KEY MESSAGES

- The October to December 2019 rainfall season ranked among the wettest rainfall seasons in East Africa in at least 40 years (Figure 1). Exceptionally above-average rainfall led to widespread floods, resulting in the displacement of hundreds of thousands of people and causing crop and livestock losses in worst-affected areas. According to OCHA, approximately 3.4 million people were affected across the region.

- The floods have occurred in the context of consecutive seasons of climatic shocks in the greater Horn of Africa, including the severe 2016/17 drought, floods in March to May 2018, and the 2018/19 drought. Climatic shocks, coupled with the impact of conflict, insecurity, and poor macroeconomic conditions, are primary drivers of acute food insecurity across the region. In December 2019, 18-22 million people were estimated to be facing Crisis (IPC Phase 3) or worse outcomes in East Africa (Figure 2).

- Assessments of the impact of heavy rainfall and flooding and crop and livestock production are currently ongoing at the national and sub-national level. Preliminary estimates indicate that although significant crop losses occurred in riverine areas and some marginal agricultural areas due to floods or excess soil moisture, national cereal crop production in Somalia, Kenya, Ethiopia, South Sudan, and Uganda is likely near to above average. Exceptional vegetation conditions have also supported relative improvements in herd growth and milk productivity.

- High soil moisture, wind patterns, and above-normal vegetation have created conducive ecological conditions for an ongoing desert locust outbreak in the region. The outbreak is considered the worst in 25 years in Ethiopia and Somalia and in 75 years in Kenya. Although current food security impacts are not large-scale, there is high concern for breeding and spreading in early to mid-2019. This could lead to adverse impacts on cropping and vegetation conditions in the next cropping season beginning March/April 2019, especially in insecure areas where aerial spraying is not possible.

- The extreme rainfall season was largely attributed to a strong and long-lasting positive Indian Ocean Dipole (IOD) – one of the strongest on record. The event peaked in October (at +2.1 °C) and remained strong into December. Although the IOD has currently weakened to neutral mode, warmer-than-normal sea surface temperatures forecast through March may influence slightly above average rainfall in parts of equatorial East Africa.
EXTREME OND 2019 RAINFALL AND IMPACTS

Main climate driver and hydrologic outcomes

October to December (OND) 2019 rainfall totals were among the highest of the past four decades (1981-2019) in many areas in East Africa (Figure 1). For much of the region, cumulative rainfall ranged from 200 to 400 percent of average, representing either the wettest or second wettest on record since 1981. The entire region received exceptionally heavy rainfall amounts during October and November. December also brought heavy precipitation in Uganda, Kenya, and Tanzania. This FEWS NET special report provides a retrospective look at OND 2019 rainfall extremes, climatic drivers, and impacts in some of the most affected areas and vulnerable populations.

The main climate driver accounting for the exceptional OND 2019 East African rains was a very strong and long-lasting positive Indian Ocean Dipole (IOD) event (Figure 3). The OND 2019 IOD was one of the strongest events on record. Figure 3 depicts the evolution of the IOD from mid-2019 to its epic tipping-point in October, leading to immediate and atypically heavy rains and high winds in parts of eastern Horn. The IOD is indicated by the difference in tropical western and eastern Indian Ocean region sea surface temperature (SST) anomalies. During a positive IOD phase, when the western region is warmer than normal and the eastern region is cooler than normal, the SST gradient promotes strong moist winds being directed towards East Africa. This tends to enhance rainfall in the region, including the potential for flood-inducing high intensity rain events. There can also be a delay in the southward shift of the tropical rainfall system into southern African countries. During a negative IOD phase, winds and moisture are directed away from East Africa, and the region tends to experience abnormal dryness or drought. IOD impacts to rainfall are mainly in October to December. Outcomes depend on the event’s intensity and duration in addition to other regional weather influences. Historically, many positive/negative IOD events have occurred during El Niño/La Niña events. Figure 3 depicts several recent cases, such as the 2016/17 prolonged drought and the enhanced 2015/16 short-rains season. Based on the Dipole Mode Index (a common measure of IOD strength) and NOAA ERSSTv5 SST data for OND, the 2019 IOD was as strong as or stronger than the 1997 event, which was the 20th century extreme.

