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Drought in East Africa
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GDO Analytical Report

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GDO Analytical Report

Drought in East Africa - August 2022

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 10/08/2022

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GDO Analytical Report

Drought in East Africa - August 2022

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 10/08/2022

Executive summary

- A long-lasting drought is affecting Somalia, coastal regions of Kenya and Tanzania, and central-eastern Ethiopia. After two years of below-average rainy seasons, severe and persistent drought conditions are leading to severe soil moisture deficit and are affecting the agricultural sector and increasing wild-fire danger.
- In the last 24 months (July 2020 – June 2022), a severe deficit has been accumulating in Somalia (20% according to CHIRPS dataset, 45% according to the ECMWF ERA5 reanalysis). Highest local values, up to 70% (50%) based on the ECMWF ERA5 reanalysis (CHIRPS), have been estimated.
- On-going conflicts in the region, widespread poverty, and food insecurity result in a high vulnerability and low coping capacity with respect to drought and natural hazards in general.
- A total of 70 million people are exposed to some level of drought risk in East Africa. According to UN-OCHA, people needing humanitarian help include 7 million in Ethiopia, 4 million in Kenya, and 5 million in South Sudan. In Somalia, as of May 2022, 6.1 million people have been affected by the drought emergency.

Precipitation and Standardized Precipitation Index (SPI)

East Africa is characterized by two main rainy seasons per year: the so-called *long rains* from March-April to May-June, the so-called *short rains* from October to December [1].

Both rainy seasons largely failed in 2021 and the second rainy season was very poor also in 2020, resulting in a severe precipitation deficit from the end of 2020 to November 2021. Only in the second half of 2021 some small areas experienced higher-than-normal precipitation, which slightly reduced the deficit. Much more precipitation over wider areas would have been required to achieve a full recovery. Since the end of 2021, a severe and increasing deficit of precipitation has been further exacerbating the already critical conditions.

The precipitation deficit cumulated in the last 24 months (July 2020 – June 2022, compared to the reference period 1981-2020) is severe over large regions in East Africa. The driest regions are: central and southern Somalia, south-eastern Ethiopia, and eastern Kenya. Values are up to about 50% deficit according to CHIRPS dataset and even higher (up to about 70 %) according to ECMWF ERA5 reanalysis. The spatial pattern is similar between the two datasets, with main

[1] See also: https://icpac.medium.com/seasonal-forecast-for-east-africa-a-drier-than-usual-season-worries-experts-a4781c6a7a73

differences in: northern Ethiopia, southern Uganda, and northern Tanzania (deficit for ERA5, surplus for CHIRPS). The magnitude of the deficit appears to be uniformly more severe for ERA5 (Fig. 1).

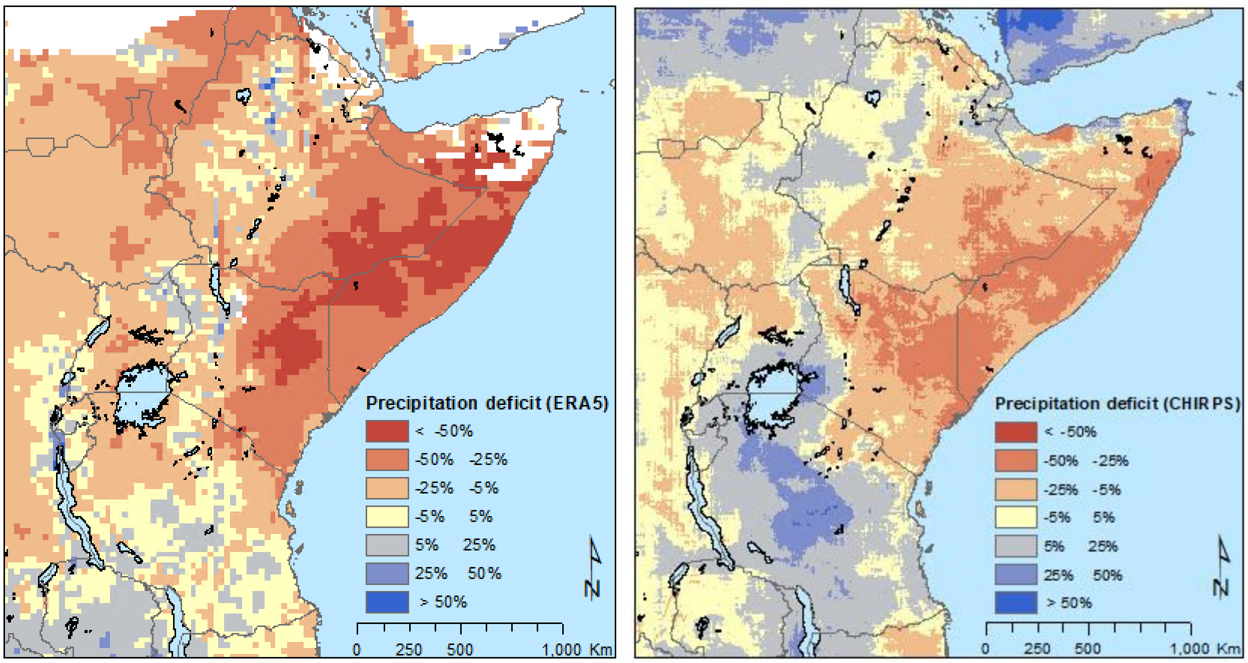

Figure 1 Precipitation deficit % compared to the reference period (1981-2020) for the period July 2020 – June 2022 according to the ECMWF ERA5 reanalysis (left panel) and CHIRPS dataset (right panel). Desert areas (based on climatology) and water bodies are masked out in ECMWF ERA5 reanalysis.

The highest precipitation deficit, from July 2020 to June 2022, has been observed in Somalia, with more than 70% maximum deficit and about 45% average deficit according to ERA5 and more than 50% maximum deficit and about 25% average deficit according to CHIRPS (Fig. 2).

The following statistics are computed by only considering the area under precipitation deficit for each country, as shown in Fig. 1.

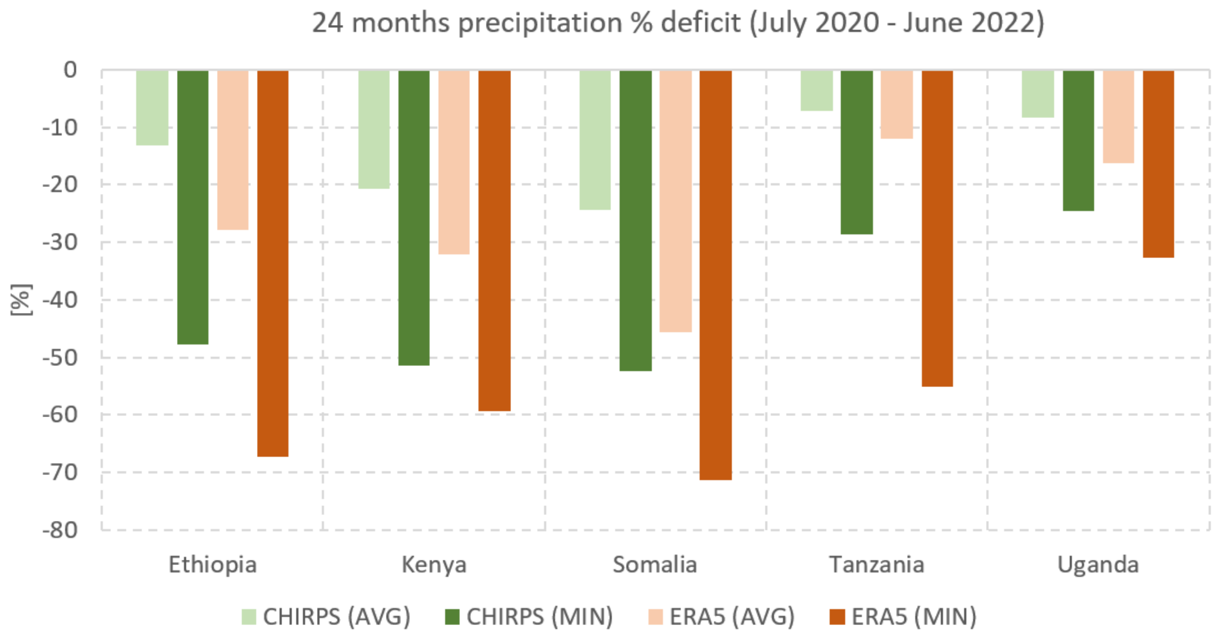

Figure 2 Precipitation deficit % compared to the reference period (1981-2020) for the period July 2020 – June 2022 according to the ECMWF ERA5 reanalysis (orange bars) and CHIRPS dataset (green bars). Statistics are computed considering only the area under precipitation deficit for each country. AVG corresponds to the spatial average of all the pixels in deficit, MIN corresponds to the pixel with the worst deficit computed for each country.

