

# SUDAN CRISIS ANALYSIS

## Remote Sensing to Monitor Impact of Conflict on Agriculture: Round 2

SEPTEMBER 2023

This paper is part of a series of crisis analysis briefing papers by Mercy Corps following the outbreak of conflict in Sudan in April 2023. It is an update to satellite imagery analysis conducted in July 2023, measuring vegetation levels in agricultural areas to better understand the impact of conflict on agriculture. This update assesses changes since the previous analysis, to help anticipate upcoming challenges with the harvest season, emphasizing the critical role of agricultural production and livelihoods in preventing further deterioration of food security.

### Key Findings

- Although until the end of July 2023, the average vegetation index across the whole of Sudan was higher than previous years, from August, vegetation levels started to fall below previous years.
- Comparing vegetation levels in previous years to the national cereal production indicates that there may be some correlation between higher vegetation levels and better harvests, though this has not been statistically tested and is indicative only.
- Until mid-September 2023, the downward trend in vegetation indicates that the harvest is unlikely to be as positive as last year.
- Within the country, vegetation compared to previous years has declined most notably in Khartoum, as well as in certain hotspots in east Sudan. Across the east, in September the vegetation index anomaly (difference with 10-year average) declined in comparison to July. This is despite the FAO Agricultural Stress Index showing smaller areas affected by severe drought in September compared to July, indicating that non-climate related factors may be affecting vegetation, such as the impact of conflict on irrigated agriculture. In comparison, agriculture in the Darfurs and Kordofans is typically rainfed, and vegetation indexes in September were higher than ten-year averages (though the increase was less than in July).
- Gedaref state, a key producer of sorghum, has been relatively unaffected by direct conflict. Whilst at the end of July, vegetation levels were higher than 10-year averages, by mid-September, some areas in the north and west had started to decline. With the upcoming harvest season, a critical issue will be ensuring that farmers are supported to harvest and sell their produce, given that key sorghum markets such as Khartoum and El Obeid may continue to be disrupted by conflict.

## Introduction

Conflict in Sudan has had a profound impact on food security across the country. Since April 2023 the number of people classified as acutely food insecure has risen steadily, reaching 20.3 million people (42% of the population) for the period July-September 2023.<sup>1</sup> Agricultural production in the country is critical as it directly supports food availability – prior to the conflict, Sudan produced roughly as much millet and sorghum as it consumed<sup>2</sup> – and is the main source of income and livelihood for 60-80% of the population.<sup>3</sup>

The early planting season for sorghum and millet, in June-July 2023, was disrupted in certain areas across the country. In some locations, farmers faced direct security threats due to conflict, disruption of markets and trade routes, and destruction of infrastructure.<sup>4</sup> Further, farmers faced challenges obtaining inputs as state authorities and agricultural banks failed to provide the usual support, as did many private companies based in conflict-affected Khartoum.<sup>5</sup> Whilst a Mercy Corps survey in Blue Nile and South Kordofan found that 90% of farmers had started preparing their fields or intended to plant in July 2023,<sup>6</sup> it was extremely challenging to collect primary information across the entire country.

As such, at the end of July 2023, Mercy Corps analysed satellite imagery to better understand potential impact of conflict on agriculture across the country. This early analysis showed that vegetation levels in agricultural areas in Sudan were generally high compared to long-term averages, largely attributed to good early season rainfall and following an above-average harvest for many staple crops in 2022. However, Khartoum was a notable outlier, with indications that agricultural activity had been severely disrupted by hostilities. In White Nile and Al Jazirah states, large-scale industrial farms also exhibited lower than average vegetation levels, potentially due to conflict-related fuel availability and price shocks. Further, in parts of the east of the country, there were indications of the start of drought-like conditions causing agricultural stress.

**With the harvest season upcoming, this second paper aims to provide an update on these findings. Analysis is updated to mid-September 2023, when pre-harvest average vegetation levels typically peak.**

### Methodology

The paper uses satellite imagery analysis to monitor the Normalized Difference Vegetation Index (NDVI) in agricultural areas of Sudan. It compares vegetation levels since April 2023 to average vegetation levels in previous years, which can serve as a rough proxy to indicate potential agricultural production later in the year.

