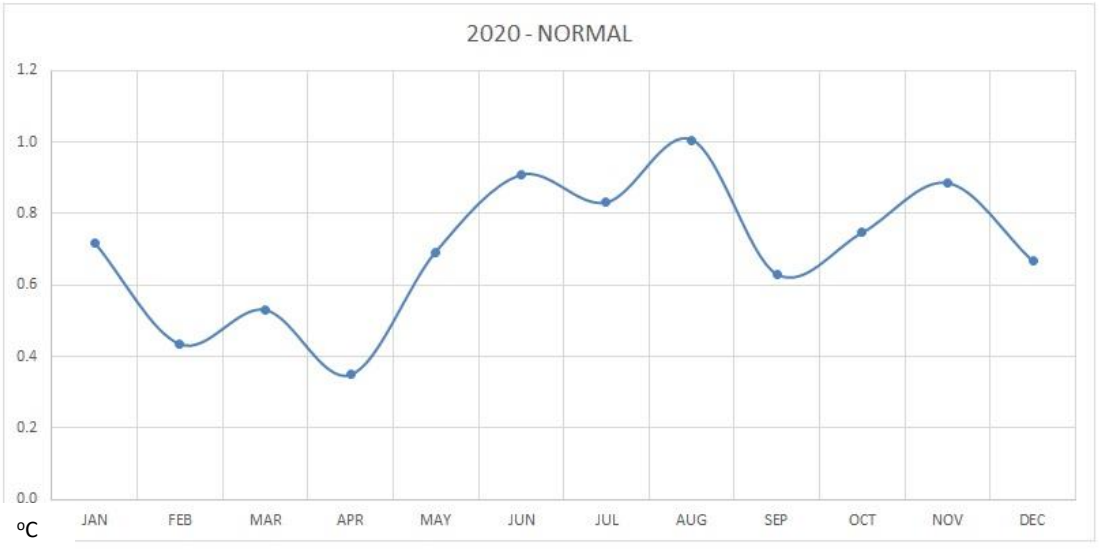

Figure 23: Average country temperatures minus the LTM (1981 – 2010)

Chapter 4: Observed Climate Drivers

During the month of April, 2020, equatorial Sea Surface Temperatures (SSTs) over western Pacific were neutral tending to warmer than average conditions while neutral to below average SSTs dominated eastern Pacific oceans. Neutral to warmer than average SSTs dominated the Western, Central and Eastern Indian Ocean. This pattern presented a neutral phase of the Indian Ocean Dipole (IOD). These temperature patterns were conducive for rainfall over the Eastern sector of Kenya. The zonal arm of the rain-bearing Inter-Tropical Convergence Zone (ITCZ) was mainly diffuse over the region. The rainfall received from mid-April was mainly influenced by the 2nd phase of the Madden-Julian Oscillation (MJO). This situation led to generally improved rainfall over most parts of the country.

During the season of June to August, the equatorial SSTs were above average across the western Pacific Ocean, the western Atlantic Ocean, and the western and central Indian Ocean. The SSTs were, however, near to below average in the east-central and central Pacific Ocean. The tropical atmospheric circulation was therefore consistent with ENSO-neutral. The Mascarene region was characterized by strong to moderate pressures which led to significant strong southerly winds over the eastern sector. Pressures over the Arabian region were generally weak for most of the month, creating a northward pressure gradient force. The Meridional (North-South) arm of the ITCZ was mainly over the central parts of Africa, Uganda and parts of western Kenya while the zonal arm was mainly situated in Ethiopia and South Sudan.

The poor rainfall performance during OND 2020 was mainly as a result of the La Nina conditions owing to the prevailing cooler than average SSTs in the central and eastern Equatorial Pacific Ocean and the warmer than average SSTs in the western Equatorial Pacific Ocean. The Indian Ocean dipole largely remained neutral during the season.

During the month of November 2020, below average SSTs were observed from the western central to eastern equatorial Pacific Ocean (the Niño areas) while above average SSTs prevailed over western equatorial Pacific Ocean. The warmer than average SSTs that were observed over the equatorial Indian Ocean constituting a neutral IOD led to occasional heavy rainfall.

