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THE IMPACT OF SYSTEMATIC RAZING OF AGRICULTURAL COMMUNITIES AROUND EL-FASHER: A REMOTE SENSING STUDY

Yale SCHOOL OF PUBLIC HEALTH
Humanitarian Research Lab

HARVEST
EARTH DATA
FOR INFORMED AGRICULTURAL DECISIONS

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I. Executive Summary

Yale School of Public Health's Humanitarian Research Lab (HRL) assesses with high confidence that the Rapid Support Forces (RSF) intentionally razed at least 41 rural farming communities north and west of El-Fasher, Sudan between 31 March to 12 June 2024. At least ten (24 percent) of these communities were attacked more than once, including one community attacked on at least seven distinct occasions within the study period. Through the analysis of remote sensing data, Yale HRL assesses a substantial decrease in agricultural activity in communities razed in 2024 in the vicinity of El-Fasher. Analysts found that since the razing, 28 (68 percent) of these communities appear to have no visible pattern of life (POL), five (12 percent) have reduced POL, and eight (20 percent) have near-normal POL. Many of these communities show reduced or no pattern of life, abnormal increases in vegetation within communities, and decreased agricultural activity compared to that of previous years. These findings suggest the attacks displaced and/or killed residents of farming communities, which has subsequently led to decreased food production in the region.

Humanitarian access in North Darfur is significantly curtailed by warring parties, impacting humanitarian operations such as conducting food security assessments. As a result, experts including the Famine Review Committee (FRC) increasingly relied on remote sensing data as evidence for food security assessments. This report demonstrates the application of remote sensing in assessing food security in non-permissive environments, specifically within active conflicts. In these contexts, remote sensing data is the often only means for systematic, persistent collection of data and evidence for accountability of alleged violations of international humanitarian law.

This report uses a fusion of three remote sensing methodologies to develop a novel approach to assess food insecurity, characterizing:

- **Intentional burning of communities** through analysis of thermal anomaly data from NASA's Visible Infrared Imaging Radiometer Suite (VIIRS) and Moderate Resolution Imaging Spectroradiometer (MODIS), multitemporal change detection of low, moderate, and very high-resolution (VHR) satellite imagery, and open-source data analysis;

- **Visible pattern of life (or lack thereof) and forced displacement within communities** through changes in normalized difference vegetation index (NDVI) to detect vegetation overgrowth within communities. Multitemporal change detection with low, moderate, and VHR satellite imagery supported the NDVI analysis and informed the three pattern of life (POL) classification categories: Normal or near normal POL, Reduced POL, and No Visible POL.

- **Decreases in agricultural activity during the growing period following the razing of communities** assessed through year-on-year changes in land use/land cover (LULC) classification of crop from Dynamic World. This assessment was supported by POL analysis through multitemporal change detection in low and very high-resolution satellite imagery of select agricultural areas near communities.

This study's findings of intentional razing of at least 41 farming communities, abnormal vegetation growth likely indicative of no visible pattern of life, and decreases in agricultural activity near the assessed communities corroborate reports of intentionally induced famine in El-Fasher, North Darfur.[1] Findings from this study appear consistent with a pattern of systematic attacks on objects relevant for the sustainment of civilian life — particularly in context of the conflict escalation that began with RSF's siege on El-Fasher in April 2024 and culminated with alleged mass killings in October 2025.

II. Background

The focus of this report is on the impact of armed conflict on 41 agricultural communities to the north and west of El-Fasher, Sudan razed between 31 March and 12 June 2024, allegedly attacked by Rapid Support Forces (RSF). Major conflict events also occurred after the intentional razing and subsequent lack of visible pattern of life and agricultural activity in these 41 communities.

The Janjaweed (the forerunner of the RSF) targeted rural indigenous communities in North Darfur with arson over 20 years before the 2024 study period. Analysis in this report demonstrates a similar pattern by RSF that supports reports of intentional starvation.

The timeline of events leading up to and following the 2024 study period is critical to understanding how attacks on agricultural communities may have served as a forewarning of RSF's actions over the course of the 18-month siege of El-Fasher from April 2024 to October 2025.

Darfur Genocide, 2003-2005

The RSF is derived from the Janjaweed, the militia group central to the Darfur Genocide in the early 2000s, targeting Indigenous Black African ethnic groups across Darfur including the Masalit, Fur, Berti, and Zaghawa communities. In 2004, Human Rights Watch released a report describing alleged intentional arson attacks on Masalit and Fur communities in South and West Darfur and aerial bombardment in North Darfur allegedly perpetrated by the Janjaweed.[2] These rural communities were located on the most fertile lands in Darfur but were looted and intentionally razed, forcibly displacing civilians to camps and settlements near larger towns.

The Sudan Conflict, 2023 to Present

The conflict between the Rapid Support Forces (RSF), Sudanese Armed Forces (SAF), and their aligned forces started on 15 April 2023. In the beginning of April 2024, RSF initiated their multidirectional attack on El-Fasher, North Darfur. Yale HRL has confirmed a total of nearly 110 communities razed from April 2023 to November 2024 across North Darfur, including the 41 communities north and west of El-Fasher which are the focus of this report.[3] To date, HRL has identified at least 75 communities attacked in El-Fasher locality. According to the *Sudan Tribune*, some residents were killed while others reportedly fled to larger population centers at Zamzam Internally Displaced Persons (IDP) Camp, El-Fasher, and Shagara, although it is impossible to know with certainty exactly where all residents fled.[4] The intentional razing and subsequent displacement of farming communities targeted those who produced critical food for the El-Fasher area.

Status of Food Security and Humanitarian Operations

Heavy fighting paired with limited freedom of movement and humanitarian access further exacerbated the already dire humanitarian situation, making it difficult for aid groups to conduct needs assessments and deliver life-saving assistance.[5] Escalation of hostilities and the ongoing siege contributed to the delay and limited delivery of both commercial and humanitarian supplies, according to the United Nations Office for the Coordination for Humanitarian Affairs (OCHA).[6] In November 2024, only one delivery of humanitarian aid was able to reach Zamzam. Humanitarian assistance was blocked from reaching El-Fasher for nearly a year and only allowed passage after RSF took full control of the city in October 2025. At least two humanitarian convoys were attacked while attempting to deliver aid to the El-Fasher area in Kuma on 1 June and in Mellit on 20 August 2025, likely by SAF.[7]

Nearly 70 percent of bank branches have closed and ceased operation in conflict zones across Sudan. Bank closures, limited cash liquidity, and high transfer commission rates ranging from 10 to 30 percent have contributed to financial strain and limits any ability to sell and purchase food commodities, exacerbating food insecurity.[8]

Ground-based food security assessments are difficult, when not impossible, due to limited humanitarian access contributing to a lack of available data regarding community food security. Organizations such as the Famine Review Committee (FRC) are beginning to incorporate remote sensing data and analysis. A report by the Famine Early Warning Systems Network (FEWS-NET) published on 1 August 2024 declared that Famine (IPC Phase 5) thresholds were passed in June 2024 for Zamzam IDP Camp and that Possible Famine was present in Abu Shouk IDP Camp and Al Salam IDP Camp.[9] The same report stated that the risk of famine was possible across El-Fasher, North Darfur. An update released by the Famine Review Committee in December 2024 declared Famine was evident and expected to continue in Abu Shouk IDP Camp as well as Al Salam IDP Camp in El-Fasher in North Darfur.[10] In the same December update, famine was projected to spread to other localities in North Darfur including El-Fasher.