The SPI analysis at different accumulation periods shows a clear persistence of the extremely dry period especially in: eastern Somalia, central-eastern Ethiopia, and northern Uganda (Figs. 3 and 4). The one based on the ECMWF reanalysis ERA5 shows a more homogeneous and severe spatial pattern extending over the region. The GPCC-based SPI analysis is here not considered as in depth analysis is required to better understand the issues in catching this severe drought.

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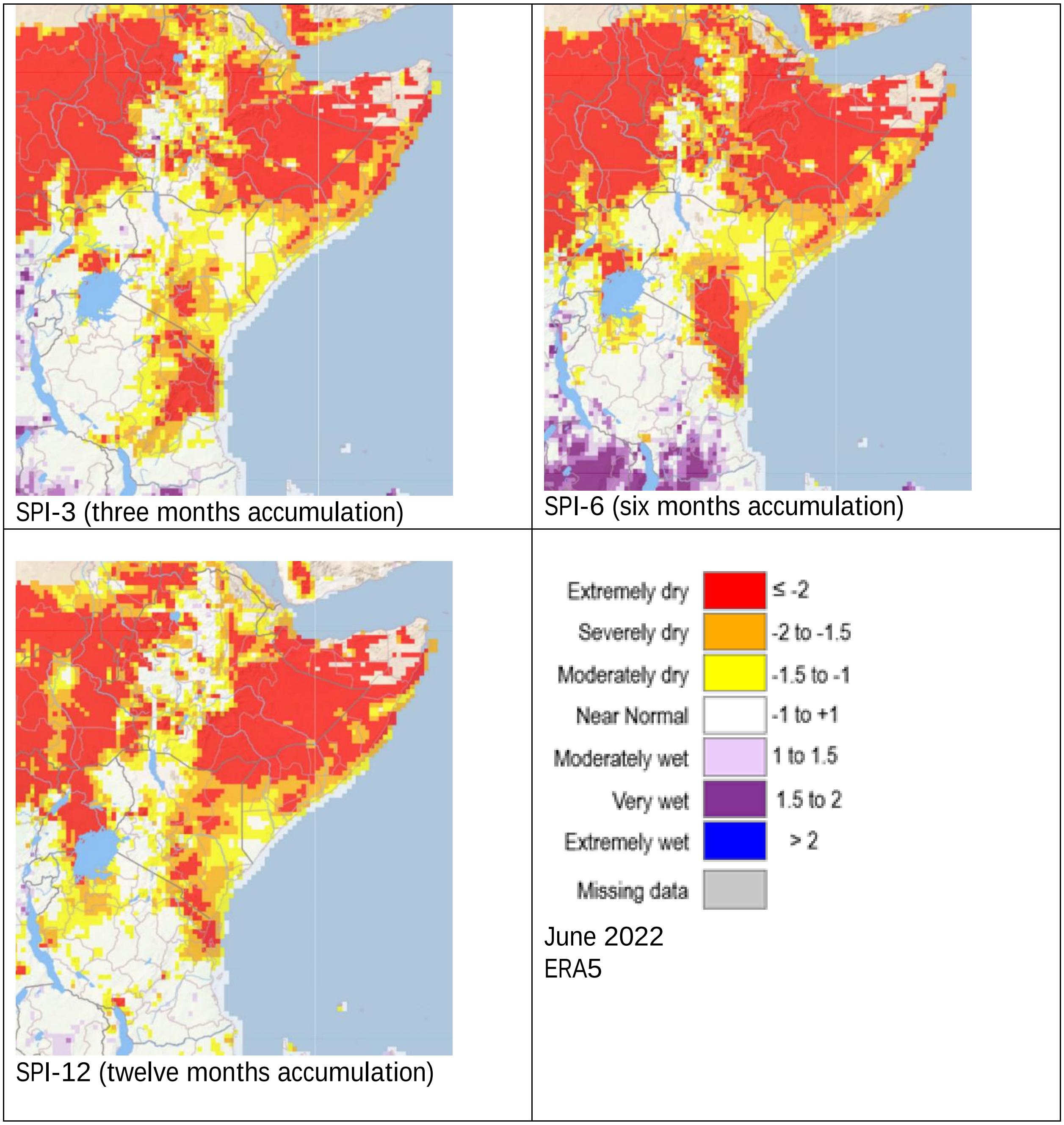

Figure 3 Standardized Precipitation Index (SPI-3; SPI-6; SPI-12) June 2022 based on the ECMWF reanalysis ERA5.

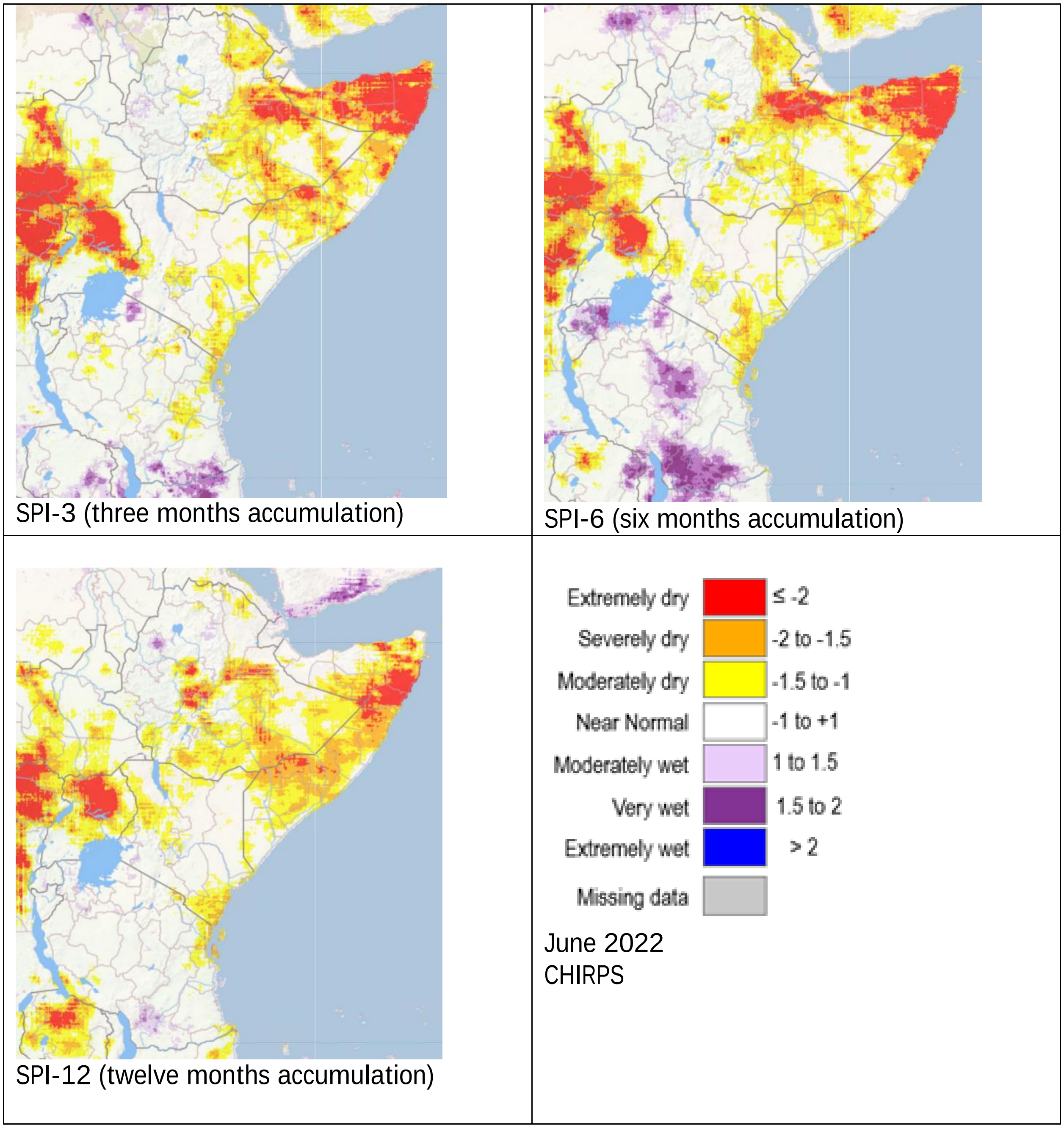

Figure 4 As Figure 3 but based on CHIRPS data.