Some caveats apply given limitations of NDVI analysis. The index does not differentiate between different types of vegetation so, for example, certain agricultural crops can be indistinguishable from other types of vegetation given similar reflectance properties that NDVI relies upon – with potentially important implications for conclusions regarding agricultural production. This points to the merit of validating vegetation indices with other data sources and including contextual expertise of Sudan's agricultural sector.<sup>1</sup>

<sup>1</sup> IPC (August 2023) Sudan: IPC Acute Food Insecurity Analysis, June 2023-February 2024 (<https://reliefweb.int/report/sudan/sudan-ipc-acute-food-insecurity-analysis-june-2023-february-2024-issued-august-2-2023>)

<sup>2</sup> Insecurity Insight (July 2023) The Sudan Crisis, Conflict and Food Insecurity (<https://reliefweb.int/report/sudan/sudan-crisis-conflict-and-food-insecurity-july-2023>)

<sup>3</sup> Sudan Forests National Corporation (2021) Republic of Sudan National Land Cover Map: 2020 Report ([https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/sudan\\_land\\_cover\\_report.pdf](https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/sudan_land_cover_report.pdf))

<sup>4</sup> FAO (May 2023) GIEWS Update Sudan: Dramatic increase in Acute Food Insecurity due to the Ongoing Conflict (<https://www.fao.org/3/cc6119en/cc6119en.pdf>)

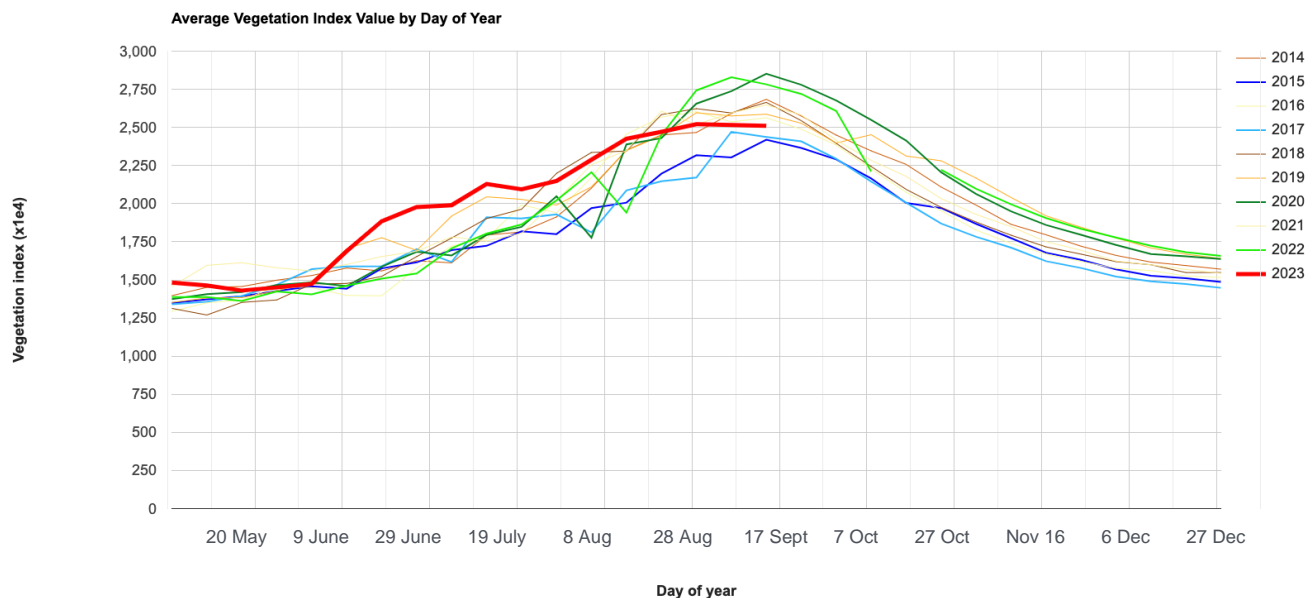
<sup>5</sup> Ayin Network (September 2023), A Struggle to Plant (<https://3ayin.com/en/farmstruggles/>)

<sup>6</sup> Mercy Corps (August 2023), Survey of Farmer Capacities and Intentions in South Kordofan and Blue Nile.

## Average Vegetation across Agricultural Areas, April-September 2023

- Figure 1 shows the average vegetation index across all agricultural areas across Sudan until mid-September 2023, compared with the average vegetation index in previous years (2014-2022). Until the end of July, the 2023 vegetation index was higher than recent years, likely due to high early season rainfall,<sup>7</sup> and following a good harvest for many staple crops in 2023.
- However, from August 2023 – when the main planting season for millet and sorghum is over and crops are growing – vegetation levels started to fall below previous years' averages. By mid-September, when vegetation levels typically peak (prior to the main harvest season<sup>8</sup>), 2023 vegetation levels were lower than most previous years, with the exception of 2015 and 2017. This is despite above-average rainfall across the country (when aggregated to the state level; there may have been some localised decline in precipitation).<sup>9</sup>

Figure 1: Average Vegetation Index in agricultural areas in 2023, compared to previous years