Chapter 5: Extreme events in 2020

Drought

According to reports by the National Drought Management Authority (NDMA) due to the below normal rainfall during the OND season some counties had drought conditions with trends indicating worsening conditions. By October 2020 Garissa, Mandera and Wajir counties were in the alert level of drought status. Attributed to the drought were reports of acute malnutrition across the Arid and Semi-Arid Land (ASAL) counties. The food security situation in the ASAL counties was reportedly at one of the lowest levels in the last 15 years (UNOCHA, 20th October 2020)

Windstorms

A case of strong winds was reported during the month of July 2020 as a result of the pressure gradients described in Chapter 4. The areas affected were in the North-eastern parts of the country. Table **1** shows the recorded winds in knots

Table 1: Recorded windstorm events in July 2020

Date	**Region**	**Station**	**Winds**
17/7/2020	Eastern	Marsabit	30knts
		Wajir	25kts
		Garissa	25kts

Reports received through feedback mechanisms from marine industry, media and Indian Ocean users, indicate that there were significant large waves associated with the strong winds. This was confirmed by County Directors of Meteorological services from Mombasa, Kwale, Kilifi and Lamu counties.

Other extreme events relevant to the country

Desert locust invasion into the country spilled over from 2019 into 2020, with large swarms spreading across 14 Kenyan counties and gradually invading neighbouring countries - influenced by both wind and rainfall occurrences within the region.

Flood events

Several flash floods and flooding events were recorded throughout the year. **Tables 2 & 3** provide details of these flooding events.

Table 2: Heavy rainfall events during the long rains season (MAM)

OBS start time (to nearest h in UTC)	OBS end time (to nearest h)	observations (list all reports in region)	Event	Issued Message
13/04/2020 1300UTC	13/04/2020 2300UTC	Ppt Butere 56.2mm	Flash flood	Warning issued before event
14/04/2020 1400UTC	14/04/2020 1400UTC	Ppt:Kabarak 126.0mm	Minor flash flood	Warning issued
16/04/2020 1300UTC	16/04/2020 1300UTC	Ppt: Ngong 65.1mm	Flooding	No Warning issued
17/04/2020 1500UTC	18/04/2020 0400UTC	Ppt: Karurumo 74.1mm	Flash flood	No Warning issued
18/04/2020 1300UTC	18/04/2020 2300UTC	Ppt: Embu 61.8 mm,Wilson 92.5, Kabete 61.3mm,Kangema 50.0mm	Flash flood	Warning issued before event
19/04/2020 2000UTC	20/04/2020 0400UTC	Ppt: Embu 62.1mm,Marsabit 82.4mm	Minor flash flood	Warning issued but misplaced
20/04/2020 0800UTC	21/04/2020 0400UTC	Ppt: Meru 57.5mm, Machakos 65.7mm Karurumo 76.5mm	Flash flood	Warning issued before event start
20/04/2020 1300UTC	20/04/2020 2000UTC	Ppt: Meru 57.5mm, Machakos 65.7mm, Karurumo 76.5 mm	Flash flood	Warning issued before event started
21/04/2020 1200UTC	22/04/2020 0600UTC	Ppt :Mandera 85.6mm, Kitui 79.8mm, Karurumo 68.0 mm, Wundanyi 92.0mm, Shigaro 70.0mm	Flash flood	Warning issued before event started

22/04/2020 1100UTC	23/04/2020 0600UTC	Ppt: Garissa 60.2mm,Nyeri 52.0mm, Kangema 93.0mm, Ngerenyi 84.0mm, Karurumo 50.5mm,kitui 67.9mm, wilson 58.0mm	Flash flood	Warning issued before event start
23/04/2020 1300UTC	23/04/2020 2200UTC	Ppt:Moyale 42.8mm	Flash flood	Warning issued before event start
24/04/2020 0500UTC	24/04/2020 0600UTC	Ppt:Kabete 55.3mm,Eldoret Airport 51.6mm	Flash flood	Warning issued before event start
25/04/2020 1700UTC	26/04/2020 0400UTC	Ppt:Butere 54.7mm	Flash flood	Warning issued before event start
26/04/2020 1900UTC	27/04/2020 0000UTC	Ppt:Embu 62.4mm, Tutho 51.1mm	Flash flood	Warning issued before event start
28/04/2020 1200UTC	29/03/2020 0400UTC	Ppt:Meru 68.3mm,Matungu 57.4mm	Flash flood	Warning issued before event start

Table 3: Heavy rainfall events during the Short rains season (OND)

Date	**Region**	**Station**	**Amount in 24 hrs**
27/11/2020	Eastern	Kitui	123.8mm
	Central	Kabete	46.2mm
28/11/2020	Southeastern	Marungu	50.0mm

Chapter 6: Socio-economic Impacts of extreme events in various sectors of the economy

Agriculture and Food Security

The food security situation in Kenya was negatively impacted by the locust invasion of 2019 that spilt into 2020. Floods exacerbated this already dire situation. In some regions such as Baringo County, maize farms were flooded, and crops were lost to the floodwaters.