Despite some differences between the ERA5- and the CHIRPS-based analysis, both confirm that a drought has been affecting Eastern Africa for more than a year (Figs. 5 and 6). The ERA5-SPI points to longer persistence and to a broader spatial extent, but both show a worsening of the conditions since the end of 2021 and especially after March 2022 (Figs. 5 and 6).

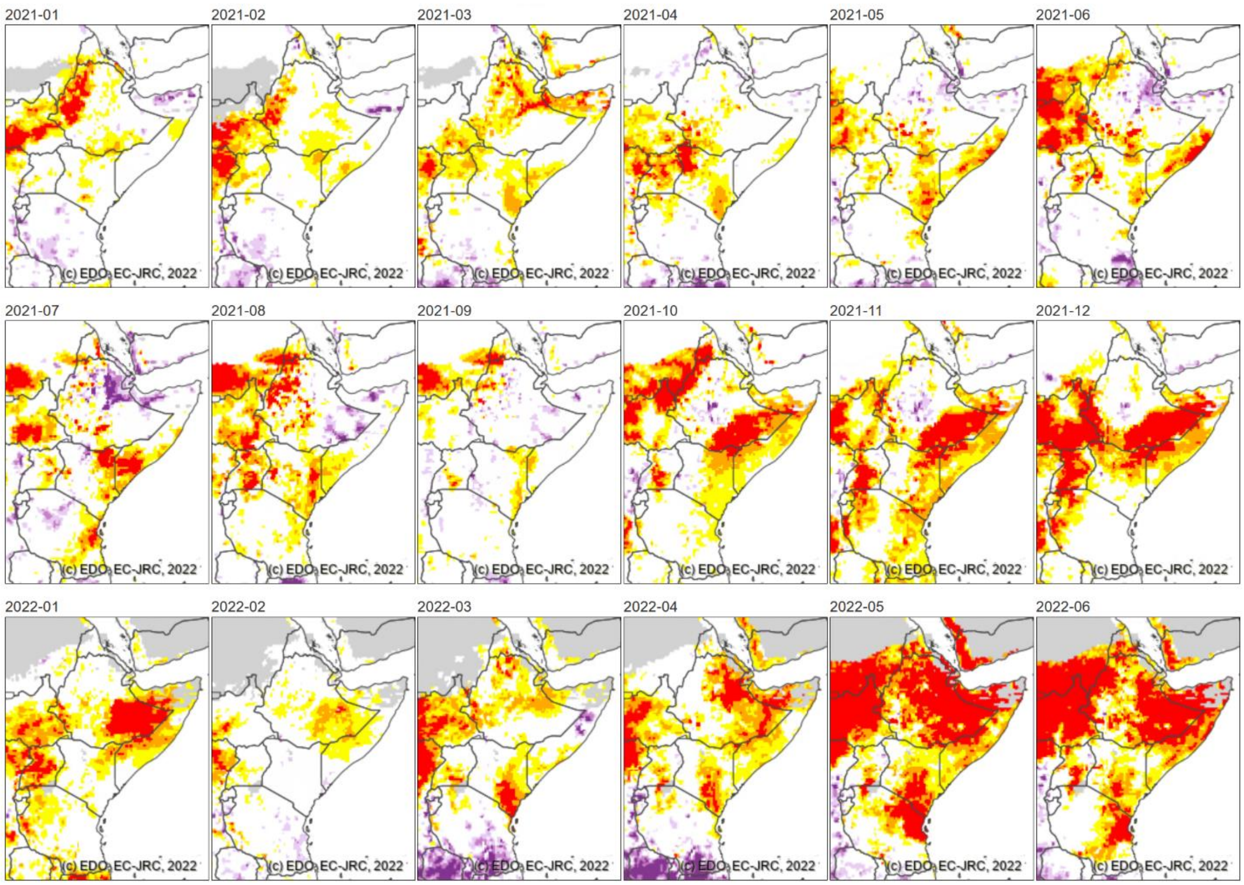

Figure 5 Temporal evolution of the Standardized Precipitation Index SPI-3 from January 2021 to June 2022 based on the ECMWF reanalysis ERA5.

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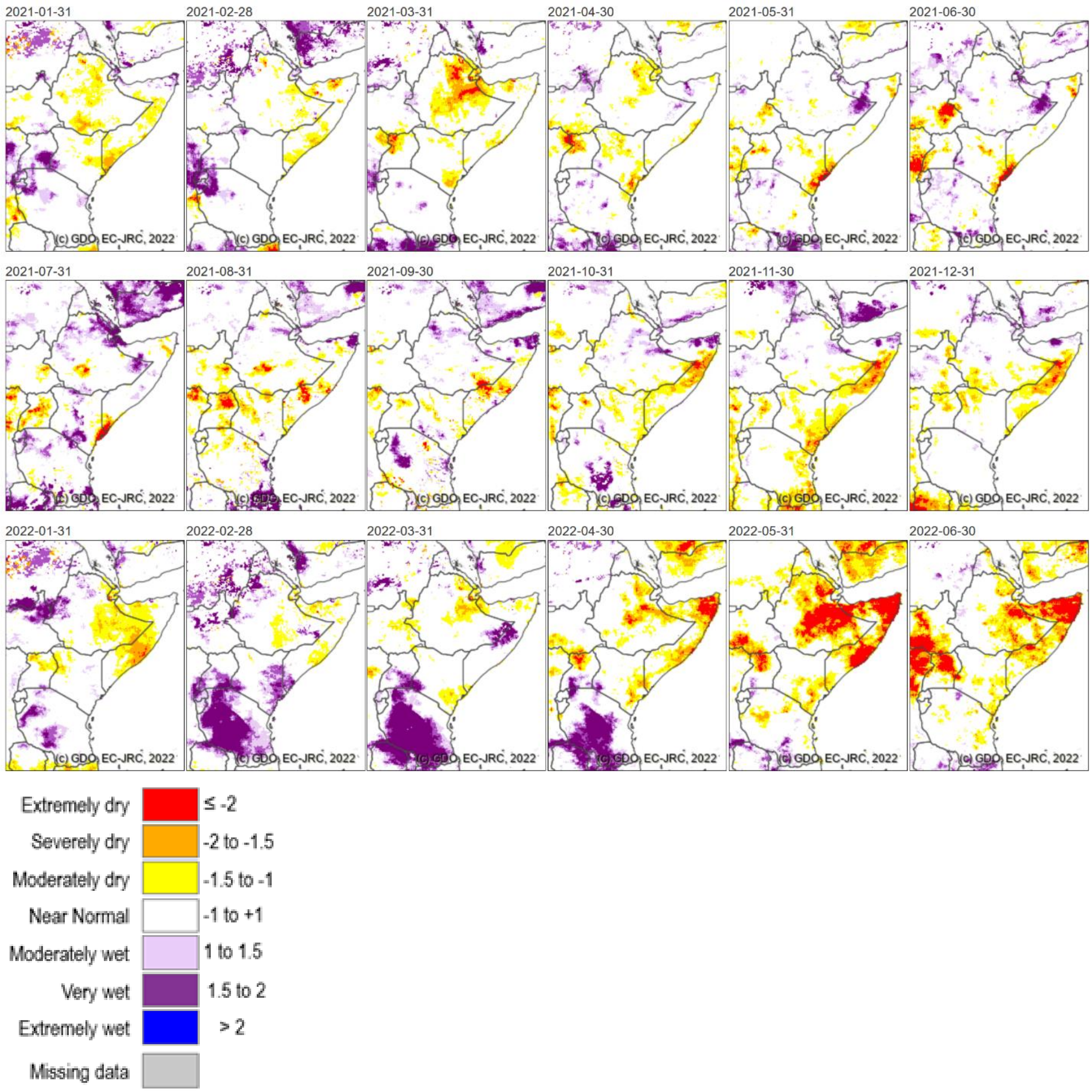

Figure 6 As Figure 5 but based on CHIRPS data.