- To understand how vegetation levels compare to harvest production, harvest data from the annual FAO Crop and Food Supply Assessment Missions (CFSAM) was collated. Each year, this estimates the national cereal production (sorghum, millet, wheat) across Sudan. Cereal production can be compared to average vegetation levels between August and September, when sorghum and millet are growing, as well as the mid-September vegetation peaks for each year.
- As shown in the graphs below and above, in 2020 and 2022 when vegetation levels (both the mid-September peak and August-September average) were higher than any previous year assessed, the total cereal harvest was also relatively high, at 7,970,000 tonnes and 7,468,000 tonnes respectively. In 2015 and 2017, the lowest-performing years in terms of vegetation, the harvest was also low, at 4,700 tonnes and 5,100 tonnes. Tentatively, higher vegetation peaks appear to correspond to higher

<sup>7</sup> FAO (2023) Earth Observation: Sudan Country Indicators, Precipitation Indicators (<https://www.fao.org/giews/earthobservation/country/index.jsp?type=33&code=SDN#>)

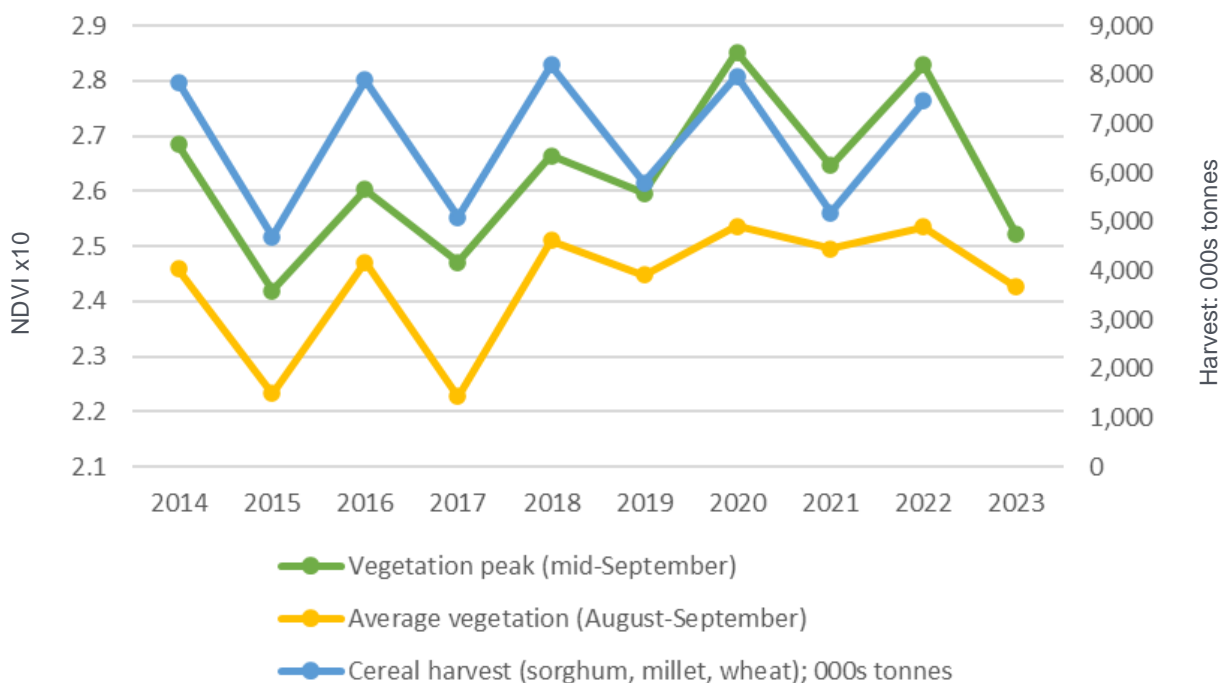
<sup>8</sup> For millet and sorghum; wheat is harvested the following year, usually around April, though production is comparatively much smaller.

<sup>9</sup> FAO (2023) Earth Observation: Sudan Country Indicators, Precipitation Indicators, Accumulated Precipitation (<https://www.fao.org/giews/earthobservation/country/index.jsp?type=33&code=SDN#>)

harvests, and lower peaks to lower harvests, though any correlation has not been statistically tested and is highly indicative only.

- For 2023/24, IPAD (US Department of Agriculture) estimate that the cereal harvest in Sudan will be lower than 2022/23, though slightly higher than the 5-year average.<sup>10</sup> Considering that a fall in vegetation from the previous year usually corresponds to a fall in production, this aligns with findings from this analysis. In 2022, the positive harvest was attributed to favourable weather, sufficient availability of inputs, and limited damage by pests and disease.<sup>11</sup>
- It is also worth noting that El Niño conditions are currently present and are forecast to continue until at least early 2024. In flood-prone areas, increased rainfall could negatively impact the upcoming harvest in terms of damaging critical infrastructure and crops, further reducing humanitarian access, and damaging water sources and sanitation infrastructure. Although this not has been flagged as a major concern for Sudan as seasonal rainfall anomalies have not been significant in 2023,<sup>12</sup> and ICPAC forecast normal rainfall and generally dry conditions in Sudan between October and December 2023,<sup>13</sup> any localised increase in precipitation should be observed in the coming months.
- Further, there may be additional impacts of conflict on the harvest season that these analyses have not taken into account, discussed on the following pages, which could further negatively impact total production.