Persistent, above-normal rainfall and the high intensity and frequency of rainfall events resulted in saturated ground conditions in OND 2019 (Figure 4). Extreme rainfall and high soil saturation further contributed to widespread, above-average streamflow, which increased the likelihood of flooding. Figure 4 shows the number of days in which the upper 1 meter of soil was more than 90 percent saturated. Although the number of saturation days in most of Somalia was near average, crop producing regions of Kenya and Uganda experienced prolonged periods of saturated soil ranging from 30 to 90 days above
average. Excessive soil saturation increases concerns for adverse impacts to crop production and for continued locust breeding and spreading.

Further historical context of region-wide hydrologic impacts is provided by comparison to 1997, a previous extreme wet OND season during a very strong positive IOD. Figure 4 shows modeled streamflow for both the 2019 OND seasonal rains and the corresponding period in 1997. The seasonal streamflow totals for OND 2019 and OND 1997 ranged from 200 to more than 500 percent of normal in many areas. In 2019, extreme streamflow totals were relatively widespread throughout East Africa, including most of Uganda, Kenya, Ethiopia, and parts of Tanzania, Sudan, South Sudan, and Somalia. In 1997, extreme streamflow totals were mainly located in the eastern Horn, especially eastern Kenya, Somalia, and Somali region of Ethiopia. In Somalia, our hydrologic model identifies large differences from 1997. Production data from the extreme wet 1997 Deyr season show substantially below normal outcomes, with 1997 national maize production approximately 37 percent of average (based on the 1983-2014 mean). The less extensive runoff extremes in 2019 compared to 1997 and mainly average soil saturation frequency in 2019 are indicative of smaller negative impacts to national production in 2019. The hydrologic model does show excessive runoff in the Juba River basin and along the upper Shabelle River in 2019, and combined with below-normal production in Lower Juba in 1997, a data-based assessment points to the possible substantial production losses in some of those areas. This is in line with field information from Somalia (see Preliminary Crop Production Impacts below).

Reported Damage from Flooding and Landslides

Widespread, severe damage to lives and livelihoods have been reported. According to the IGAD Climate Prediction and Applications Centre, floods across the region affected 3.4 million people, causing more than 350 deaths, extensive damage to infrastructure (over 130,000 housing units), cropland (73,000 hectare of cropland), and animal losses (over 96,000 animal deaths). In South Sudan, an unprecedented scale of flooding in riverine and low-lying areas in the east and the north affected more than 900,000 people, displaced 420,000 people, and caused crop and livestock losses. Worst-affected areas were primarily located in Jonglei and Upper Nile states. In Somalia, severe river and flash floods in riverine and lowland areas affected 570,000 people and delayed crop production activities. Worst-affected regions include Hiiraan, Gedo, Middle Shabelle, and Middle Juba in the south. In Ethiopia, floods and landslides displaced 140,000 people, caused more than 40 deaths, and led to localized crop losses and an estimated loss of 10,000 livestock. In Kenya, more than 160,000 people were affected by floods or landslides, including an estimated 18,000 people who were at least temporarily displaced and 120 people who lost their lives. Landslides in West Pokot county in late November account for a high proportion of those displaced or killed, resulting in 10,000 people displaced and 72 deaths. Severe flooding also occurred in Garissa and Tana River counties in late November, particularly along the Tana River. In Uganda, floods and landslides caused damage to homes, infrastructure, and crops in eastern and western sectors of the country. According to reliable Government of Uganda sources, an estimated 38 people died, 65,000 people were displaced, and at least 300,000 were affected in Bududa, Sironko, Manafwa, Soroti, Buikeda, Butaleja, Katakwi, Kumi, Ntoroko, and Bundibugyo districts.

Desert Locust

Extreme rainfall, saturated soil, abundant vegetation, and supporting environmental conditions such as wind direction have contributed to a serious and widespread desert locust outbreak in East Africa. According to FAO, the current outbreak is considered to be the worst in 25 years in Ethiopia and Somalia and the worst in 75 years in Kenya. Locust infestations have been observed in Ethiopia, Eritrea, Kenya, Sudan, and Somalia. There is a high risk the outbreak could spread to South Sudan.