The drought conditions are confirmed by the Combined Drought Indicator (CDI) provided by the East Africa Drought Watch of the IGAD Climate Prediction & Applications Centre (ICPAC) [2] showing drought stress related to rainfall deficit over large part of southern and eastern Ethiopia, most of Somalia, Uganda, southern South Sudan, coastal regions of Kenya and some spots in Tanzania. Warning and Alert levels due to soil moisture deficit and vegetation stress are shown in central Ethiopia, central Somalia, southern South Sudan and Northern Uganda (Fig. 7). The low-value areas must be interpreted with caution as they may represent a partial assessment due to the soil moisture anomaly signal (referred to very low absolute values) and to the absence of vegetation in desert areas, masked out in FAPAR data (see the next sections).

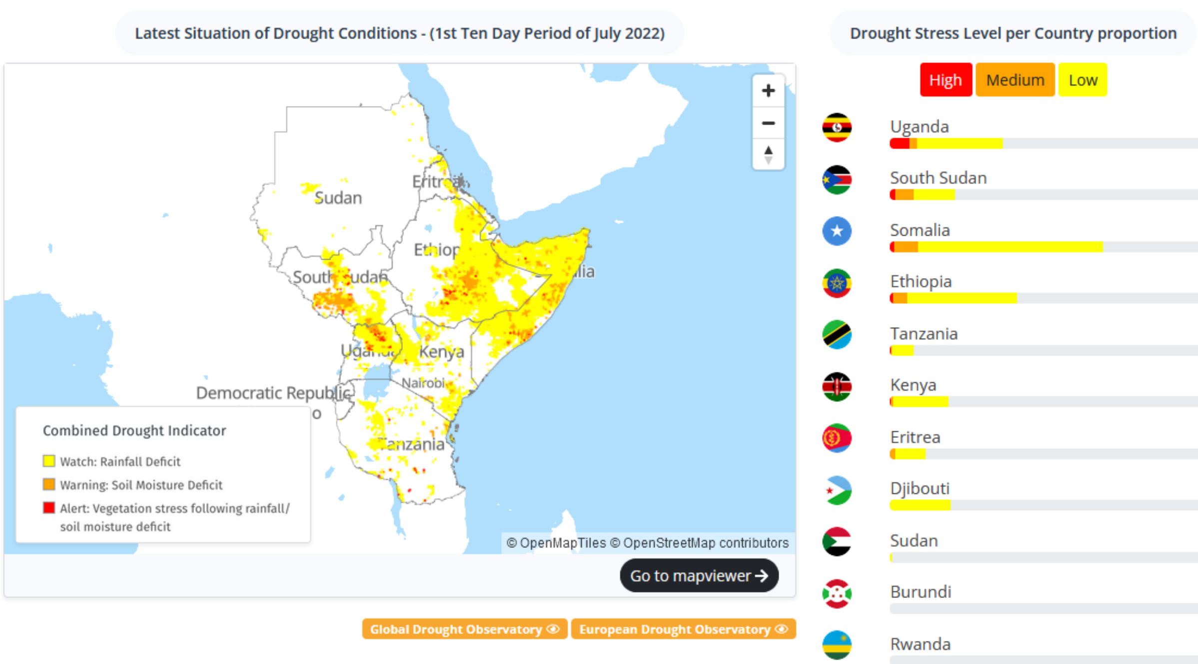

Figure 7 Combined Drought Indicator (CDI). Source: East Africa Drought Watch of IGAD Climate Prediction & Applications Centre (ICPAC).

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[2] https://droughtwatch.icpac.net/

Soil moisture anomaly

At the beginning of July 2022, drier than average soil moisture conditions were observed in central and western Ethiopia, Uganda, coastal Kenya and Tanzania, and some spots in Somalia. Some positive anomalies are visible in central and eastern Ethiopia but as related to normally dry period they are not very promising in terms of recovery (Fig. 8). Recurrent dry periods and the failure of many consecutive rainy seasons have resulted in drier than normal condition.