**Figure 2: Average vegetation, peak vegetation, and total cereal production between 2014 and 2022**



<sup>10</sup> International Production Assessment Division, US Department of Agriculture (12 September 2023), Sudan Production- Country Summary (<https://ipad.fas.usda.gov/countrysummary/default.aspx?id=SU>)

<sup>11</sup> FAO (March 2023) Special Report – 2022 FAO Crop and Food Supply Assessment Mission (CFSAM) to the Republic of Sudan (<https://www.fao.org/documents/card/en/c/cc5009en>)

<sup>12</sup> FEWSNET (2023) Strong El Niño event will contribute to high food assistance needs through 2024 (<https://fewsn.net/global/alert/october-2023>)

<sup>13</sup> ICPAC (2023), Seasonal Forecast October - December 2023 (<https://www.icpac.net/seasonal-forecast/>)

## Geographical Vegetation: Differing Impacts of Conflict across the Country

- When the vegetation index is visualized geographically, disparities across the country are evident. On Map 1, green indicates that there has been an increase in vegetation compared to the 10-year average, whilst red indicates a decrease in vegetation of more than 35%, and orange, a decrease of between 0-35%.
- In some states in the East, the vegetation index is more than 35% lower than the 10-year average. This is most notable in Khartoum, where agricultural areas already exhibited a decrease in vegetation in July, likely due to the impact of conflict on the planting season. Other hotspots are notable in Blue Nile, Kassala, White Nile, and Al-Jazirah. In the latter two states, vegetation decreases correspond with locations of large-scale industrial farms, potentially partially due to fuel price shocks impeding mechanised agricultural activity. Similarly, in Blue Nile, local sources report that large-scale farms did not receive the usual loans, reducing the ability to plant.
- Additionally, since July, the vegetation index in the East has dropped even further below the 10-year average. This is despite the FAO Agricultural Stress Index improving slightly in mid-September compared to July, showing smaller areas affected by severe drought,<sup>14</sup> likely due to above-average rainfall in August<sup>15</sup> and overall normal or above-normal rainfall between June and September in most agricultural areas in the East.<sup>16</sup> As such, the decline in average vegetation is likely due to the impact of conflict on irrigated agriculture: one report states that in Sennar, lack of funding has reduced agriculturally productive areas in the irrigated sector by around 60%.<sup>17</sup> A key issue has been lack of available fuel and prohibitive cost; for example, Mercy Corps sources reported that in Al Jazirah, hardly any fuel has arrived in the past few weeks.
- In the Darfurs and Kordofans, agriculture is more typically rainfed. Across these states, until mid-September vegetation indexes were higher than ten-year averages, though the increase was less than in July. July and August saw normal or slightly above average rainfall across most of the Darfurs.<sup>18</sup>

### Cereal Production in Sudan

**Sorghum:** staple food for most rural and lower income households in central and eastern Sudan; the most common crop grown by crop-producing households. Most common crop in Eastern region, Khartoum, White Nile and Blue Nile; second most important in Kordofan.

**Millet:** staple food in Darfur and parts of Kordofan; the second most common crop grown by crop-producing households.

**Wheat:** grown in parts of Central and North Sudan, often commercially, though production has been falling since 2020. The planting / harvest season is different to sorghum in millet: usually planted in November and harvested in March/April.

<sup>14</sup> FAO (2023) Earth Observation: Sudan Country Indicators, Seasonal Indicators- Agricultural Stress Index (<https://www.fao.org/giews/earthobservation/country/index.jsp?type=33&code=SDN#>)