Conflict Events Post-Analysis

After the razing of the 41 communities analyzed in this report, heavy fighting continued across El-Fasher, including damage to neighborhoods, shelling inside the city, and attacks on hospitals and humanitarian infrastructure.[11] Nearly one year after the communities analyzed in this report were attacked in 2024, RSF captured Zamzam IDP Camp in April 2025, leading to

the mass displacement of civilians on foot to Tawilah, about 60km (37.28 miles) west of the city, as well as to the southeast toward Dar As Salaam locality and north towards El-Fasher city. After the capture of Zamzam, widespread reports described people dying of starvation and exposure on the way to Tawliah; reports included children dying of thirst upon arrival.[12]

After RSF's capture of Zamzam, RSF completed the construction of an over-75 kilometer earthen wall encircling El-Fasher and surrounding areas. Civilians who remained in El-Fasher were trapped with limited means to flee; the only available routes out of the city were through RSF-controlled checkpoints or over the earthen wall.[13] After 18 months of siege, RSF captured El-Fasher on 26 October 2025. Evidence has since emerged of RSF allegedly conducting widespread mass killings. It is widely estimated that the scope of the killings in El-Fasher is in the tens of thousands based on a review of objects consistent with clusters of human remains visible in satellite imagery.[14] There is limited information on the number of people who fled El-Fasher, and the total number of people still living in El-Fasher is not known at this time.[15] In the most recent update from FEWS-NET released in November 2025, FEWS-NET concluded that famine in El-Fasher may be occurring and assesses a risk of famine in Tawilah during the September 2025 period of analysis and projected into October 2025-January 2026.[16] The United Nations Independent International Fact-Finding Mission for the Sudan has found that RSF conducted mass killing and other atrocities after capturing El-Fasher that are "are indicators of a genocidal path."[17]

III. Methodology

This assessment used data identifying razed communities with a fusion of open source data, low, moderate, and very high-resolution (VHR) very high-resolution (VHR) satellite imagery, as well as thermal detections during a period between 31 March to 12 June 2024. Pattern of life and agricultural activity was assessed in and around these communities months later after the rainy season (typically occurring between June to September) and during the subsequent growing season in August to October with harvest typically occurring between November to December.[18]

Area of Interest

The area of interest in this study was created through documentation of razed communities in the region north and west of El-Fasher, North Darfur (*Appendix 1*). Yale HRL identified 41 total communities between 31 March to 12 June 2024. The 41 communities and their surrounding areas are the area of interest for this study.

Time Period of Interests for Analysis

This report assesses attacks on small agricultural communities to the north and west of El-Fasher between 31 March to 12 June 2024. This report monitors pattern of life using available VHR satellite imagery from August to November 2024 and agricultural activity during the subsequent growing season between 1 August to 30 September 2024. Analysts compared the data collected during the study periods to previous years.

Overview of Data Sources

This analysis involved six primary datasets (*Appendix 2*):

- Visible Infrared Imaging Radiometer Suite (VIIRS) and Moderate Resolution Imaging Spectroradiometer (MODIS) data retrieved from NASA's Fire Information Resource Management System (FIRMS);[19]
- A dataset generated by Yale HRL through analysis of thermal anomaly data and damage consistent with intentional razing of communities visible in low resolution imagery, VHR satellite imagery analysis, and open source data including social media, local news reporting, and multimedia;
- A land use/land cover (LULC) dataset called Dynamic World developed by Google and the World Resources Institute, which was reclassified to identify "Crop";[20]
- Cumulative rainfall estimate data of the greater

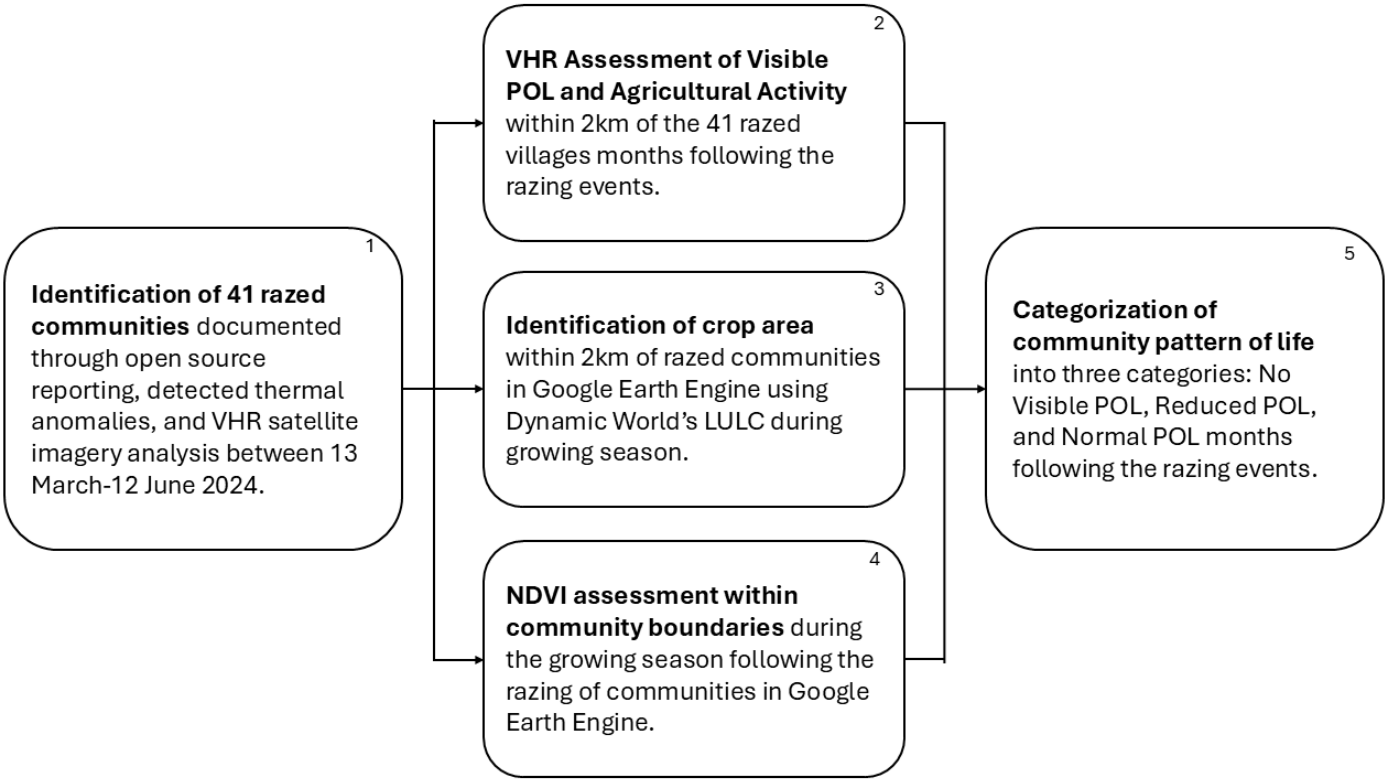


Figure 1. *Project workflow*

El-Fasher area from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) for the years 2019 through 2024;[21]

- Sentinel-2 imagery of the assessed communities, used to calculate NDVI values for the growing season (1 August to 30 September) from 2019 to 2024; and

- VHR and moderate-resolution satellite imagery retrieved from Vantor, Planet Labs, and Airbus used to categorize community pattern of life (POL), agricultural activity, and damage to livestock corrals.

Workflow

Using these multiple datasets, a series of interrelated analyses were combined to form a workflow (***Figure 1***) which describes the steps of analysis. The first step was identifying communities assessed as intentionally razed. Analysis using satellite imagery and NDVI was then completed to assess pattern of life and abnormal vegetation growth within community boundaries, and satellite imagery and LULC data were analyzed to detect changes in identified cropland areas.

Active Fires and Thermal Anomalies

Active fires and thermal anomalies from 31 March to 12 June were collected each year between 2019-2024 using VIIRS and MODIS sensors and retrieved from NASA Fire Information Management System (FIRMS). The period of 31 March to 12 June was selected to align with the period the communities were attacked and to establish a baseline for comparison.[22] Thermal anomaly detections from sources such as MODIS Collection 6.1, VIIRS S-NPP, VIIRS NOAA-20, and VIIRS NOAA-21 were collected.[23]

Any thermal detections within two kilometers of razed communities were summed between 31 March to 12 June from 2019 to 2023 and compared to those within the same area and period of interest in 2024. Yale HRL compared thermal detections during the 2019-2023 period to 2024 to assess whether the 2024 detections fell within previously observed patterns of thermal activity. Due to the substantial number of thermal detections in 2024 compared to prior years, Yale HRL assesses that this thermal activity was likely abnormal. Thermal detections within a two-kilometer radius of the razed communities (outlined in **Appendix 3**) were counted across these same periods compared within the same AOIs.

Data on Verified Conflict-related Razing of Communities

Yale HRL cross-corroborated open source data, including social media, local news reporting, multimedia, and other reports with multi-temporal change detection using satellite imagery and thermal sensors to assess a pattern of damage consistent with intentional razing. This fusion approach assisted spatiotemporal verification of razing incidents during the period of interest between 31 March to 12 June 2024.