The swarms entered central-eastern Ethiopia in August, spread to northwestern Somalia by mid-October, and entered eastern Kenya in late December (Figure 5). In Ethiopia, more than 2,350 km² of land have been infested across 125 woredas (districts), consuming more than 1.3 million metric tons of vegetation. In Kenya, a rapid increase in swarm activity occurred in late December and early January in northeastern Kenya. At present, thirteen counties are now affected, but the potential spread threatens pastoral areas in the northwest to marginal agricultural areas in the southeast. In Somalia, an estimated 70,000 hectares of land have been affected in the northwest, northeast, and central regions. Locusts have recently migrated to southern crop-producing areas, but this has occurred toward the end of the Deyr cropping season in late December and January, primarily affecting only late-planted crops. Mature swarms are present in the Garbahare area near the Kenyan border (Kenya/National Drought Management Authority).

To date, the impact of locusts is generally localized, with destruction mainly to rangeland biomass. Above-average vegetation continues to be observed in late January, with relatively minor impacts on regional crop production. However, the rainfall forecast in early 2020 is expected to favor further breeding, which would see new swarms hatching from February through
June – a period that overlaps with long rains crop production activities. Aerial control measures are underway in Kenya and Ethiopia, but is restricted by insecurity in northeastern Kenya and southern Somalia.

**Figure 5. Desert locust presence and potential spread**

*Source: FAO*

**Preliminary Crop Production Impacts**

Despite high soil saturation and significant flooding during the OND 2019 season across the region and the current spread of locusts in the greater Horn, preliminary crop production estimates for this period indicate that cereal harvests broadly range from near average to slightly above average in countries of concern. Crop production assessments are currently ongoing at the national and sub-national levels. Cereal crop losses from flood-induced damage were mainly concentrated in riverine areas and localized marginal agricultural areas, and these losses were largely counterbalanced by increased area planted/replanted and above-average yields in areas where soil saturation and extreme rainfall were relatively less severe. However, legume production – particularly in Kenya and Uganda – is most likely below average, given the lower moisture tolerance of these crops. In addition, post-harvest losses are likely above normal in western Kenya, Uganda, eastern Ethiopia, and South Sudan due to excessive rainfall during harvesting and drying activities.

In Somalia, field information collected by FSNAU and FEWS NET suggest that 2019 Deyr national production is slightly above average due to high cereal production in Bay and Lower Shabelle agropastoral regions. However, severe river and flash floods in riverine areas in Gedo, Hiiraan, Middle Shabelle and Middle and Lower Juba regions resulted in significant local maize crop losses. Although off-season harvests are expected in March/April in most riverine areas, riverine areas in Middle Shabelle remained inundated as late as mid-January, which has diminished off-season harvest prospects to zero. Currently, locust damage to crop and pasture is not significant. In crop-producing areas, locusts arrived during the mature crop development stage of early- to timely-planted crops, which minimized losses. However, approximately 30 percent of late-planted crops were damaged by locusts. In pastoral areas, the regeneration of pasture due to favorable rainfall has broadly outpaced locust damage and rangeland vegetation currently remains above normal. However, in a worst-case scenario, unchecked locust breeding could lead to more adverse, widespread locust impacts during the Gu 2020 season.

In Kenya, field information collected by the National Drought Management Authority and FEWS NET indicate above-average rainfall had mixed effects on short rains crop production in marginal agricultural areas, which is most likely to result in a near-average harvest on aggregate in January. In many areas, area planted and yield prospects were above normal. However, excess soil moisture and flooding in some coastal and southeastern areas – particularly Kilifi and Kwale counties – is expected to result in below-average, short-cycle legume production and localized maize losses. At present, the impact of locusts on the marginal harvests remains low since these crops are in the maturation stages. However, locusts pose a significant threat to cereal and cash crop production at the start of the February to August unimodal cropping season and the March to May bimodal cropping season.