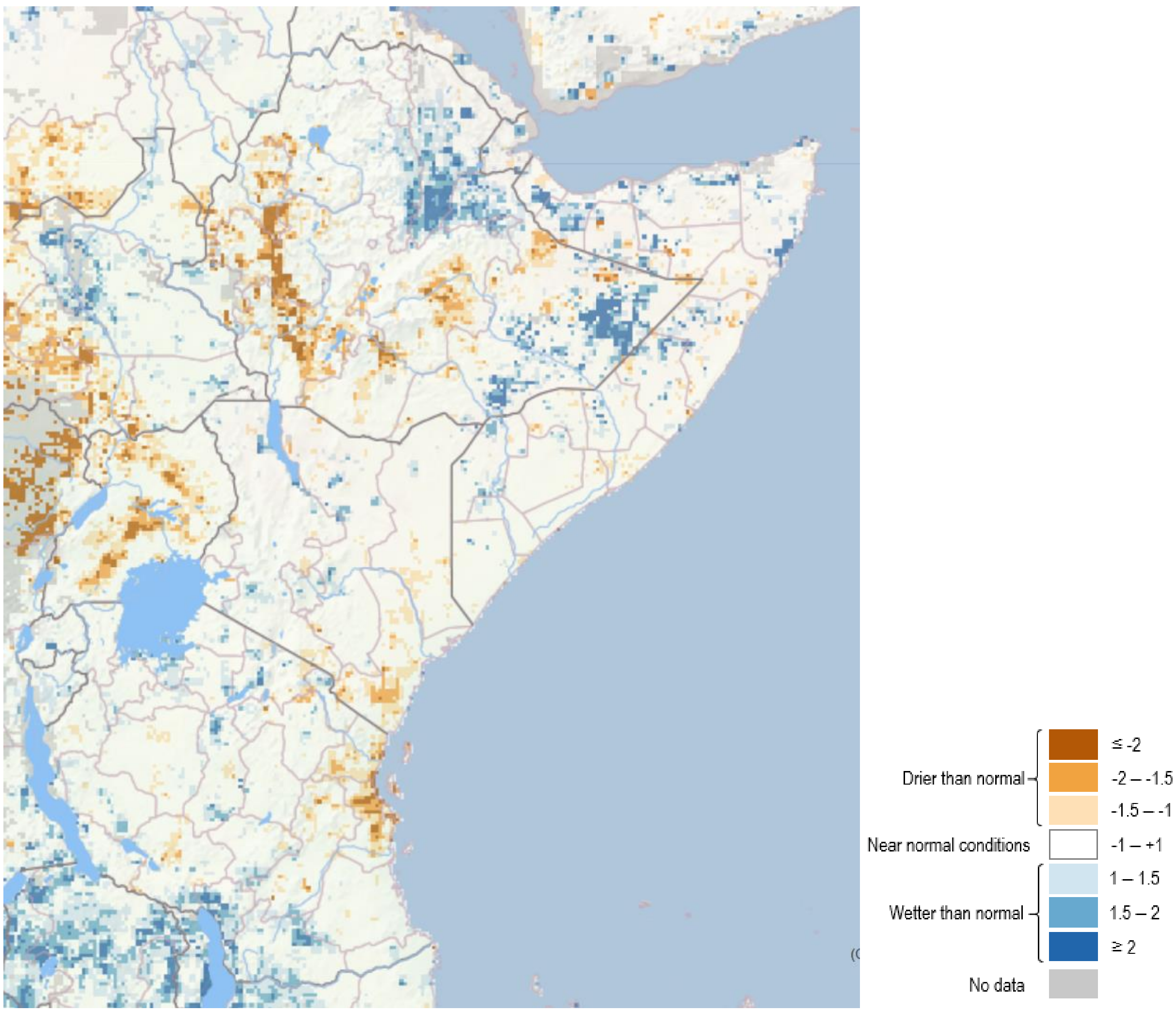

Figure 8 Soil Moisture Anomaly - beginning of July 2022

The temporal evolution of Soil Moisture Anomaly shows how the driest periods happened in correspondence with the failure of the rainy seasons. In some cases wetter-than-normal conditions are associated with very low absolute values and, thus, are not very relevant in terms of recovery. Driest periods were observed in March, April and June 2021 (mainly in central Ethiopia and Uganda). The worst dry period occurred from October to December 2021 with a widespread and severe spell in November 2021, involving southern Ethiopia, Southern Somalia, Kenya, Uganda and northern Tanzania. Finally, April 2022 was the onset of the ongoing dry period (Fig. 9).

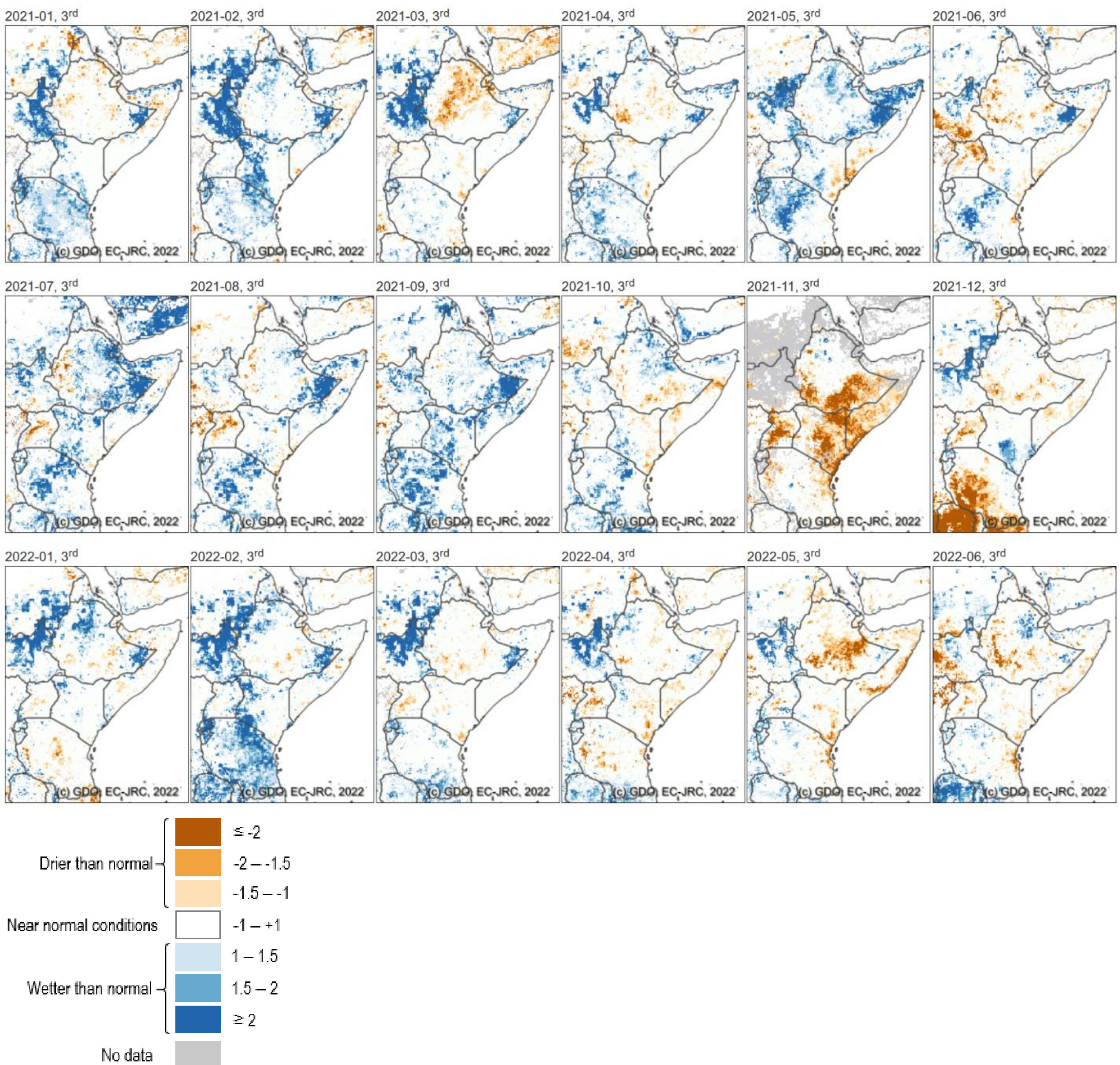

Figure 9 *Soil Moisture Anomaly – end of each month from January 2021 to June 2022.*

fAPAR anomaly

The vegetation response to the lack of rainfall at the beginning of July 2022 shows a reduction in the photosynthetic activity over most of central Ethiopia, central-southern Somalia, central Uganda, Kenya, and southern Tanzania (Fig. 10).

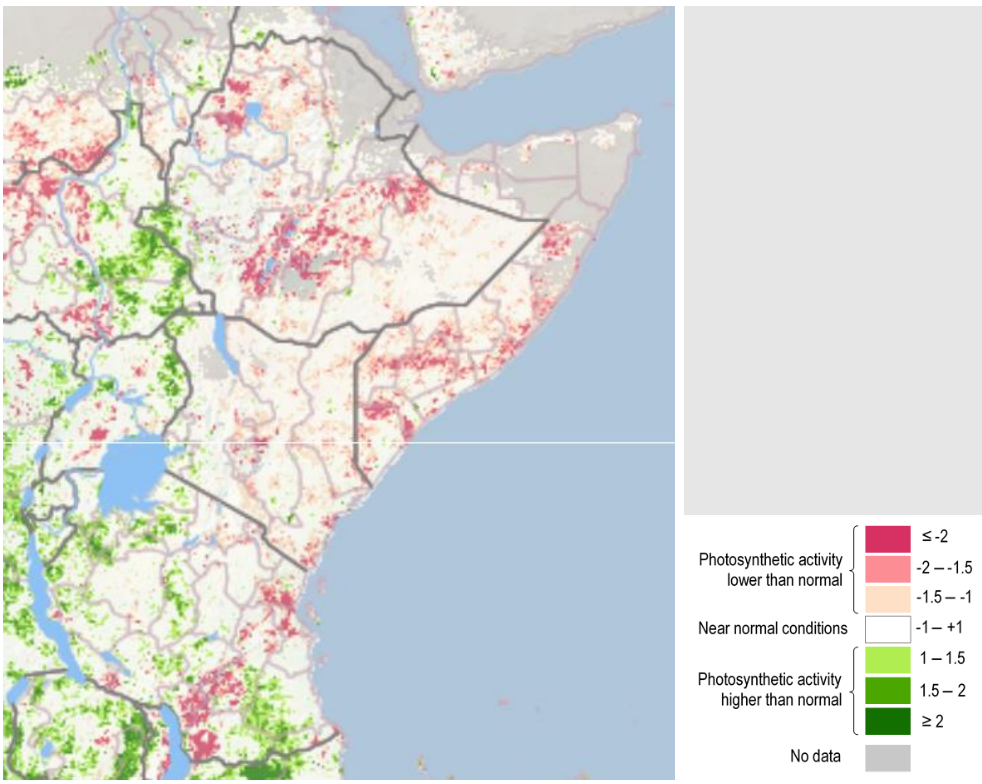

Figure 10 fAPAR Anomaly - beginning of July 2022.