Yale HRL analysts assessed the credibility and reliability of open source data based on level of detail, past credibility, and corroboration by other independent sources. Analysts used detections of thermal anomalies co-located at or near communities to assess possible destruction and to narrow down possible event dates. Multispectral satellite imagery from Sentinel-2 was used with VHR satellite imagery from Vantor for baseline comparison to observe thermal scarring patterns. This assessment used an interpretation guide created by the Signal Program at the Harvard Humanitarian Initiative to determine burning selection and intentional targeting, based on the presence of spacing between burnt and non-burnt structures were spacing between burnt structures may indicate targeting.[24] This interpretation guide assists in understanding the intentional burning of communities, which may be consistent with systematic ethnic-based targeting.[25]

Place names were identified where possible using the fusion of open source and map data including: Open Street Map (OSM), Google Maps, Wikimapia, UN Global P-Codes from the UN Humanitarian Data Exchange (HDX), and open source reporting including local media.[26]

Dynamic World Land Use/Land Cover: Crops

Annual crop area data were derived from Dynamic World.[27] Dynamic World is a near real-time 10-meter land use/land cover (LULC) dataset developed by Google and the World Resources Institute.[28] The Dynamic World dataset includes nine different LULC types: Water, Trees, Grass, Crops, Shrub & Scrub, Flooded Vegetation, Built-Up Area, Bare Ground, and Snow & Ice. Dynamic World does not use temporal information for classification and instead segments and classifies individual Sentinel-2 images.[29] For this analysis, the crop class was the primary LULC class of interest assessed between 1 August to 30 September from 2019 to 2024. The period of interest (1 August to 30 September) for crop was selected to represent the period of the first growing cycle to estimate impacts to crop area after the communities were razed between 31 March to 12 June 2024.[30]

All available classification maps within the period of interest for each year were stacked to create yearly datasets. For each of these six yearly datasets, the mode LULC value was extracted for each set of stacked pixels, resulting in six raster composites representing the most common LULC values for each year between 2019 and 2024. Then, for each of these yearly composites, pixels with a LULC class of Label 4, ("Crops") were selected, creating six new separate yearly composites of only those pixels that were most classified as Label 4 or

"Crops" (hereafter referred to as crop). Finally, a single baseline composite for identified crop was created by taking the mode of the 2019-2023 yearly composites to depict areas that were commonly classified as crop prior to heavy fighting in the El-Fasher area.

The area in kilometers was calculated using the pixel size and the number of pixels in the crop class for baseline and 2024 crop composites. Areas classified as crop in 2024 were intersected with the crop baseline to assess spatial changes in the 2024 crops detections overall and within a two-kilometer buffer around the razed communities. The distance from each community center to nearest crop as identified by the baseline and 2024 crop layers was calculated then averaged across all communities to assess how identified crop area changed when comparing baseline crop to 2024 estimates.

Sentinel-2 Imagery to Estimate Normalized Difference Vegetation Index (NDVI) Change within Communities

The use of NDVI to assess presence of pattern of life builds off the work by Russell Schimmer and colleagues, which found the displacement of Zaghawa pastoralists during the first genocide in Darfur resulted in an increase in NDVI across the greater Darfur area due to the lack of livestock grazing fields and inability to farm caused by forced displacement in the region.[31]

Changes in healthy vegetation within communities were assessed using Normalized Difference Vegetation Index (NDVI) values. NDVI is an index from -1 to 1 that measures healthy vegetation. The closer the value is to 1, the heathier the vegetation. The NDVI was calculated across all pixels within these areas between 1 August and 30 September for each year from 2019 to 2024 using the formula below:

Formula 1: Normalized Difference Vegetation Index (NDVI)

Where Band 8 is Near-infrared (NIR) and Band 4 is Red when using multispectral imagery from Sentinel-2.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

The mean of these pixel values for all years between 2019 and 2023 was then calculated to establish a single NDVI baseline for each community. The NDVI change for each village was derived by the difference between the 2024 NDVI value and the NDVI baseline. The resulting NDVI change was used to inform further POL analysis to determine pattern of life within communities. A larger increase in NDVI values within community boundaries suggests no visible pattern of life, while a more moderate increase and subsequent decrease may suggest either minimal activity or normal activity within the village.

CHIRPS Rainfall Estimates

Monthly rainfall estimates for the greater El-Fasher area were retrieved from HDX and aggregated yearly.[32] Monthly rainfall estimates at the second-level administrative division were aggregated by year and

Table 1. *Categories of Community Pattern of Life via VHR Satellite Imagery*

ACTIVITY LEVEL	CATEGORY DESCRIPTION
Normal or Near Normal PoL	• No widespread vegetation within the community and within dwellings • Apparent reconstruction of previously burned structures and/or newly built structures • Similar activity as seen in historical imagery
Reduced PoL	• Some reconstruction activity and/or new structures and some remaining burned structures • Possibly overgrown vegetation in some areas of the community, but not blanketing the community nor widespread • Observable indicators of some activity but not seen at the same level when compared to historical imagery • Few structures with removed metal roofs, while some metal roofs remain.
No Visible PoL	• Widespread abnormal vegetation overgrowth • No construction of new structures or reconstruction activity of previously burned structures • Removal of nearly all metal roofs possible.

Table 2. *Categories of Agricultural Activity Status via VHR Satellite Imagery*

ACTIVITY LEVEL	CATEGORY DESCRIPTION
Normal or Near Normal Activity	Fields participating in agricultural preparation at a similar level as seen in historical imagery. Fields with agricultural growth may appear visually similar as seen in historical imagery.
Reduced Activity	Some fields actively participating in agricultural preparation and some fields have agricultural growth visually similar to those seen in historical imagery while other fields in the area may have blanketed vegetation or remain barren.
No Visible Activity	Fields appear barren and/or have abnormal dense vegetation not consistent with historical imagery.

used to assess the relationship between rainfall and the observed increase in NDVI within communities.

Satellite Imagery for Post-Razing Community Pattern of Life Assessment

Yale HRL analysts used VHR and moderate resolution satellite imagery to investigate the extent of activity in communities after the communities were razed between 31 March and 12 June 2024. The goal of this analysis was to understand and confirm, where possible, the degree of community pattern of life and presence (or absence) of agricultural activity from August to November 2024 and extent of damage to livestock corrals immediately following razing events and before vegetation growth obscured damage to these corrals.

The VHR satellite imagery available of each community at the time of Yale HRL's analysis between August to November 2024 was compared to pre-razing imagery and immediate post-razing imagery. Based on the analysis described above, activity levels in each community were categorized into one of three classes: Normal or nearly normal POL, reduced POL, and no visible POL (***Table 1***). Agricultural activity was assessed similarly into three categories: consistent with baseline, reduced activity, and no activity (***Table 2***). Damage to livestock corrals were classified into one of three categories: no damage, partial damage, and entirely damaged.

Indicators consistent with no visible pattern of life may include widespread vegetation growth within the community, specifically the observation of abnormal vegetation growth within dwellings and structures. If there is no widespread vegetation within the community and within dwellings, the village may likely have some pattern of life. Repair of burned structures and construction of new structures signal the village may be active, especially after the razing occurred. Conversely, stripping of metal roofs and the deconstruction of dwellings and structures may indicate no visible POL or reduced POL. Indicators of agricultural activity may include apparent turning of fields. Indicators of no agricultural activity include barren, fallow, or abnormally blanketed fields. Observations of livestock corrals damaged during the razing period in 2024 were documented, with corrals not repaired months after the razing were noted in assessments of pattern of life.

IV. Detailed Findings

Razing of Agricultural Communities

Conflict-related Razing of Agricultural Communities (31 March to 12 June 2024)

Yale HRL assessed that 41 rural communities north and west of El-Fasher, North Darfur were intentionally razed between 31 March to 12 June 2024 by the Rapid Support Forces (RSF), as shown in ***Figure 2***. The communities that the RSF and aligned forces attacked are predominantly ethnically Zaghawa.[33] Visual indicators consistent with intentional razing, including discoloration to structures, differences in object burning and charring of structures, were documented along with indicators of selection including spacing between burned structures and repeated burning across a community (***Figure 3***).[34]

Twenty-four percent (10) of the 41 communities razed between 31 March to 12 June 2024 were intentionally razed more than once, and one community was targeted at least seven times during the same period (***Figure 4***). In 2024, 176 (35 percent) of the 504 total thermal detections in 2024 occurred within two kilometers of the same communities.[35] At least six of the 41 razed communities were attacked three or more times. The period during which razing occurred (31 March to 12 June 2024) precedes a period during which there were substantial changes to agricultural activities (1 August 2024 to 30 September 2024), which is evidence of the conflict's impact months after the communities were razed.