In Ethiopia, national Meher production is expected to be average with localized areas of below-average production due to the impact of poor Kiremt rainfall earlier in 2019 (July to September), the ongoing desert locust infestation, and heavy OND rainfall. Flooding in Somali region during the OND 2019 Deyr/Hagaya season damaged nearly 17,500 hectares of riverine crops and nearly 10,000 livestock were lost. The largest crop losses were in Kalafo and Mustahil woredas along the Shabelle River. The immediate impacts of flooding decreased agriculture labor opportunities and availability of crops; however, as flood waters receded households have planted short-maturing crops for off-season cultivation since soil moisture is above average. Although an estimated 97,000 hectares (ha) of crops and 43,000 ha of rangeland were infested in Amhara, for
example, well-coordinated efforts by farmers, local communities, and the government implementing control measures have prevented widespread crop and pasture losses. Nevertheless, localized crop losses amount to 30 percent of local sorghum crop production in some of the worst-affected areas in Amhara, including Bati and Dawe Harawa woredas in Oromiya Zone.

In South Sudan, preliminary estimates of crop losses by FAO suggested a loss of more than 72,000 metric tons of cereals in the 2019 production year in flood-affected areas. Due to the impact of flooding, the harvest is expected to be lower than last year in Northern Bahr el Ghazal state and parts of Upper Nile and Jonglei states. Nevertheless, based on FEWS NET’s monitoring and preliminary results of the Crop and Food Security Assessment Mission, 2019/20 national crop production is expected to be slightly higher than last year and near the five-year average. This is attributed to improved security that led to increase in planted areas relative to 2018 as well as high crop yields in areas not directly affected by the flooding, particularly in the Greater Equatoria region and parts of Lakes and Western Bahr el Ghazal states. At present, no locusts have been reported in South Sudan. However, given the proximity of locusts located 200 km away in Kenya, the risk is high that locusts could enter southeastern regions through northwestern Kenya.

In Uganda, above-average rainfall since July that continued through the end of December favored early planting and supported favorable crop development, resulting in early availability of the green/dry harvest in November. Second season maize harvests were likely average to above average in most bimodal areas, though increased post-harvest losses are expected due to poor crop drying conditions. Perennial crops as bananas, tea, coffee, and sugarcane are reported to have performed well. However, excessive soil saturation was particularly damaging to legumes and pulse crops, and the total production of beans and groundnuts is likely to be below average. Landslides in mountainous areas, including in the western Rwenzururu sub-region and in the eastern Teso sub-region, resulted in localized, significant food and cash crop losses – including cocoa, coffee, and vanilla – and widespread loss of livestock. Crops were also waterlogged in areas affected by flooding in the Lake Victoria Basin, Lake Kyoga, and Nile River tributaries.

**FOOD SECURITY OUTCOMES**

Prior to the onset of the short rains season, many households in the Horn were still recovering from the loss of typical food and income sources and loss of productive assets that occurred during the severe 2016/2017 drought and the 2018/2019 drought. The high frequency of drought in the region, especially in parts of the Horn, has significantly eroded household coping capacity. In parts of Kenya, Somalia, and eastern Ethiopia, four to six of the past eight March to May and October to December rainfall seasons were considered drought seasons, based on the Standardized Precipitation Index (Figure 6).

Normally, above-average rainfall in the region is broadly associated with improved food security, driven by seasonal crop and livestock production activities and improved wild food availability. However, the exceptionally above-average OND 2019 season had significant, short-term negative impacts on food availability and access, which delayed the originally anticipated timeline for recovery and sustained atypically high food assistance needs through late 2019. Extreme rainfall and floods disrupted trade flows in several parts of the region and delayed the harvest of unimodal crops that would usually reach the market by November, which sustained or worsened already-high food prices – especially in areas experiencing macroeconomic crises. Planting of short rains crops was also delayed in many areas or completely suspended in riverine areas, resulting in low agricultural labor demand and a loss of labor income (cash or in-kind) at a time when households were heavily reliant on food purchases. In pastoral areas affected by extreme rainfall, households lost some livestock to flash floods or increased waterborne disease incidence, while also experiencing increased difficulty of movement to access pasture and markets. In December 2019, FEWS NET estimated 18-22 million people would continue to face Crisis (IPC Phase 3) or worse outcomes in East Africa through January 2020 (Figure 2).