The temporal evolution of the fAPAR anomaly (Fig. 11) reflects the long sequence of failed wet seasons. The most critical months were April, July, November, and December 2021. Afterwards, vegetation conditions were persistently lower than normal, following the spatio-temporal pattern of soil moisture data (Fig. 9). As expected, the pattern is not always perfectly synchronous with the one of the soil moisture (e.g. March-April 2021).

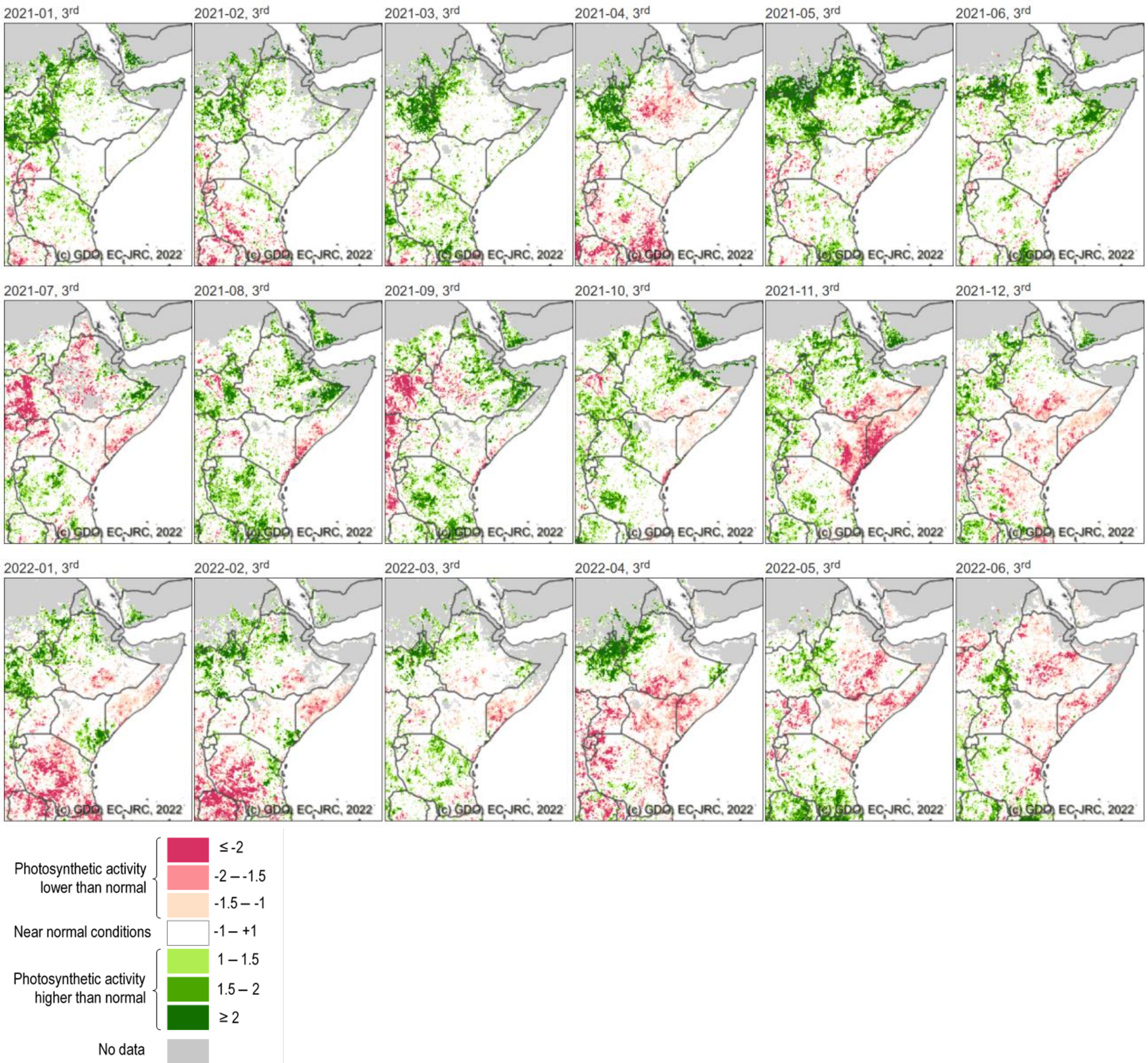

Figure 11 Evolution of the fAPAR Anomaly - end of each month from January 2021 to June 2022.

Large-scale climate patterns

The severe drought in this region is very likely related to anomalies in sea surface temperatures, especially in the Indian Ocean. In the past 12 months, sea surface temperatures in the tropical Indian Ocean exhibit clear positive anomalies on eastern side, and less pronounced negative ones on the western side (Fig. 12).

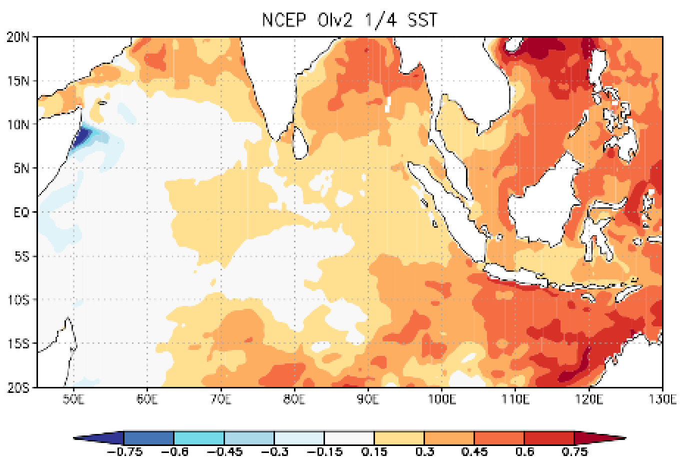

Figure 12 *Sea surface temperature anomalies during the 12-month period July 2021 – June 2022, with respect to the 2000-2019 mean (Source: WMO Climate-Explorer).*

This east-west anomaly gradient is characterized as a negative phase of the Indian Ocean Dipole (IOD), which is a leading mode of climate variability of the coupled ocean-atmosphere system. The east-west anomaly gradient has intensified since spring 2022, coinciding with the East African *long rains* (March to May) season (Fig. 13).

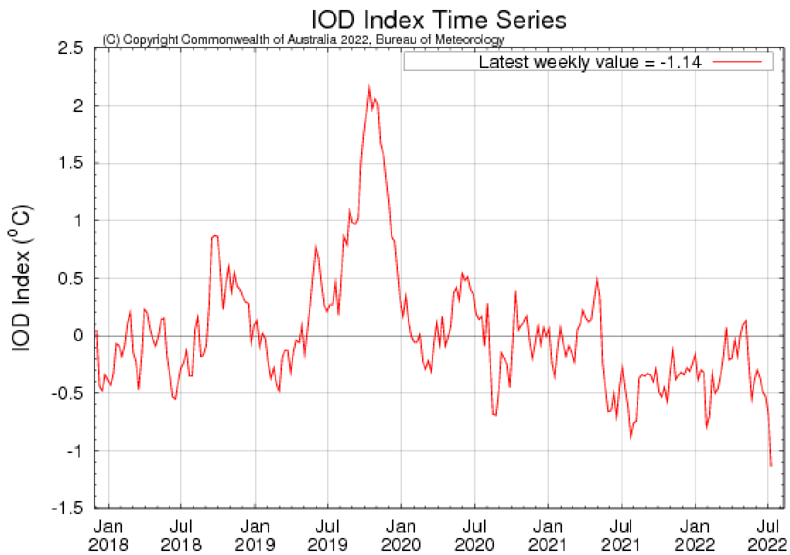

Figure 13 *Time-series of the Indian Ocean Dipole since 2018 (Source: Australian Bureau of Meteorology).*

A negative phase of the IOD is associated with below average sea surface temperatures in the tropical western Indian Ocean and reduced chance of rainfall in the extended horn of Africa due to lower-than-average atmospheric convective activity[3].