Yale HRL assesses with high confidence that the razing in this report was perpetrated by the Rapid Support Forces based on a series of observations and key conflict events documented using VHR satellite imagery, video evidence, and public reporting of survivors describing

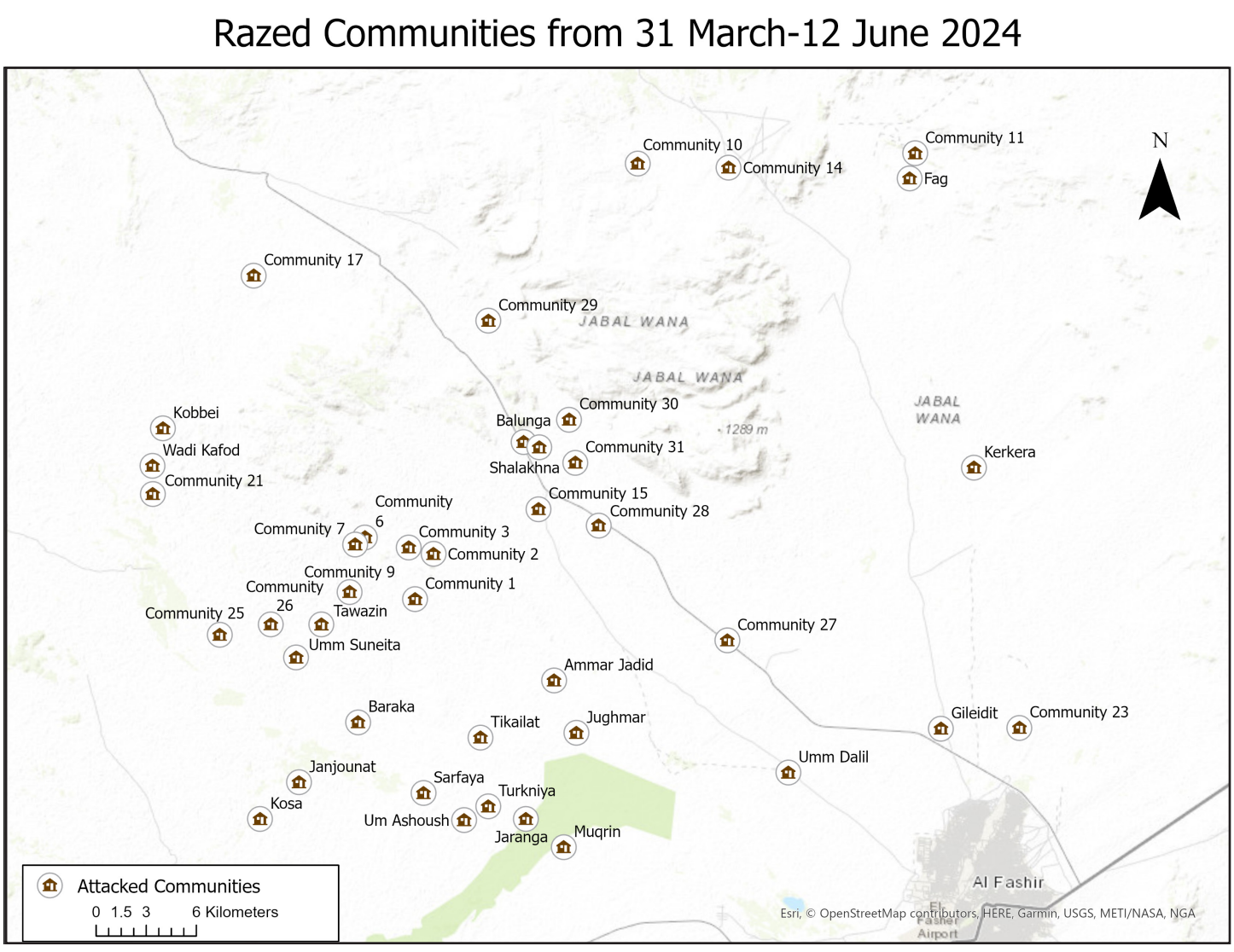


Figure 2. *Yale HRL-Verified Razed Communities from 31 March to 12 June 2024*

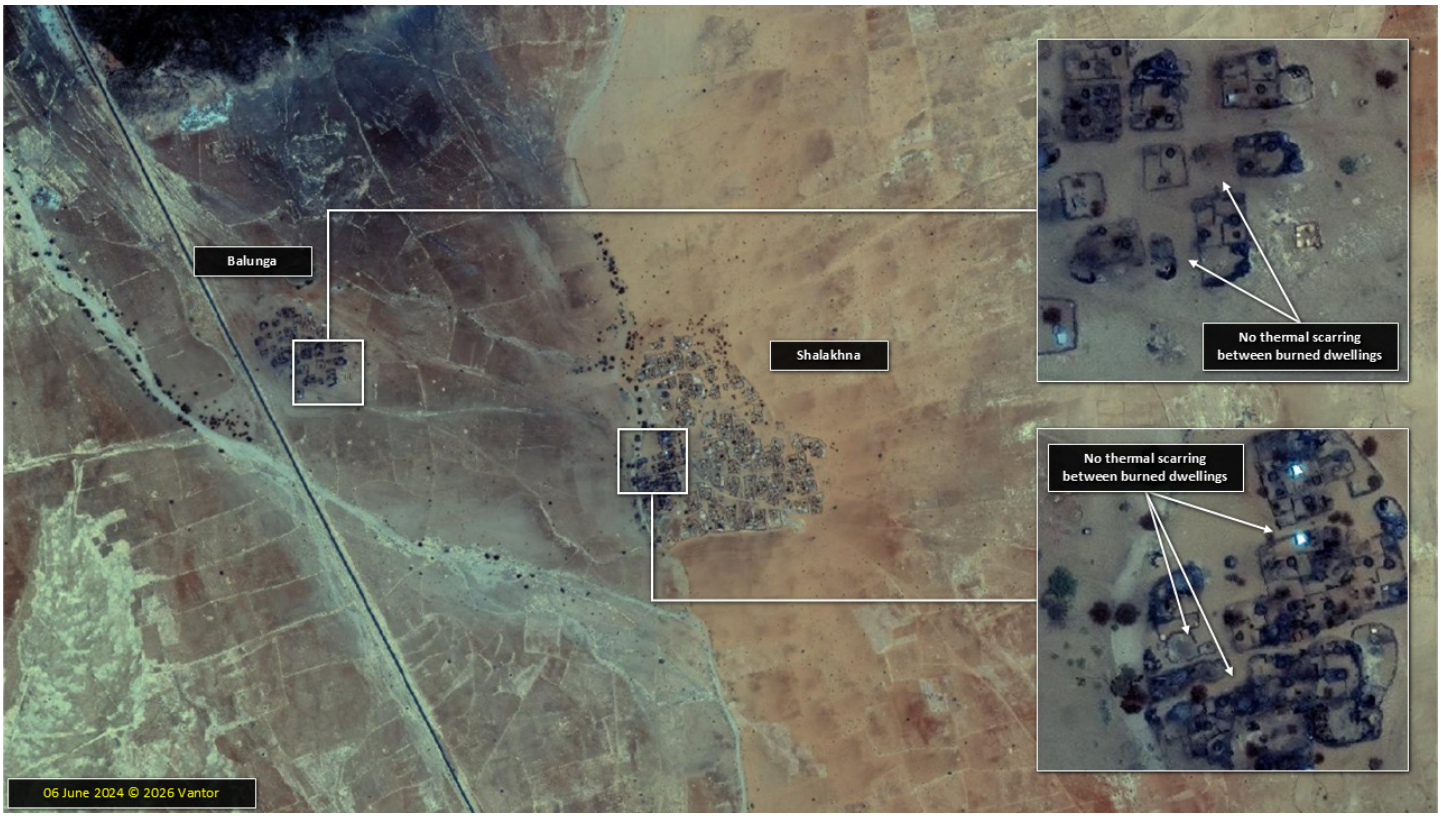


Figure 3. *Example of selection, including spacing between structures, as seen in Shalakhna and Balunga.*

the perpetrators of the attacks as RSF.[36] At the time the communities were razed, Sudanese Armed Forces (SAF) remained within the city of El-Fasher while the Rapid Support Forces (RSF) were observed surrounding the city and maintained freedom of movement throughout the greater El-Fasher area.