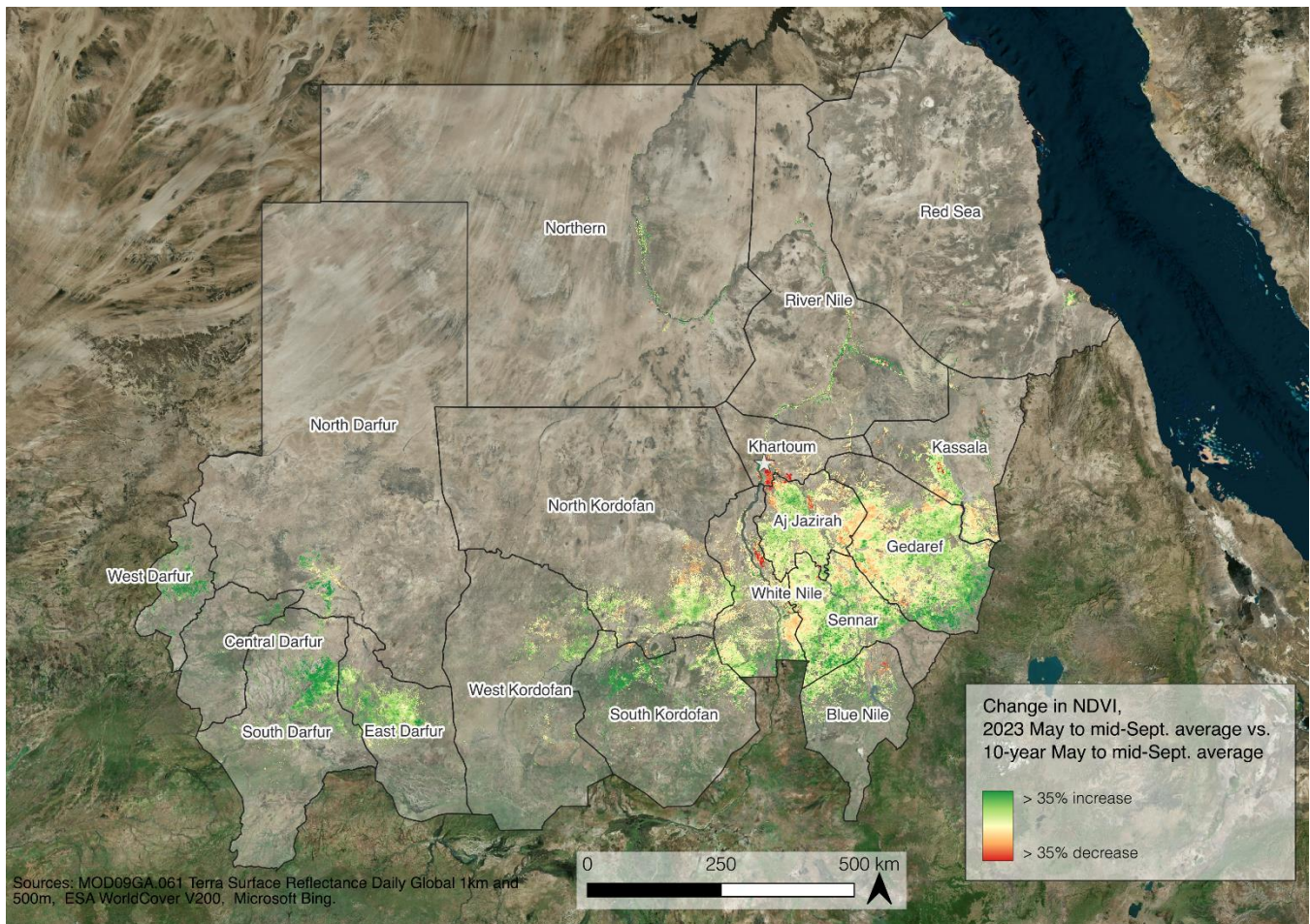
<sup>15</sup> FAO (2023) Earth Observation: Sudan Country Indicators, Precipitation Indicators- Estimated Precipitation Anomaly (<https://www.fao.org/giews/earthobservation/country/index.jsp?type=33&code=SDN#>)

<sup>16</sup> ICPAC (2023) Observed rainfall conditions for June to August (JJA) 2023 (<https://www.icpac.net/climate-monitoring/seasonal/>); CHIRPS (2023) Season Precipitation Percent of Average June to September 2023 ([https://data.chc.ucsb.edu/products/Season\\_Monitor/africa\\_east/jun\\_to\\_sep/pngs/with\\_forecast/PON\\_Current.png](https://data.chc.ucsb.edu/products/Season_Monitor/africa_east/jun_to_sep/pngs/with_forecast/PON_Current.png))

<sup>17</sup> Ayin Network (September 2023), A Struggle to Plant (<https://3ayin.com/en/farmstruggles/>)