In terms of positive impacts, Maize and beans did well in most counties except Machakos while horticultural products performed well due to good rains. green grams and Sorghum production was very good especially in Kitui county during the March to May season. Reports indicated to that milk production was good since there was good pasture and good animal body condition.

There were some negative impacts experienced in the agricultural sector as well. for tea farmers, there was over-production that led to reduction of prices. Tomatoes were negatively affected by excess rains including diseases like blight, while transport of produce was hampered due to infrastructure damage from excess rains. Excess rains affected fishing with beaches being flooded. And fish landing sites were also affected by the flooding during MAM 2020. There was flooding of farms in Garissa which affected farm inputs and machinery. Parts of River Tana changed course hence leaving some farms without water for irrigation. There was poor honey production since nectar producing flowers were washed away. According to the County Director of Meteorology Kitui county, Dr. Mbithi, crops had too much water which in some cases is not common and they grew taller than usual while compromising the bearing of fruit. Potatoes in Nyandarua did not perform well due to excess rainfall during the MAM season. During OND 2020 there was migration of bee colonies due to dry conditions to relatively wetter areas, this in recent years may impact the phenology of plants and animals as climate changes. Tea farmers also suffered from hailstorms which destroyed their crops.

Health

During the short rains season approximately 300 human lives were lost due to flooding and >160,000 households (over 800,000 people) were affected across the country.

Figure 24: Residents piled into boats with whatever they could rescue, including animals, to escape the floodwaters in Buyuku. Image :/COURTESY

Flooding was reported in more than three quarters of Kenya's counties (36 out of 47), with landslides reported in the Rift Valley and the central and coastal regions, according to the Government's National Disaster Operations Centre (NDOC).

Seven Tanzanian sailors were rescued off Kilifi, after encountering the rough seas due to strong winds. The seven had left Tanga for Pemba on a vessel named *Haina Hollo* before their boat capsized**,** their boat was pushed by strong winds into Kenyan waters, struck a reef and capsized. The vessel was ferrying 700 eucalyptus logs.

Figure 25: A Tanzanian cargo boat capsized due to high seas caused by strong winds.

Image: /COURTESY

During the short rains season heavy rainfall recorded over mainly parts of North-western Kenya landslides were recorded in West Pokot

Early Warning/Disaster Risk Reduction

The Kenya Meteorological Department (KMD) worked tirelessly throughout the year and despite the added challenges brought on by the global Covid19 pandemic to provide early warning for all these expected severe weather events. Partners for disaster reduction included but are not limited to;

- Kenya Red Cross and Red Crescent Society
- National Disaster Operations Centre (NDOC)
- Ministry of Water
- KENGEN

Transportation

Roads and bridges were damaged as a result of the floods witnessed during the short rains season. These had cascading effects on other sectors such as agriculture in delaying or even hampering transport of products. Counties affected included West Pokot, Narok, and Homa Bay

Water & Energy

The water and energy sector are in this report discussed together. During 2020 there were both positive and negative impacts of the weather experienced.
Major positive impacts include increase of water levels in the dams in western Kenya which contributed to high hydro-power output by the electricity generation companies. There was also reliable water supply due to favourable recharge of rivers and lakes. This is especially in regions where water infrastructure was not damaged. One noteworthy positive impact was also that there was reduced water conflicts in most areas.
Negative impacts included the floods documented here; flash floods in ASALs as well as water contamination due to flooding and subsequent water infrastructure destruction. Over the eastern sector water related conflicts remained. Also, there were cases of power interruptions associated with destruction of power transmission lines/infrastructure.

Infrastructure

There were reports from the media showing the negative impacts of the strong winds episode and large waves that caused destruction of property and socio-economic activities.

A telecommunication mast which was being constructed was destroyed by strong winds in Kwale County as reported by Mr Dominic Mbindyo, Kwale County Director of Meteorological services. Roads and bridges were flooded and submerged and, in some cases, partially washed away as a result of the heavy rains. Additional impacts are discussed in the Transport sector section.