Light armored vehicles and light vehicles were visible in VHR satellite imagery at some of the identified communities, including Gileidit and Community 23 (***Figure 5***). In addition to vehicles visible in satellite imagery, open source reporting describes the looting, burning of dwellings and livestock corrals and reported cattle rustling.[37]

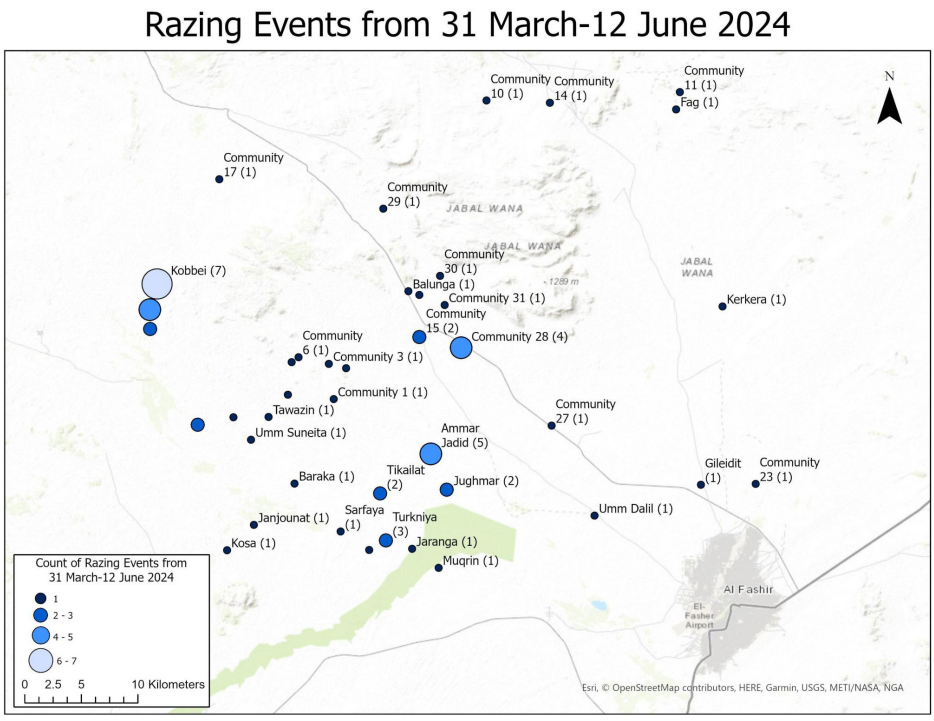


Figure 4. *Repeated attacks on communities razed between 31 March to 12 June 2024. Twenty-four percent (10) of communities were razed more than once, with one community razed at least seven times during this period.*

A third group, the Sudan Liberation Army (SLA) under the control of Abdulwahid Al-Nour was in the area but remained closer to Tawliah (approximately 60 km west of El-Fasher) and has remained neutral to the conflict.

Increase in Thermal Detections (31 March to 12 June comparing 2019-2023 to 2024)

Yale HRL identified an over 330.8 percent increase in thermal detections through VIIRS and MODIS from 31 March to 12 June in 2024 (504) compared to the sum of 2019-2023 (117) within the area of interest (AOI) (***Appendix 2***), which includes both the greater El-Fasher area and a two-kilometer radius of razed

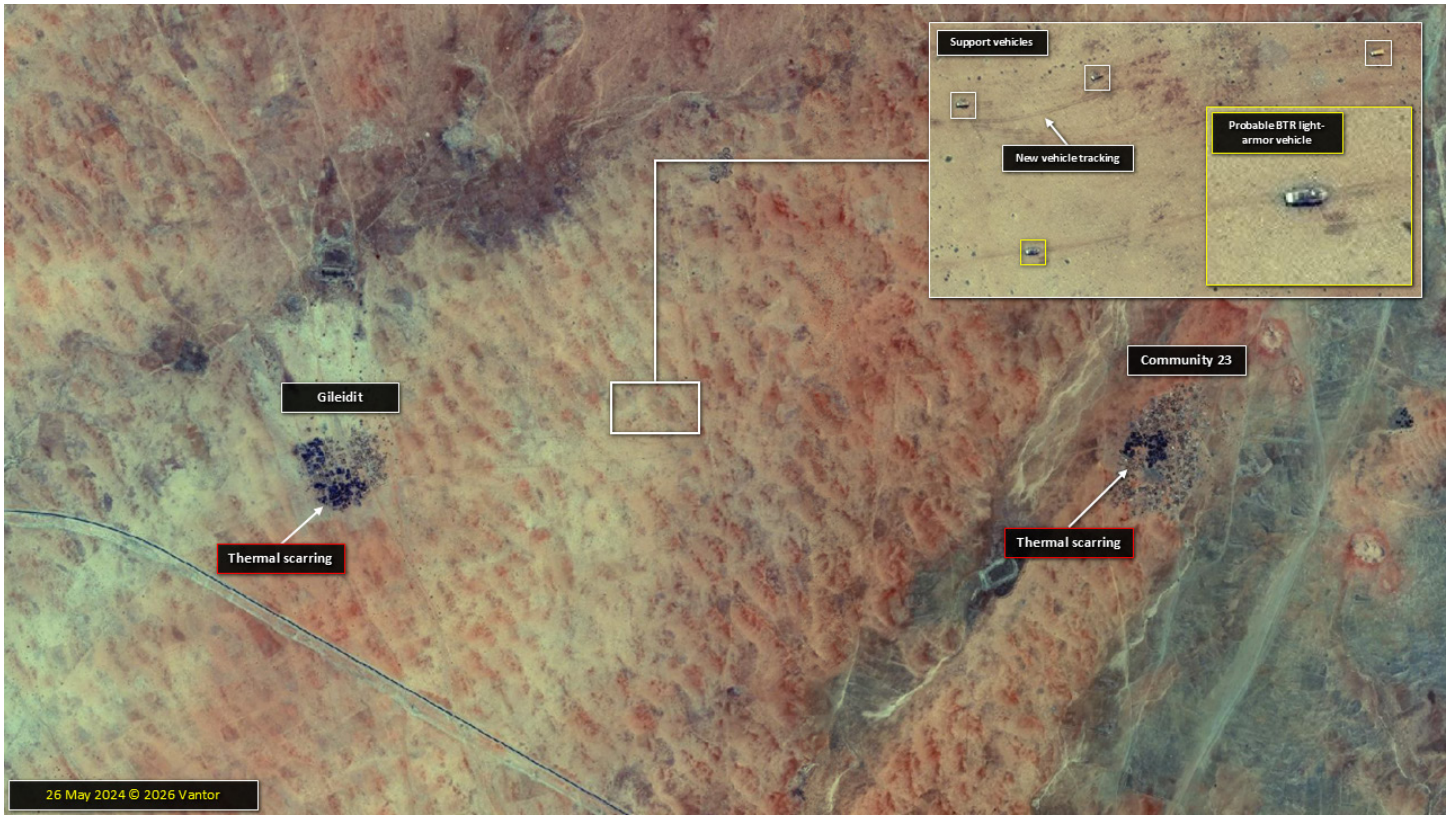


Figure 5. *RSF-consistent vehicles seen in satellite imagery collected on 26 May 2024 between two razed communities, Gileidit and Community 23. The vehicles present in satellite imagery include a probable BTR light-armored vehicle accompanied by two support vehicles.*

communities.[38] Between 2019 and 2023 there were 117 total thermal detections across the El-Fasher area, but only two of the total thermal detections (1.7%) occurred within two kilometers of the razed communities (***Figure 6***). In 2024, 176 (35%) of the 504 total thermal detections in 2024 occurred within two kilometers of the same