In the medium-term, near-average to slightly above-average cereal crop production coupled with significantly above-average pasture and water resources for livestock are expected to drive widespread improvements in food availability and access.
Famine Early Warning Systems Network

Flood-recession agriculture, increased availability of wild foods and fish, and seasonal livestock milk availability, coupled with a forecast of an average to above-average long rains March to May season, are additional contributing factors to anticipated, relative improvements in food security in early 2020. As a result, much of the Horn is expected to improve to Stressed (IPC Phase 2) from February to May 2020. However, riverine and agropastoral areas that experienced significant crop losses and pastoral areas where herds assets remain low are most likely to sustain Crisis (IPC Phase 3) or worse outcomes. Also of concern are breeding and spread of desert locusts, which could lead to adverse impacts on crops and rangelands in the next cropping season beginning March/April 2019. Based on current information and forecast movements, desert locusts are most likely to cause localized, significant impacts to crops or pasture, especially in insecure areas without aerial control measures. Close monitoring of the situation is required, however, as the food security impact of locusts could rapidly worsen should the infestation spread to large, key crop producing areas.

A RETROSPECTIVE LOOK AT 2019 INDIAN OCEAN EXTREMES AND RAINFALL PREDICTIONS

Warming trends and 2019 extremes in the Indian Ocean

What is the role of climate change in Oceanic warming and extreme rainfall events in East Africa? Consistent with climate change, the Earth’s oceans are absorbing more and more heat from the warming atmosphere. Data indicate strong sea surface temperature (SST) increases in the Indian Ocean and climate models project this warming to continue. Extreme positive IOD events may be twice as likely to occur at 1.5 °C global warming from pre-industrial levels, according to a recent study in Nature Communications. The IOD is a naturally occurring and complex mode of ocean-atmosphere variability in the tropical Indian Ocean basin. However, the warming of the Indian Ocean means that when a strong positive (or negative) IOD does occur, there is a high level of heat available to produce and maintain a very strong SST gradient. The risk of large hydrologic impacts is further increased by the physical relationship that links warmer air to higher moisture content and increased chances for extreme precipitation.

In the case of OND 2019, there was near-record warmth in the western tropical Indian Ocean that data show as the latest peak in a long-term warming trend (Figure 7). This region has been warming very quickly. Importantly, this region of exceptionally warm surface water lay adjacent to anomalously cool waters in the eastern Indian Ocean. These conditions were capable of producing wide-spread hydrologic anomalies. This was similar to 1997, a case of a concurrent strong El Niño and a very strong positive IOD, except that in 2019 the western Indian Ocean region had warmed nearly 0.5 °C since 1997. According to this data, the west was actually warmer than the east, not in anomaly space, but in actual SST value. This reversal of the Indian Ocean SST gradient is unprecedented or extremely infrequent. Indian Ocean SSTs exhibit complex behavior, with strong warming trends punctuated by periodic large temperature fluctuations. The OND 2019 season is an indication that both the contrast and the extremity of SSTs will be important for prediction of future IOD events and impacts.

Figure 7. October –November Sea Surface Temperatures (SST) in the western and eastern Indian Ocean, 1900-2019. The western region time series is average SST for 20°S-3°N, 40°E -80°E, the eastern region is 15°S-3°N, 80°E -110°E. These are similar to IOD index regions, but not the same, and were chosen to highlight areas with the strongest SST gradient, which was slightly to the south of the equator in 2019. The data are based on the NOAA Extended Reconstruction SST archive, version 5.
An overview of OND 2019 climate forecasts and products for communication

A retrospective look at which forecast and communication methods were successful during this season can help provide guidance for the future. Going forward, this may improve lead time and communication regarding predicted hydrologic and agricultural impacts, particularly in extreme events. While extreme precipitation is inherently more difficult to predict than extreme droughts, the same staged forecast approach that FEWS NET uses for its food security outlooks may be applicable in many cases (see article here). This process begins with analysis underscoring baseline vulnerabilities. The earliest forecast process begins with the identification of exceptionally warm SSTs and SST gradients, such as theIOD which set up in August and September of 2019 (Figure 2).