In addition to the IOD, a negative phase of El Niño Southern Oscillation (ENSO) has previously been linked to lower probability of rainfall in East Africa[4]. ENSO has indeed been in a negative phase for many months, possibly exacerbating the effects of the IOD. It is worth noting that establishing the exact cause(s) leading to the current drought in East Africa would require dedicated studies considering the effect of different drivers. However, the overall large-scale climatic conditions observed in the past months appear as important factors driving or enhancing the recent drought.

[3] Rowell, D. P. (2019). An observational constraint on CMIP5 projections of the East African long rains and southern Indian Ocean warming. Geophysical Research Letters, 46(11), 6050-6058.

[4] Marchant, R., Mumbi, C., Behera, S., & Yamagata, T. (2007). The Indian Ocean dipole–the unsung driver of climatic variability in East Africa. African Journal of Ecology, 45(1), 4-16.

Fire danger forecast

The wildfire hazard is a direct consequence of the elevated temperature anomalies and surface dryness, in combination with the availability of fuel (dry litter and wood). The Global Wildfire Information System (GWIS) provides mapping services of the fire danger forecast all over the world. A high-to-extreme danger is shown for most of Somalia, south-eastern part of Ethiopia, Kenya, Tanzania, and Uganda up to the 16th of August (Fig. 14).

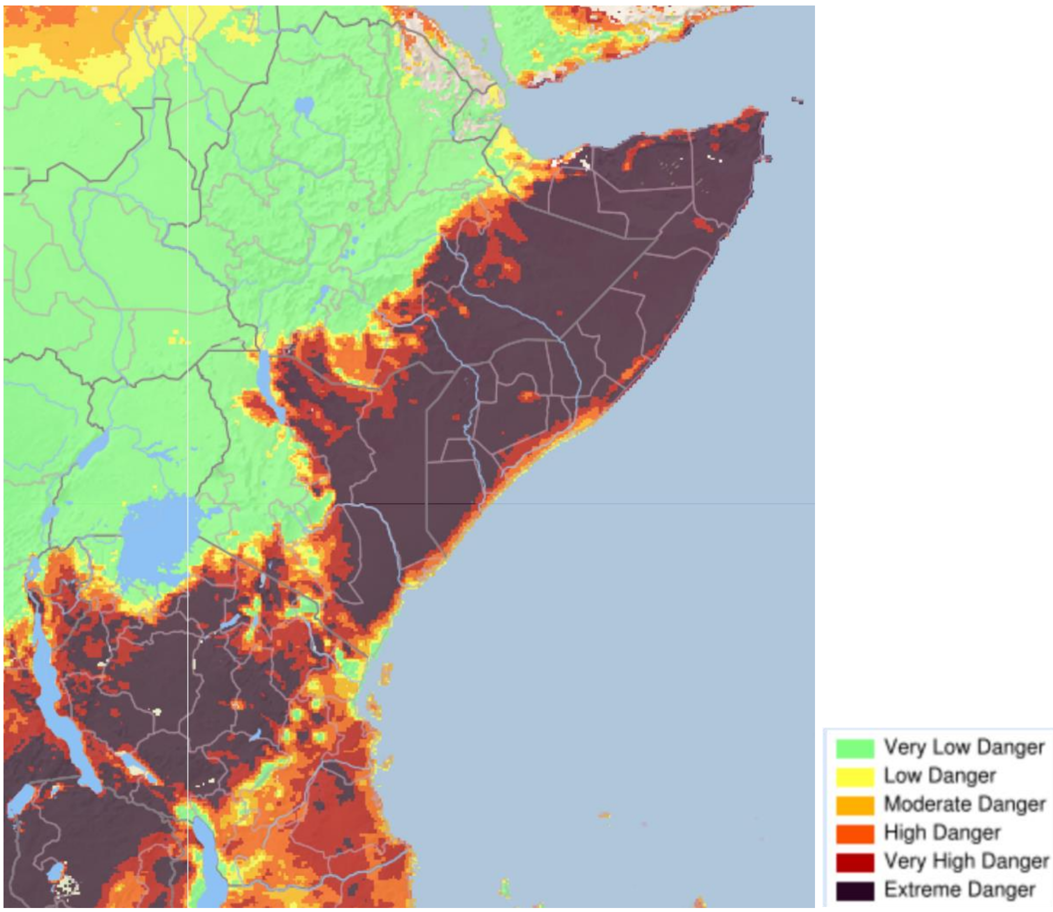

Figure 14: *Fire danger forecast expressed by the Fire Weather Index up to 16th of August 2022 issued on 9th of August 2022. Source: Global Wildfire Information System, GWIS.*

Seasonal forecast

According to the GDO seasonal forecasts, drier than normal weather conditions are expected over the coastal region of Kenya and southern Somalia, where the already critical situation could be further exacerbated. In the other areas, wetter than normal or normal conditions are expected. The anomalies are a relative measure that should be carefully interpreted especially in the dry season. Normal-to-wet conditions during the dry season, indeed, may not significantly ameliorate the sequence of failed rainy seasons. Given the current and forecasted conditions, it will likely take longer to recover conditional on having at least normal precipitation during the next rainy season (Fig. 15).

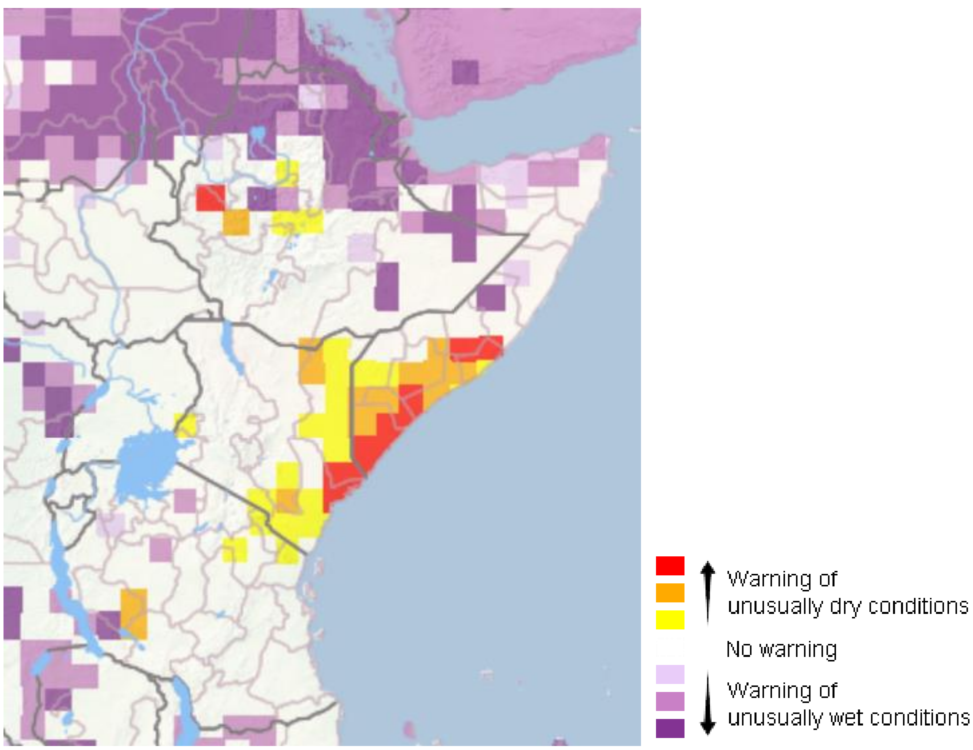

Figure 15: Indicator for forecasting unusually wet and dry conditions for 3 months, July to September 2022.