Chapter 7: Projected Climate patterns for 2021 and likely socio-economic impacts

The chances of La Niña are greater than 60% through March-May 2021, with a 60% chance of a transition to ENSO-neutral in April-June 2021. The situation will be monitored as it progresses to see what effects it may have for the short rains season from October.

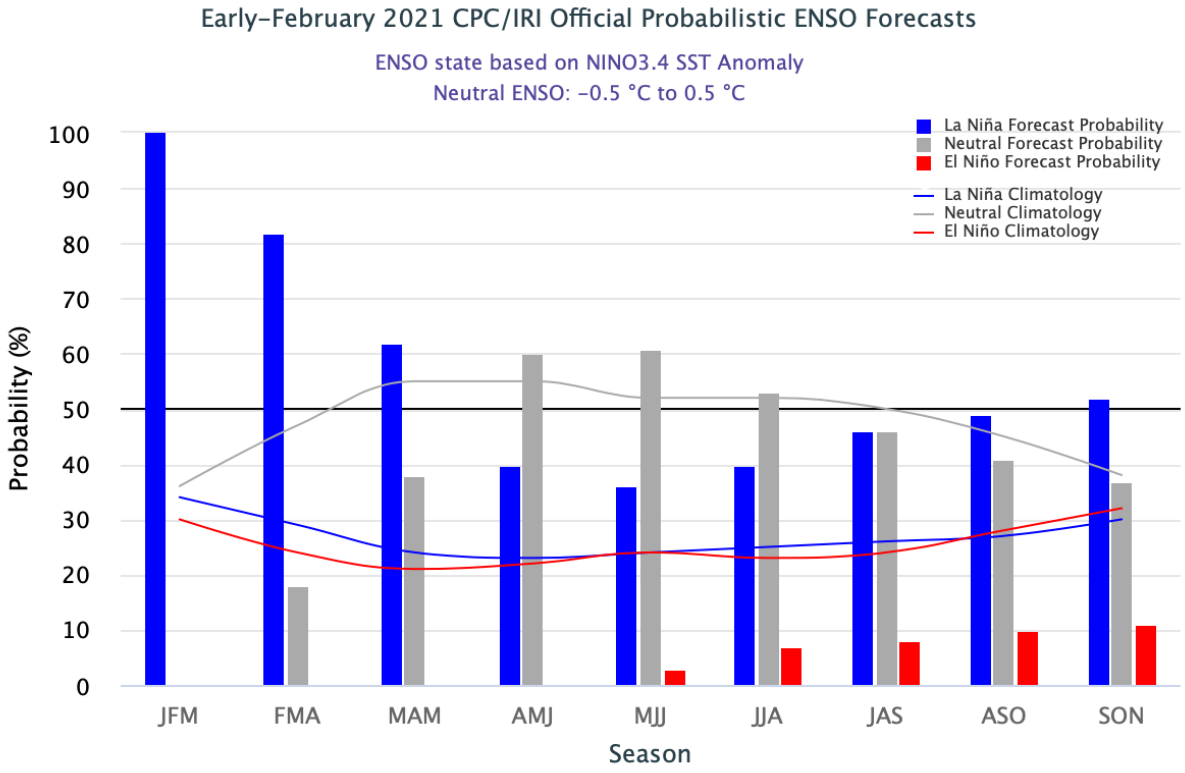

Figure 26: ENSO projection (Source: IRI)

Currently La Niña conditions are prevailing and equatorial sea surface temperatures (SSTs) are below average from the west-central to eastern Pacific Ocean. The tropical atmospheric circulation is consistent with La Niña. There is a ~60% chance of a transition from La Niña to ENSO-Neutral during the Northern Hemisphere spring 2021 (April-June).

The Indian Ocean Dipole (IOD) is also a strong driver for Kenyan weather. Projections carried out in February portrayed the IOD index as neutral and with a tendency to remain neutral through to May 2021.

Chapter 8: Summaries of sectoral applications

Agrometeorological Report for Year 2020

According to the **Agrometeorological report 2020**, maize, beans and tea grown in western Kenya were impacted by the rainfall seasons. Maize yields ranged from near normal to above normal while beans yield ranged from below normal in some counties due to excess rainfall at the beginning of the season to above normal in others. Hailstorms and isolated landslides affected the crop growing season.