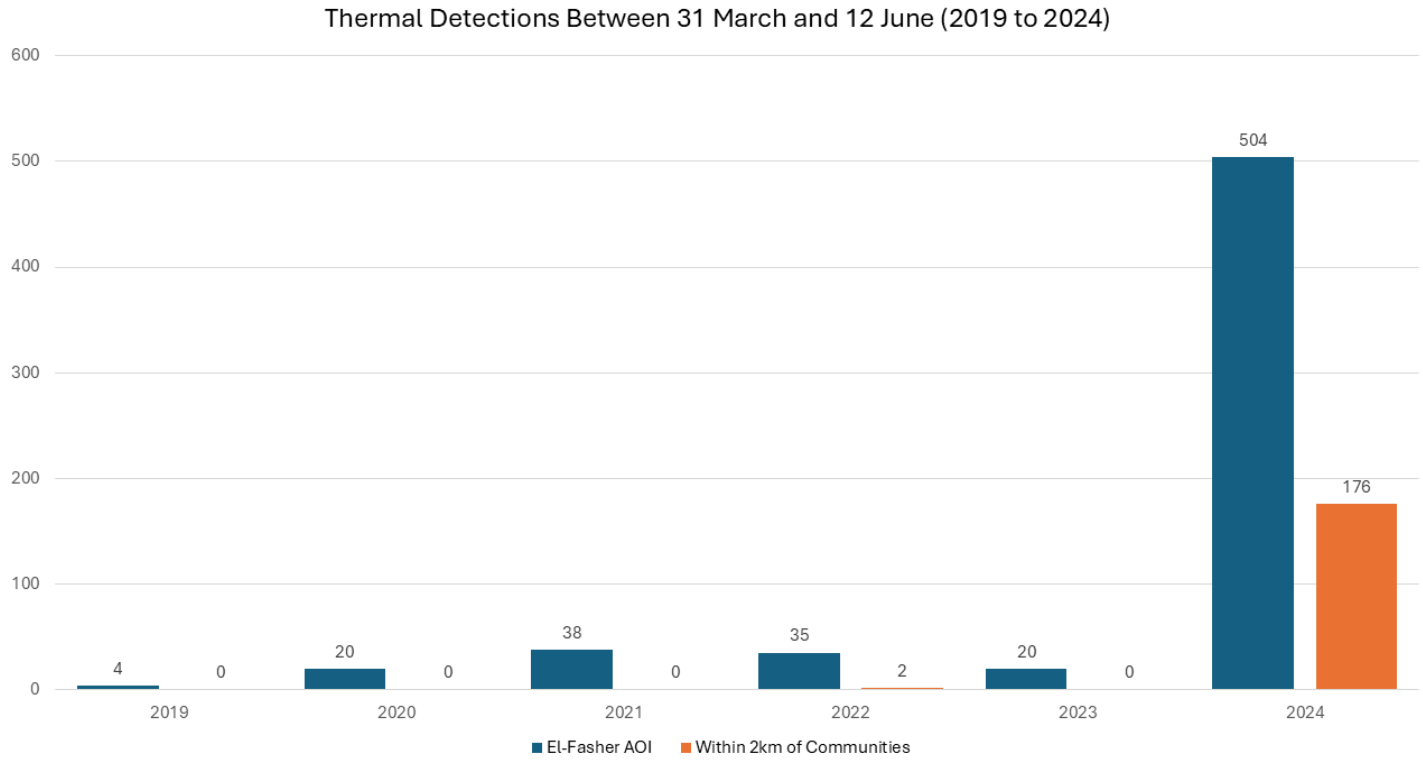


Figure 6. *Thermal detections from 2019 to 2024 sharply increase in 2024 using VIIRS and MODIS sensors.*

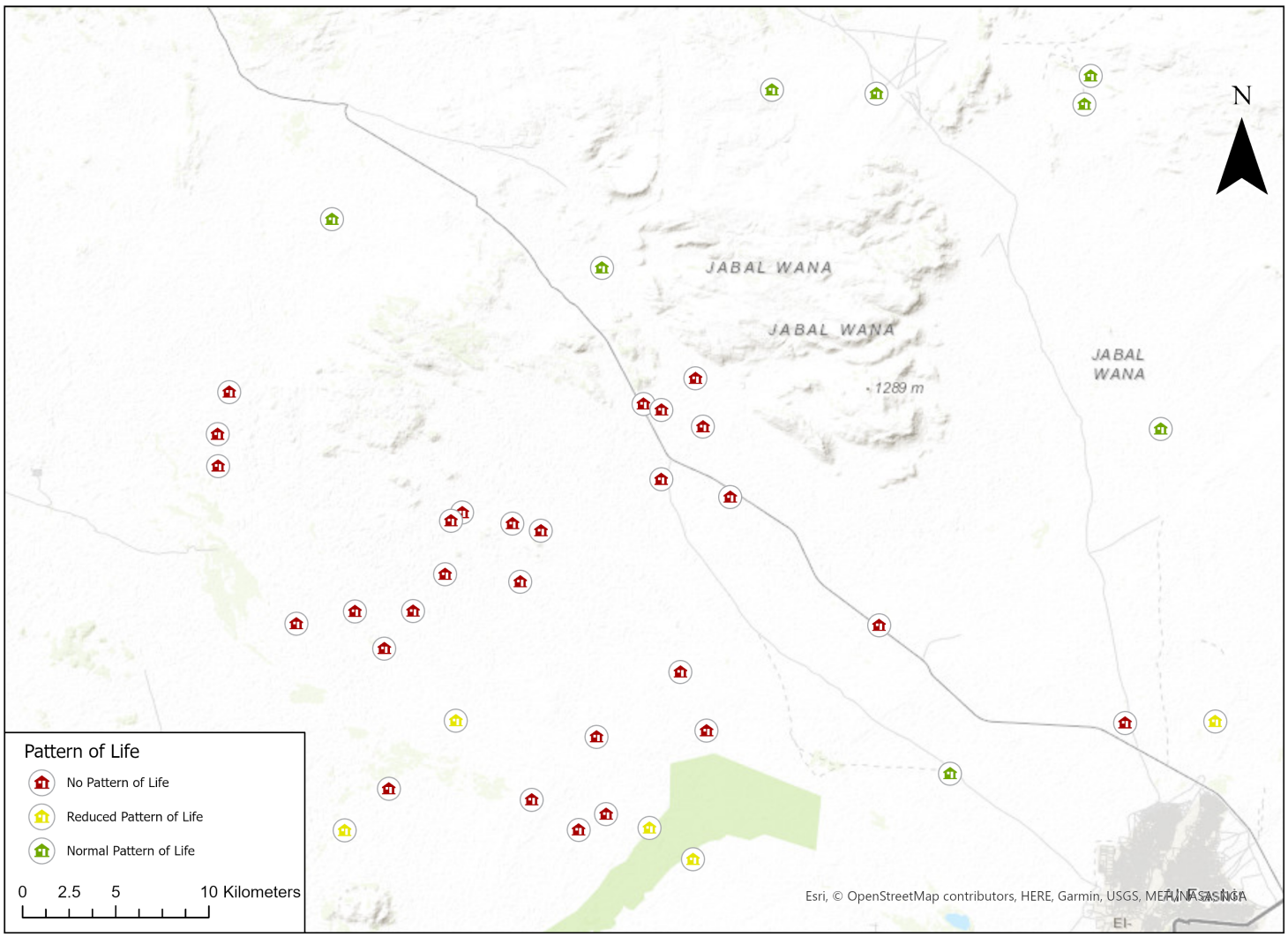


Figure 7. *Community Pattern of Life Post-Razing*

communities.[39] This stark increase in thermal detections within the El-Fasher AOI and within two km of razed communities compared to historical trends rules out the likelihood that these thermal detections are random.

Pattern of Life and Agricultural Activity Post-Razing of Communities

No Visible Pattern of Life Post-Razing of Communities in VHR Satellite Imagery (1 September to 30 November 2024)

Yale HRL analysts assessed that at least 28 of the 41 communities (68 percent) razed between 31 March to 12 June 2024 have no visible pattern of life (POL) months later as seen in VHR satellite imagery collected between August to November 2024 (***Figure 7*** and ***Figure 8***). At least five communities (12 percent) show a reduced POL (***Appendix 4***), indicative of possible civilian displacement and impact to livelihoods. Of the 41 total razed communities, eight communities (20 percent) were assessed to have little to no changes in their POL (***Appendix 5***) months later. Many communities with no or reduced pattern of life were located along the Wadi toward El-Fasher, likely near fertile land.

Yale HRL documented partial and total damage to livestock corrals, which are critical to food security and livelihoods in North Darfur, in at least 20 communities.

Normalized Difference Vegetation Index (1 August to 30 September from 2019-2024) and Rainfall (annual from 2019-2024)

There was an increase in healthy vegetation observed in VHR satellite imagery collected between August to November 2024, within fenced areas of the dwellings, indicative of limited to no presence of civilians or livestock. NDVI was utilized to quantify the change in healthy vegetation from baseline (2019-2023) to 2024 using Sentinel-2 satellite imagery collected between 1 August to 30 September.