The IOD is an important factor in seasonal rainfall predictions. As described on Page 2, historical data show an overall tendency for well above average rainfall during a positive IOD phase, and this is the case for both El Niño-related and “pure IOD” -- a positive IOD event when the El Niño Southern Oscillation (ENSO) is in a neutral state. Challenges for prediction come from the variety of rainfall outcomes during past IOD events and the Indian Ocean tendency to undergo rapid temperature changes on weekly to seasonal time scales. OND 2019 is an example of a “pure IOD” -- a positive IOD event when ENSO was in a neutral state. While very strong positive IOD events like in 2019 and 1997 are rare, other notably strong OND IOD events were in 2006, 1994, 1972, and 1961.

In September 2019, the National Meteorological Services (NMS) and IGAD Climate Prediction and Applications Centre (ICPAC) issued a consensus forecast for increased likelihood for above-average rains in the region (Figure 8). Multi-model ensemble systems forged with August and September sea surface temperature data, e.g. NMME and C3S, predicted a positive IOD and supported outlooks for a wetter than normal season for OND 2019. Dynamical forecast systems have shown good skill for the East Africa short rains season, and this is typically associated with forecast skill during ENSO events.

Confidence in the 2019 seasonal forecasts increased in September after the IOD quickly transitioned into a strong positive state. At this time, there was substantial warming in the western Indian Ocean and cooling in the eastern Indian Ocean, which conspired to produce a strong SST gradient. Agricultural outcomes across the region were assumed to be generally positive, but with some uncertainty due to concerns about rainfall distribution.

SST extremes materialized in October (see previous section), and the sharp upward positive turn in IOD and resulted in widespread intense rains, with strong winds and flash floods over several areas in eastern Horn and neighboring regions. The adverse impacts of the episodic rains resulted in close monitoring of the IOD development and outlooks, resulting in significant revisions in FEWS NET climate assumptions and potential impacts.

As the situation developed, FEWS NET science partners actively communicated with FEWS NET and with the public. This included frequent monitoring of rainfall, remotely sensed and modeled vegetation, and modeled hydrologic data. This also included communication about short term forecasts, such as from daily-updated GEFS weather forecasts, and longer lead middle range outlooks, such as from the weekly-updated sub-seasonal forecast system (SubX). Beginning in October, these forecasts began to predict heavy precipitation, and these forecasts generally performed well when compared with observed outcomes. Weekly hazards assessments led by NOAA CPC and reports from regional partners (ICPAC and FAO SWALIM) provided rapid updates, and monthly updates included the FEWS NET food security outlook process, the FEWS NET Seasonal Monitor, and the GEOGLAM Crop Monitor for Early Warning.

Recent advancements in data and visualization also proved useful. UCSB CHC and USGS EROS science partners have operational systems that help users visualize the impact that forecast rain would have on recent accumulations. This combines CHIRPS monitoring data with a compatible (unbiased) version of the GEFS forecast. UCSB CHC provides these data and maps that show how recent rainfall accumulations could change if these forecasts were to materialize. These are updated every five days and depict anomalies, historical rank, and more (see https://chc.ucsb.edu/monitoring). An operational system managed by the USGS EROS provides time series of these data, combined and aggregated to administrative zones (see Figure 8).
NASA also has a hydrologic modeling system that provides estimates of soil moisture and runoff based on CHIRPS and also NMME forecasts (see Figure 4).

At a regional scale, it should be noted that East African precipitation exhibits an incredible degree of persistence from October to November. The correlation of 1981-2019 regionally averaged October and November CHIRPS data is 0.83 (Figure 10). When the region faces either an extremely dry or extremely wet October, there is a very strong chance that these conditions will persist into November. October East African rainfall, combined with the October Indian Ocean SST gradient, provides a solid basis for predicting extreme November regional rainfall. This simple regression very clearly indicated that 2019 November rainfall was very likely to be exceptional and similar to 1997. A staged assessment approach, in which dynamical model forecasts for rainfall and SST drivers and the latest observations are collectively assessed, especially with respect to the extremity of drivers, can motivate successful sub-seasonal outlooks and decision support at advanced lead time.

![Figure 9. Examples of unbiased GEFS forecasts being combined with CHIRPS monitoring data to provide accurate and geographic-area-specific rainfall forecast with 15 days lead-time, based on USGS EWX time series data for flood advisories](image1)

![Figure 10. 1981-2019 Regression estimates of November East African rainfall based on October rainfall totals and the October Indian Ocean SST gradient](image2)