In Central Kenya, where maize, potatoes, peas and beans are grown, there was a false onset of the MAM rains and a depressed season. In April there was excess rainfall leading to yields ranging from below normal to near normal.

Over South-eastern and Coastal Kenya, maize and beans are the main crops grown; yields were poor due to depressed rain during the short rains season.

Western Kenya Counties

Summary

Table 4: Summary of Agrometeorological impacts in Western Kenya

Agromet center		Observed Impacts
KAKAMEGA	MAM 2020	• Rains were above normal resulting to above normal maize harvest. • But the excess rains affected beans. Maize was slightly affected by hailstones
	OND 2020	• Rains were near normal resulting in near normal yield for maize. • Excess rains in the first decade of October affected beans resulting to below normal yield. Maize was also slightly affected by hailstones
KITALE	MAM 2020	• Rains were above normal resulting to above normal maize harvest. But the excess rains affected beans. • Maize was also slightly affected by hailstones.
	OND 2020	• No major planting is usually done in this season
KERICHO	MAM 2020	• Rains were above normal and this resulted in above normal yields for maize and beans. • There were a few but isolated landslides in sloping areas.
	OND 2020	• Rains were near normal but was enough for maize and beans resulting in above normal yields. • Tea was however affected by hailstones
KISII	MAM 2020	• The rains were above normal resulting in above normal maize yields. • Beans were affected by excess rains resulting in near normal yields.

		• Both crops were also affected hailstones
	OND 2020	• The rains were above normal resulting in above normal maize yields. • Beans were affected by excess rains resulting in near normal yields. Both crops were also affected hailstones.

KAKAMEGA

Table 5: Kakamega MAM & OND impacts review

KAKAMEGA MAM 2020				
	M	A	M	total MAM
Rain (mm)	260.2	333.3	238	831.2
	planting date	**growing period (days)**	**yield**	**climate hazards/adverse effects**
Maize	25-2-2020	5 months	ABN	Hailstones
Beans	25-2-2020	60-90	NN	excess rain

KAKAMEGA OND 2020				
	O	N	D	total OND
Rain (mm)	222.2	86.3	77.8	386.3
	planting date	**growing period (days)**	**yield**	**climate hazards/adverse effects**
Maize	30-9-2020	4 months	NN	hailstones
Beans	30-9-2020	60-90	BN	Excess rain in the 1st decade of October affected beans

Kitale

Table 6: Kitale MAM & OND impacts review

KITALE MAM 2020				
	M	A	M	total MAM
Rain (mm)	323.9	188.1	207	718.6
Crop	**planting date**	**growing period (days)**	**yield**	**climate hazards/adverse effects**
Maize	28-3-2020	6 - 7 months	ABN	Hailstones
Beans	28-3-2020	60-90	NN	excess rain

KITALE OND 2020				
	O	N	D	total OND
Rain (mm)	146.6	130.6	9.1	286.3
	planting date	**growing period (days)**	**yield**	**climate hazards/adverse effects**
Maize	Only one season in Kitale no major planting			nil
Beans				nil

Kericho

Table 7: Kericho MAM & OND impacts review

KERICHO MAM 2020				
	M	**A**	**M**	**total MAM**
Rain (mm)	268.5	360.8	252	881.1
	planting date	growing period (days)	yield	climate hazards/adverse effects
Maize	Feb	5 months	ABN	isolated landslides
Beans	feb	60-90	ABN	isolated landslides
Tea	Perennial crop	N/A	ABN	Nil

KERICHO OND 2020				
	O	**N**	**D**	**total OND**
Rain (mm)	196.61	147.25	70	413.87
	planting date	**growing period (days)**	**yield**	**climate hazards/adverse effects**
Maize	sept	4 months	ABN	nil
Beans	sept	60-90	ABN	nil
tea	N/A	N/A	NN	hailstones

Kisii

Table 8: Kisii MAM & OND impacts review

KISII MAM 2020				
	M	**A**	**M**	**total MAM**
Rain (mm)	385.4	232.3	324	942
	planting date	**harvesting date**	**yiel d**	**climate hazards/adverse effects**
Maize	9/3/2020	august (5 months)	ABN	slight impact from hailstones
Beans	9/3/2020	May (3 months)	NN	hailstones/excess rains