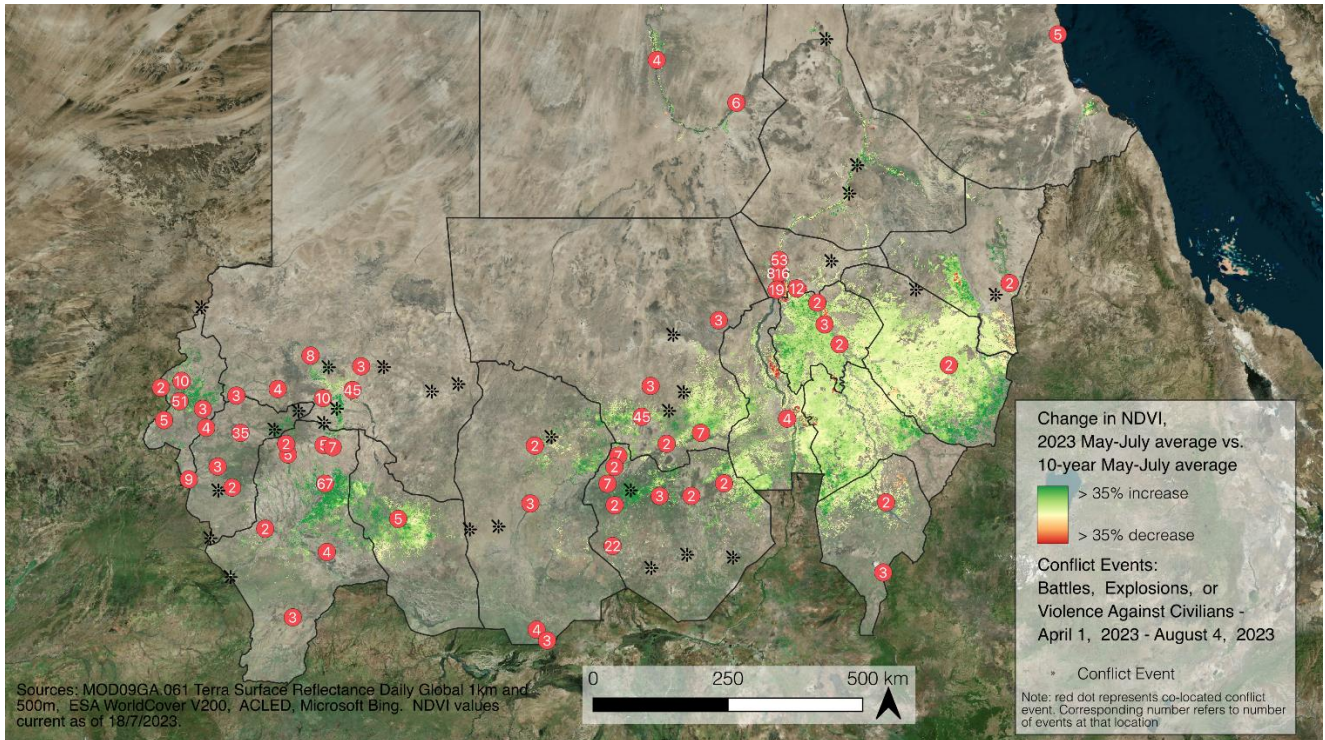
<sup>18</sup> FAO (2023) Earth Observation: Sudan Country Indicators, Precipitation Indicators- Estimated Precipitation Anomaly (<https://www.fao.org/giews/earthobservation/country/index.jsp?type=33&code=SDN#>)

*Map 1: Change in vegetation in agricultural areas in 2023 compared to 10-year average*