Figure 8. *Normalized Difference Vegetation Index (NDVI) Change within Community Boundaries (1 August to 30 September from 2019 to 2024). Progression of vegetation growth following razing in Shalakhna from baseline (left), to observed thermal scarring (center) then no visible pattern of life (right). The baseline image from 26 May 2024 precedes the thermal scarring. The middle image, dated 6 June 2024, shows thermal scarring consistent with intentional razing. The right-most satellite image from 22 September 2024 shows dense vegetation overgrowth in the months following the razing of Shalakhna, with no visible pattern of life in the community.*

Forty of 41 communities experienced an increase in NDVI; the minimum NDVI change was -0.02 in Umm Dalil, while Shalakhna experienced an NDVI increase of 0.52, the maximum change observed among the 41 communities (***Figure 9***). The average NDVI value across all 41 communities during the baseline period (2019-2023) was 0.29 while the 2024 average increased to 0.56. This increase in NDVI indicates no visible pattern of life as there is no visible activity of people, livestock, and vehicles that would typically minimize vegetation overgrowth. The average NDVI change in communities with no visible pattern of life increased by 0.34 when comparing baseline and 2024 NDVI values. The average NDVI of communities with a reduced POL experienced an average increase of 0.22. Meanwhile, the average NDVI in communities with normal or nearly normal POL increased by only 0.06 on average when comparing baseline NDVI to 2024.

To disprove an alternative hypothesis that increased rainfall was the sole reason for the abnormal increase in NDVI within the communities, Yale HRL assessed the relationship between NDVI and rainfall. It was

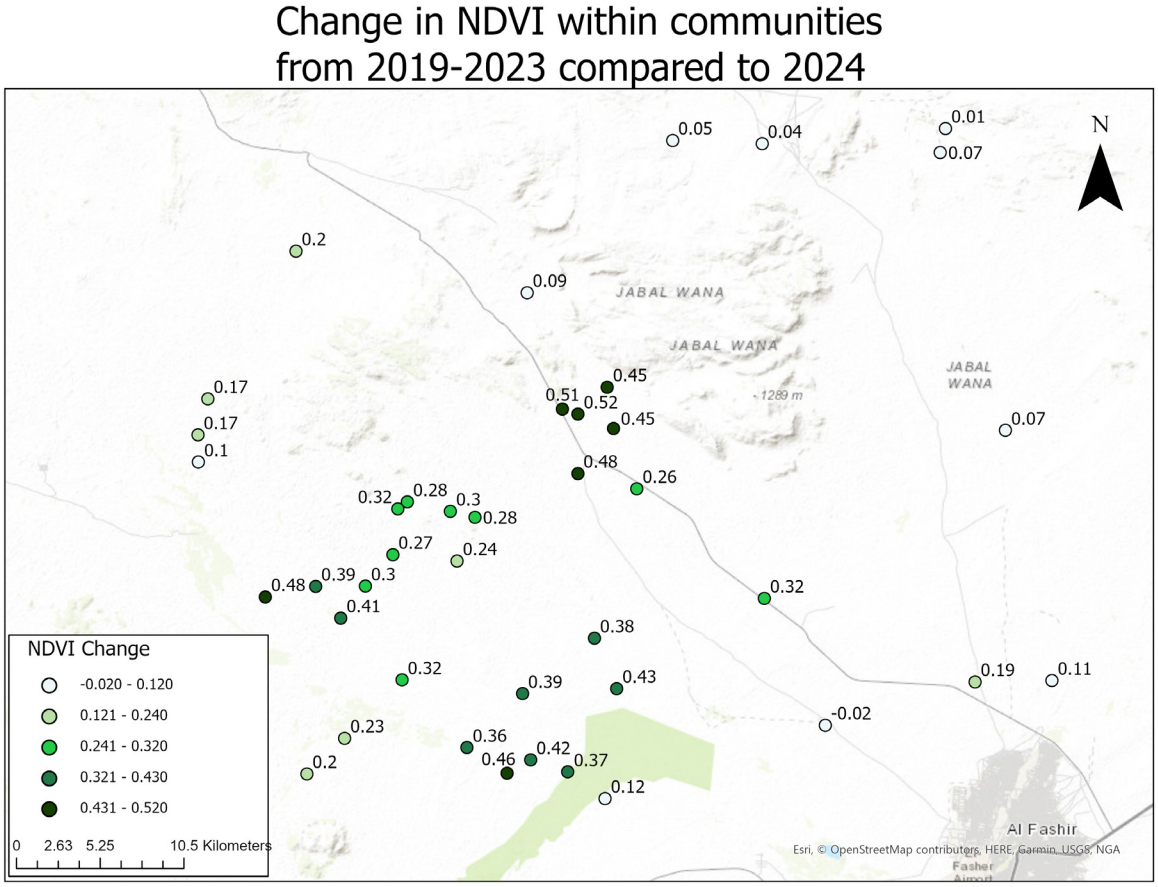


Figure 9. *Change in NDVI within communities between 2019-2023 compared to 2024*
NDVI (1 August to 30 September from 2019-2024) and Rainfall (annual from 2019-2024)

found that although rainfall likely had some effect on the abnormal increase in NDVI, this increase in NDVI is inconsistent with the historical relationship between NDVI and cumulative rainfall even when accounting for substantial rainfall in 2024. Between 2023 and 2024, cumulative rainfall estimates increased by 33.7 percent while the average NDVI within affected communities increased by 103.5 percent (Figure 10). While an increase in rainfall likely contributed to an increase in vegetation, and therefore NDVI values, the average NDVI change of 0.27 across all communities is not likely to be solely attributed to increased rainfall. Furthermore, the relationship between change in NDVI and assessed pattern of life indicates that significant increases in NDVI are unlikely to be due to increased rainfall alone. The lack of visible pattern of life, such as foot traffic and grazing, may have allowed vegetation overgrowth to persist in the aftermath of the razing of communities.

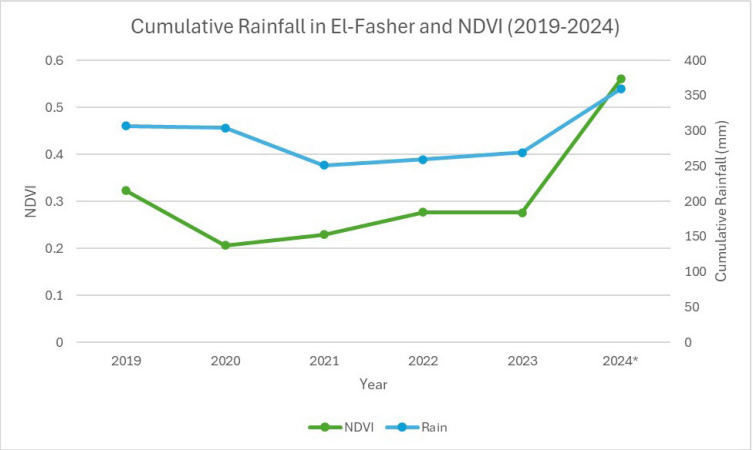


Figure 9. *Cumulative Rainfall Estimates and NDVI in El-Fasher, January 2019 - October 2024.*

Change in Agricultural Activity in VHR Satellite Imagery (August to November 2024)

Of the total 41 communities, 80.5 percent (33) have observable signs of reduced or no visible agricultural activity in VHR satellite imagery (***Figure 11***). This suggests that food security and livelihoods within the area deteriorated months after razing. Many fields assessed as inactive had visible vegetation blanketing or remained fallow when compared to a similar period in prior years. These results are further evidence that the intentional razing of communities had reverberating impacts on the food security environment in the El-Fasher area.