KISII OND 2020				
	O	**N**	**D**	**total OND**
Rain (mm)	329.4	306.2	159	794.8
	planting date	**harvesting date**	**yiel d**	**climate hazards/adverse effects**
Maize	1/9/2020	7-Feb-21	ABN	slight impact from hailstones
Beans	1/9/2020	7-Dec	NN	hailstones/excess rains

Central Kenya Counties

Summary

Table 9: Summary of Agrometeorological impacts in Central Kenya

Agromet centre		Observed Impacts
Nyahururu	MAM 2020	• Rains were near normal and prolonged resulting in above normal yields for maize and peas. • Potatoes were however negatively affected by the excess rains resulting to below normal yields.
	OND 2020	• Rains were below normal but no major planting is usually done in this season.
Nyeri	MAM 2020	• Rains were near normal and excess rains especially in the 3rd decade of April resulted in near normal yields for maize and below normal harvest for beans.
	OND 2020	• Rains were depressed and this resulted in below normal yields for maize and beans
Embu	MAM 2020	• Rains were above normal but there was a false start in March which resulted in near normal yields for maize and beans
	OND 2020	• Rains were above normal but there was an early cessation that resulted in below normal yields for maize and near normal yields for beans
Meru	MAM 2020	• Rains were above normal but the distribution was poor resulting in near normal yields for maize. There was however excess rains in the 2nd and 3rd week of April affecting beans yields that were below normal
	OND 2020	• Rains were above normal but the distribution was poor resulting in near normal yields for maize and beans

Nyahururu

Table 10: Nyahururu MAM & OND impacts review

NYAHURURU MAM 2020				
	M	**A**	**M**	**total MAM**
Rain (mm)	157.9	178.8	77.7	414.4
Crop	**planting date**	**Harvesting**	**yield**	**climate hazards/adverse effects**
Maize	March	Sept (green) and Jan (dry)	ABN	Nil
Potatoes	March	Jun-July	BN	Excess rain
Peas	March	July (green) and Aug/Sept (dry)	ABN	

NYAHURURU OND 2020				
	O	N	D	total OND
Rain (mm)	93.4	56.2	37	186.6
Crop	**planting date**	**growing period (days)**	**yield**	**climate hazards/adverse effects**
No Major planting usually done				

Nyeri

Table 11: Nyeri MAM & OND impacts review

	NYERI MAM 2020			
	M	**A**	**M**	**total MAM**
Rain (mm	123.61	436.63	213	773.46
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	2/4/2020	120	NN	
Beans	2/4/2020	80 days	BN	Excess rain in 3rd Decade of April
NYERI OND 2020				
	O	**N**	**D**	**total OND**
Rain (mm)	107.1	128.4	82.2	317.7
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	20/10/2020	120	BN	Depressed rains
Beans	20/10/2020	80 days	BN	Depressed rains

Embu

Table 12: Embu MAM & OND impacts review

EMBU MAM 2020				
	M	A	M	total MAM
Rain (mm)	195.6	351.1	229	776.1
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	15-3-2020	120	NN	false onset
Beans	15-3-2020	90	NN	false onset
EMBU OND 2020				
	O	**N**	**D**	**total OND**
Rain (mm)	274.4	282.7	92.8	649.9
Crop	planting date	growing period (days)	yiel d	climate hazards/adverse effects
Maize	15-10-2020	120	BN	early cessation
Beans	15-10-2020	90	NN	nil

Meru

Table 13: Meru MAM & OND impacts review

MERU MAM 2020				
	M	**A**	**M**	**total MAM**
Rain (mm)	133.12	433.3	187	753.42
	planting date	**growing period (days)**	**yield**	**climate hazards/adverse effects**
Maize	18/3/2020	90	NN	Poor distribution
Beans	18/3/2020	45	BN	excess rains in 2nd to 3rd Decade of April
MERU OND 2020				
	O	**N**	**D**	**total OND**
Rain (mm)	123.21	466.41	53.6	643.22
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	20/10/2020	60	NN	nil
Beans	20/10/2020	40	NN	nil

Coastal Counties

Summary for year 2020

Table 14: Summary of Agrometeorological impacts in Coastal Kenya

Agromet centre		**Observed Impacts**
Mtwapa	MAM 2020	• Rains were above normal and this resulted in above normal yields for maize and beans
	OND 2020	• Rains were depressed resulting in poor yields for Maize and beans
Msabaha	MAM 2020	• Rains were near normal resulting in near yields for Maize and beans
	OND 2020	• Rains were depressed resulting in poor yields for Maize and beans