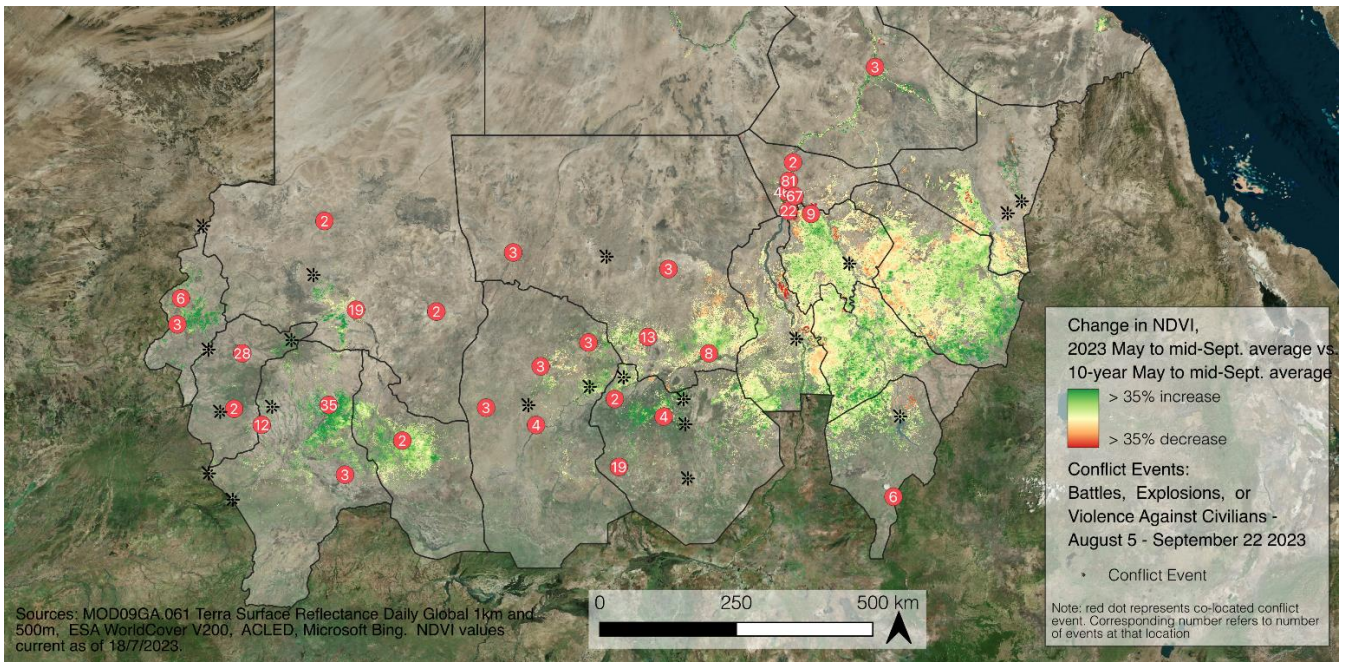


- On Maps 2 and 3, for comparative purposes the vegetation index is overlaid with conflict incidents (battles, explosions, violence against civilians), using data collected by ACLED.
- Map 2 visualises the conflict events that have occurred since April 2023, whilst Map 3 only shows events since August 2023.
- Since 5 August, conflict has continued across much of the country, particularly notable in Khartoum, the Darfurs, and parts of the Kordofans.
- In the East, outside of Khartoum very few conflict events have been recorded. During the August-September growing period, states that produce a large amount of cereal such as Gedaref, Sennar, Blue Nile (aside from the border with Ethiopia), Kassala, White Nile and most of Al Jazirah (aside from the north near Khartoum) appear to have been relatively unaffected by direct conflict.
- The following page considers the situation in one of these states – Gedaref – to further understand the impact of conflict on the upcoming harvest.

**Map 2: Change in vegetation in agricultural areas in 2023 compared to 10-year average, with conflict locations since April 2023**



**Map 3: Change in vegetation in agricultural areas in 2023 compared to 10-year average, with conflict locations since August 2023**



## Zoom-in: Gedaref

- Gedaref state, in the east of the country, is a key producer of sorghum that usually accounts for around one-fifth of Sudan's national sorghum production.<sup>19</sup>
- Gedaref has been relatively unaffected by direct conflict, as shown in Maps 2 and 3 above. It was also one of the few agricultural areas in Sudan to receive support from the Agricultural Bank during the summer, though this was very limited compared to normal, and it was still particularly difficult for farmers to obtain much-needed fuel.<sup>20</sup> It is also worth noting that following distributions of multi-purpose cash assistance by Mercy Corps, spending on agriculture was one of the top three uses of cash reported (27% of 336 respondents).
- Whilst at the end of July 2023, vegetation levels were higher than 10-year averages, by mid-September, areas in the north and west of the state (orange areas on map below) have dropped slightly below the ten-year average. In the west of the state, these areas correspond with the small areas of cropland (10-25%) estimated to be affected by severe drought, according to the FAO Agricultural Stress Index.<sup>21</sup> In August 2023, most of the state received normal or near normal rainfall, though in the centre and north-east of the state, where vegetation indexes show positive results, there was very high rainfall leading to flooding, with more than 80% precipitation recorded compared to the long-term average.<sup>22</sup>
- In contrast, in the south towards the border with Ethiopia, agricultural areas exhibited vegetation levels higher than the ten-year average (green areas on map below), likely attributable to normal or slightly above normal rainfall throughout July and August.<sup>23</sup>
- Gedaref usually produces a surplus of sorghum, trading the largest quantity of any state in Sudan.<sup>24</sup> Whilst there are key markets located in the state, Khartoum is a vital transit point and wholesale market, and El Obeid plays a central role in sorghum trade between surplus-producing markets. Both these urban areas, particularly Khartoum, have faced significant levels of conflict. If this continues, a critical issue will be ensuring that farmers are supported to harvest and sell their produce, for example, ensuring that humanitarian assistance aims to source locally before importing food.