Reported impacts

According to UN-OCHA at least 18 million people in East Africa are food insecure due to one of the most severe drought in the recent history. People needing humanitarian help are estimated to be: 7 million in Ethiopia, 4 million in Kenya, and 5 million in South Sudan. Deaths related to the drought were also reported. Subsistence farmers are at risk of losing their cattle, due to lack of fodder, as well as taking on debt and/or fleeing to displacement camps. The impact of the drought has been further compounded by inflation in food and fuel prices. This drought follows four consecutive seasons where there has been hardly any rain and little chance for people to recover. The ongoing situation has put a strain on people in the region, drastically reducing their resilience to today's emergency.[5] In Somalia, according to UN-OCHA, as of May, 6.1 million people have been affected by the drought emergency, of whom 771,400 have been displaced from their homes in search of water, food and pasture: the majority being women and children.[6]

According to JRC's Monitoring of Agricultural Resources (MARS) – Anomaly Hotspots of Agricultural Production (ASAP):

- In Ethiopia (Tigray), the planted area at this time of the year looks smaller than the area of 2021 and below-average vegetation conditions are registered, particularly visible in the centre and in the south for crops and also in the east for pastures. The dry conditions in pastoral areas are expected to further deteriorate animal fodder and water conditions, cause deaths of livestock and a sharp decline in milk production. Likely below-average crop production combined with the severe effects of conflicts on both local agricultural production and humanitarian access, may have seriously impacted the livelihoods of people in the Tigray, Amhara and Afar regions. Four consecutive drought seasons in the southern and eastern parts of the country, the pandemic, and the low economic activity are triggering higher food prices across the country.
- In Somalia, low water levels are reported in the main rivers, meaning that water stress is also affecting irrigated crops and contributing to water scarcity for both human consumption and livestock needs. Acute food insecurity is due to prolonged drought, resource-based conflicts and the pandemic that continues to destroy lives and livelihoods since the beginning of the year.
- In Kenya, vegetation conditions show negative anomalies in Samburu, Isiolo, Laikipia, North/East, and Southern Coastal and Inland areas. Pastoral vegetation conditions across the country are worsening with population needing to trek longer distances for drinking water. For many of these areas, a failed 2022 *long rains* season continues to lengthen

[5] https://reliefweb.int/report/ethiopia/drought-east-africa-needs-assessment-older-people-ethiopia-south-sudan-and-kenya-21-june-2022

[6] https://reliefweb.int/report/somalia/somalia-drought-situation-report-no7-20-may-2022

an exceptional sequence of previous drought seasons. For pastoral households in arid lands, who have already lost part of their livestock, this leads to rapid depletion of coping strategies, especially in a context of increasing food and fuel prices. According to the Ministry of Agriculture report (April 2022), milk production has declined by 20% causing an increase of consumer prices. Cereal prices have also increased considerably in the last month. The Global report on Food Crises released on May 4th also predicts major increases in food insecurity in Kenya due to the consecutive droughts. During the *short rains* season that ended in January, crops suffered drought stress at various stages, but particularly in the early ones. The northern, eastern, and coastal parts of Kenya experienced the worst situation due to below-to-well below average rainfall for a third consecutive rainy season.

- In Uganda, vegetation conditions appear below the average. Final yields will depend on the degree of damages experienced in the early part of the season.[7]

The Famine Early Warning System (FEWS) reported millions of people facing starvation due to the exceptional four-season drought, the ongoing conflicts, pandemic effects, rising prices, and desert locust. Multiple agencies says that large-scale humanitarian food assistance is urgently needed to deal with severe-to-extreme food insecurity outcomes. Already alarming levels of food insecurity are reported in Ethiopia, Kenya, and Somalia. According to the Food Security and Nutrition Working Group (FSNWG), 16.7 million people in the region currently face high levels of acute food insecurity. Global prices of food, fuel and fertilizer are concurring worsening impacts of the exceptional drought. [8]

FAO Food Price Index (FFPI) is still about 23% above its value one year ago, but since May it reduced by 2.3%. FAO Cereal Price Index as well reduced but it is still almost 30% above the same period of 2021[9]. The high prices, driven by different and concurrent causes, have a critical impact over East Africa countries that rely on food imports.

The extremely severe sequence of failed rainy seasons led to critical and long-term damages to agriculture, pasture and livestock over large areas of Somalia, Ethiopia, Kenya, northern Uganda, South Sudan, and Sudan. The pressure on food security caused by the exceptionally prolonged drought is rapidly increasing. Drought is only one of the factors contributing to

[7] JRC's Monitoring of Agricultural Resources (MARS) – Anomaly Hotspots of Agricultural Production (ASAP) https://mars.jrc.ec.europa.eu/asap/index.php

[8] https://fews.net/sites/default/files/Press%20Release%20-%20Eastern%20Horn%20of%20Africa%20OND%20%2722.pdf

[9] https://www.fao.org/worldfoodsituation/foodpricesindex/en/

exacerbate food insecurity together with conflicts, pandemic issues and energy crisis.[10] According to the IGAD Regional Focus on Food Crises 2022 more than 50 million people in 7 countries are forecasted to be in acute food insecurity (IPC Phase 3 or above) in 2022.[11]

Appendix

The Combined Drought Indicator (CDI) is used to identify areas that may be affected by agricultural drought. The CDI is derived by combining the Standardized Precipitation Index (SPI), the Soil Moisture Index Anomaly (SMA), and the FAPAR anomaly. Areas are classified according to three primary drought classes: (1) "Watch", indicating that precipitation is less than normal; (2) "Warning", indicating that also soil moisture is in deficit; and (3) "Alert", indicating that also vegetation shows signs of stress.

The Standardized Precipitation Index (SPI) provides information on the intensity and duration of the precipitation deficit (or surplus). SPI is used to monitor the occurrence of drought. The lower (i.e., more negative) the SPI, the more intense is the drought. SPI can be computed for different accumulation periods: the 3-month period is often used to evaluate agricultural drought and the 12-month period for hydrological drought, when rivers fall dry and groundwater tables lower.

Lack of precipitation induces a reduction of soil water content. The Soil Moisture Anomaly index provides an assessment of the deviations from normal conditions of root zone water content. It is a direct measure of drought associated with the difficulty of plants in extracting water from the soil.

The satellite-based fraction of Absorbed Photosynthetically Active Radiation (fAPAR) monitors the fraction of solar energy absorbed by leaves. It is a measure of vegetation health and growth. FAPAR anomalies, and specifically negative deviations from the long-term average, are associated with possible drought impacts on vegetation.

[10] https://mars.jrc.ec.europa.eu/asap/

[11] https://www.icpac.net/documents/572/IGAD_RRFC_2022_ONLINE_4eYMbKh.pdf

The indicator for forecasting unusually wet and dry conditions provides early risk information. The indicator is computed from forecasted SPI-1, SPI-3 and SPI-6 derived from the ECMWF seasonal forecast system SEAS5.

Glossary of terms and acronyms

CDI	Combined Drought Indicator
CEMS	Copernicus Emergency Management Service
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
EDO	European Drought Observatory
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Niño Southern Oscillation
ERA5	ECMWF Reanalysis v5
ERCC	European Emergency Response Coordination Centre
FAO	Food and Agriculture Organization of the United Nations
FFPI	FAO Food Price Index
fAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FEWS	Famine Early Warning System
FSNWG	Food Security and Nutrition Working Group
GDO	Global Drought Observatory
GDP	Gross Domestic Product
GPCC	Global Precipitation Climatology Centre
GWIS	Global Wildfire Information System
ICPAC	IGAD Climate Prediction and Application Centre
IGAD	Intergovernmental Authority on Development
IOD	Indian Ocean Dipole
IPC	Integrated Food Security Phase Classification

JRC	Joint Research Centre
MARS	Monitoring Agricultural ResourceS
OCHA	(United Nations) Office for the Coordination of Humanitarian Affairs
RDrI-Agri	Risk of Drought Impact for Agriculture
SMA	Soil Moisture Index (SMI) Anomaly
SMI	Soil Moisture Index
SPI	Standardized Precipitation Index
WMO	World Meteorological Organization

GDO indicators versioning:

The GDO indicators appear in this report with the following versions:

Ensemble Soil Moisture Anomaly, v.2.3.0
fAPAR (fraction of Absorbed Photosynthetically Active Radiation) Anomaly 1.3.2
Indicator for forecasting unusually wet and dry conditions 1.0.0
Standardized Precipitation Index SPI (CHIRPS and ERA5)

Check https://edo.jrc.ec.europa.eu/download for more details on indicator versions.

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