Mtwapa

Table 15: Mtwapa MAM & OND impacts review

MTWAPA MAM 2020				
	M	A	M	total MAM
Rain (mm)	81.5	234.91	427	743.02
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	20/3/2020	90	ABN	Nil
Beans	3/4/2020	60	ABN	Nil

MTWAPA OND 2020				
	O	**N**	**D**	**total OND**
Rain (mm)	91.24	97.91	53.5	242.68
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	1/11/2020	90	poor	drought (depressed rain)
Beans	1/12/2020	60	poor	drought (depressed rain)

Msabaha

Table 16: Msabaha MAM & OND impacts review

MSABAHA MAM 2020				
	M	A	M	total MAM
Rain (mm)	41.6	105.3	189	335.5
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	20/3/2020	90	NN	Nil
Beans	3/4/2020	60	NN	Nil
MSABAHA OND 2020				
	O	N	D	total OND
Rain (mm)	30.4	94.8	2.9	128.1
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	1/11/2020	90	poo r	drought (depressed rain)
Beans	1/12/2020	60	poo r	drought (depressed rain)

South Eastern Counties

Summary for South eastern Counties

Table 17: Summary of Agrometeorological impacts in South-eastern Kenya

Agromet centre		Observed Impacts
Katumani	MAM 2020	• Rains were near normal and this resulted in near normal yields for Maize and above normal yields for beans
	OND 2020	• Rains were depressed resulting in below normal yields for maize and beans

Katumani

Table 18: Katumani MAM & OND impacts review

KATUMANI MAM 2020				
	M	**A**	**M**	**total MAM**
Rain (mm	179.02	273.9	7.7	460.62
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	early mar	end of may	NN	nil
Beans	early mar	end of April	ABN	nil

KATUMANI OND 2020				
	O	**N**	**D**	**total OND**
Rain (mm	22.2	114.74	29.4	166.34
	planting date	**growing period (days)**	**yiel d**	**climate hazards/adverse effects**
Maize	Early Nov	90	BN	depressed rain
Beans	Early Nov	60	BN	depressed rain

Marine Sector Report

No significant marine weather was noted during the year 2020. However, strong wind of 30-40Knots and high wave of between 2.5 -3 m were noted. An advisory was issued on 14th July 2020, Valid 16th to 19th July 2020 for strong winds and high waves. During that period a small boat capsized, and six fishermen were rescued in Lamu.

Marine division also monitor earthquake and tsunami activities over the Indian ocean. On 3 **May** 2020, a 4.9 magnitude earthquake happened 60km from Lodwar, Turkana. While in August 12, 2020, an Earthquake of magnitude 6.0 occurred near Kilindoni, Pwani, Tanzania, but did not cause any high waves over the western Indian ocean. No tsunami warning was issued during the review period.

Hydro-meteorology

Hydro-meteorological events and impacts in 2020

Heavy rains experienced in the year caused death, flooding, displacement of people and destruction of infrastructure.
High water levels in the lakes resulted in flooding. Lake Victoria rose to a new record level.
Landslides and mudslides occasioned by heavy rainfall caused death and destruction of property. Riverine flooding as well as flash floods caused disruption of transport and displacement of communities.
Flash floods were also experienced in urban areas due to heavy storms.
Dams and reservoirs were full to capacity in unprecedented levels across the country.

Chapter 9: Capacity development needs

1. Climate change scenario development training urgently needed
2. Capacity building on downscaling of GPC products also required
3. Support on implementation of climate services as required by WMO is needed too.
4. There's some capacity in developing the yearly climate review but additional capacity building is needed for a more collaborative approach.
5. Tropical cyclone monitoring and forecasting capacity needed.

CONCLUSION

The Kenya Meteorological Department continues to fulfil its mandate of providing timely and accurate early warning information and services to the public as well as to government ministries and departments to support implementation of national strategies for sustainable development.

The food security situation in the country was negatively impacted by the locust invasion of 2019 that spilled over into 2020. Floods led to landslides in areas such as West Pokot County, which in turn led to loss of lives and livelihoods.

Temperatures continued to rise through the year and were higher than the long-term averages. Noteworthy was the minimum temperature rises that were higher compared to the maximum temperature rises.

Emerging areas of interest and research by the Department include determination of possible influence of weather parameters on the COVID-19 pandemic.

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