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<sup>19</sup> FAO (March 2023) Special Report – 2022 FAO Crop and Food Supply Assessment Mission (CFSAM) to the Republic of Sudan (<https://www.fao.org/documents/card/en/c/cc5009en>)

<sup>20</sup> Ayin Network (September 2023), A Struggle to Plant (<https://3ayin.com/en/farmstruggles/>)

<sup>21</sup> FAO (2023) Earth Observation: Sudan Country Indicators, Seasonal Indicators- Agricultural Stress Index (<https://www.fao.org/giews/earthobservation/country/index.jsp?type=33&code=SDN#>)

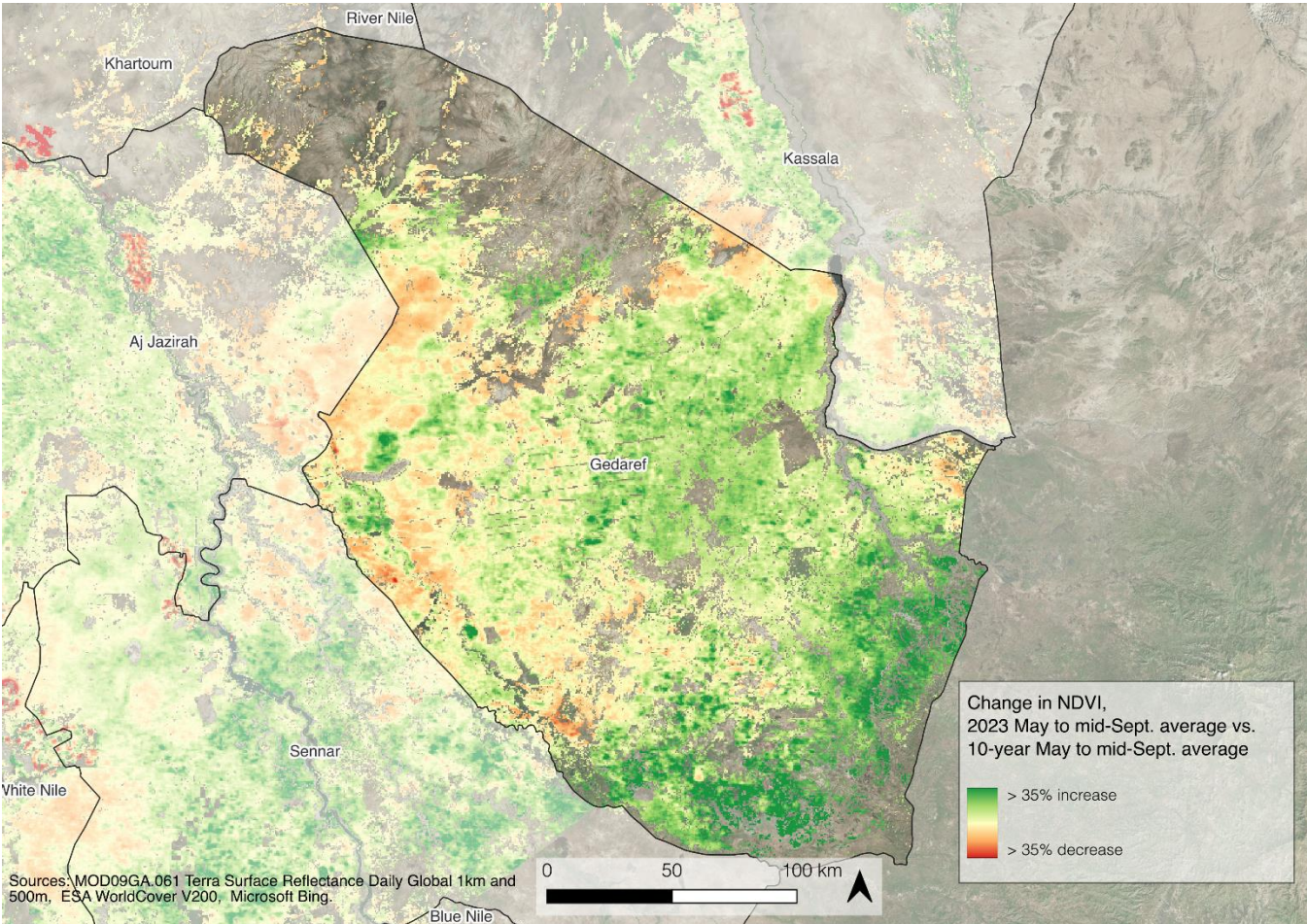
<sup>22</sup> FAO (2023) Earth Observation: Sudan Country Indicators, Precipitation Indicators- Estimated Precipitation Anomaly (<https://www.fao.org/giews/earthobservation/country/index.jsp?type=33&code=SDN#>)

<sup>23</sup> FAO (2023) Earth Observation: Sudan Country Indicators, Precipitation Indicators- Estimated Precipitation Anomaly (<https://www.fao.org/giews/earthobservation/country/index.jsp?type=33&code=SDN#>)

<sup>24</sup> Abay, Abdelfattah, Breisinger and Siddig (2023), *Evaluating Cereal Market (dis)Integration in Less Developed and Fragile Markets: the Case of Sudan* (<https://doi.org/10.1016/j.foodpol.2022.102399>)



Map 3: Change in vegetation in agricultural areas in Gedaref compared to 10-year average



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Now, and for the future.



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