Change in Distance from Razed Community to Nearest Identified Crop: Dynamic World LULC (1 August to 30 September from 2019-2024)

This report finds that both the total average estimated area of crop (as defined by Dynamic World) within two kilometers of the 41 razed communities decreased and the average distance from a razed community to its nearest crop area increased between baseline (2019-2023) and 2024. The total average estimated area of crop within two kilometers of a razed community decreased

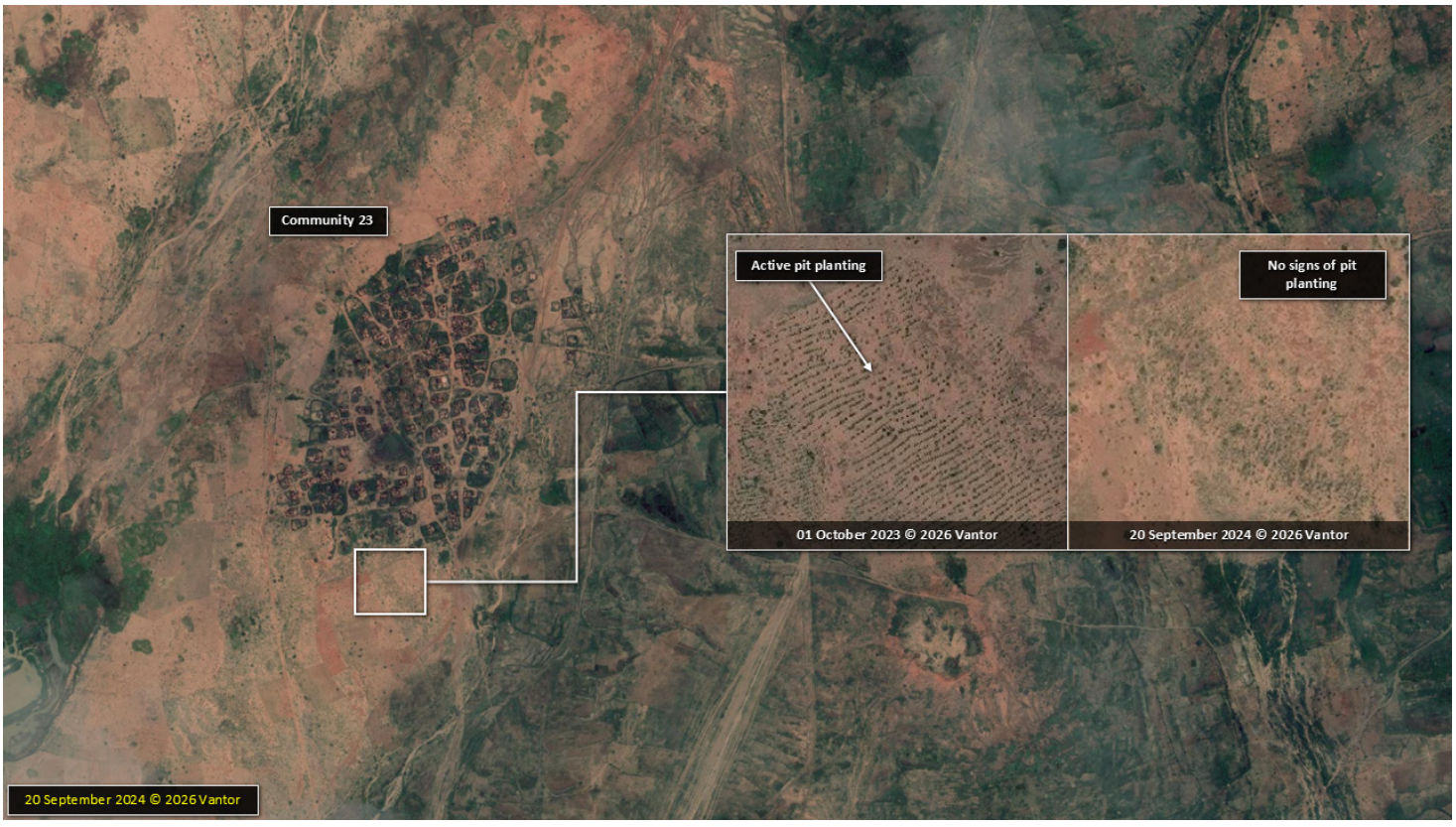


Figure 11. *No visible signs of agricultural activity consistent with pit planting seen in September 2024 when compared to historical imagery in Community 23.*

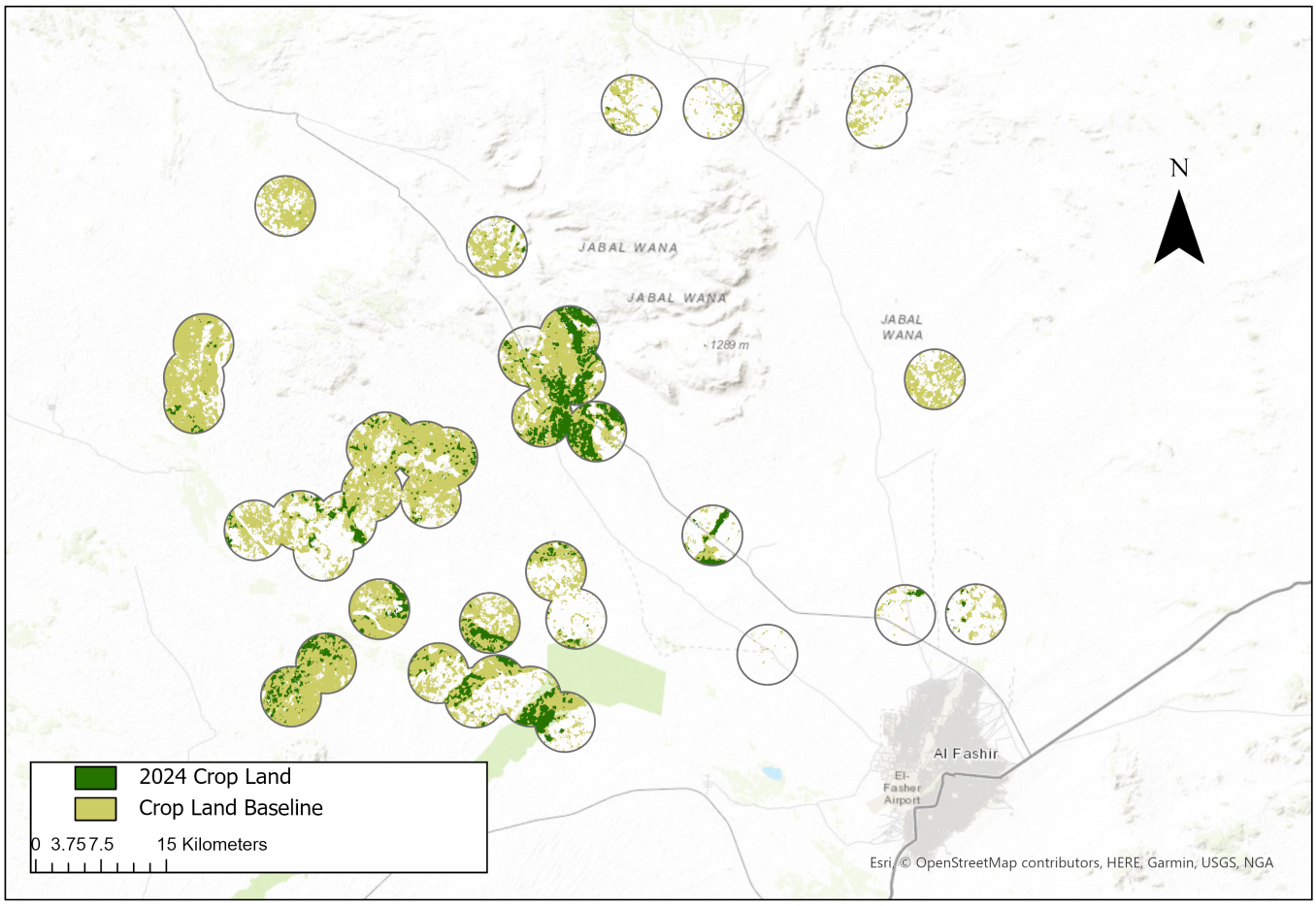


Figure 12. *Contractions in identified crop square area were seen in 2024 when compared to baseline assessed using the mode of 2019-2023, suggesting a decrease in observed agricultural area as classified by Dynamic World.*

from 7.16 km^2 in baseline to 1.25 km^2 in 2024, which represents a decrease of approximately 82% (***Figure 12*** and ***Figure 13***). Additionally, the average distance from a razed community to the closest crop area increased by approximately 4.6x or 368.08 meters between baseline and 2024 (80.67 meters to 448.75 meters respectively, seen in ***Figure 14***). Both the increase in distance and decreases in crop area within two kilometers of razed communities indicate that residents may not be planting near their community. These findings together indicate that agricultural activity near communities intentionally razed in 2024 decreased.

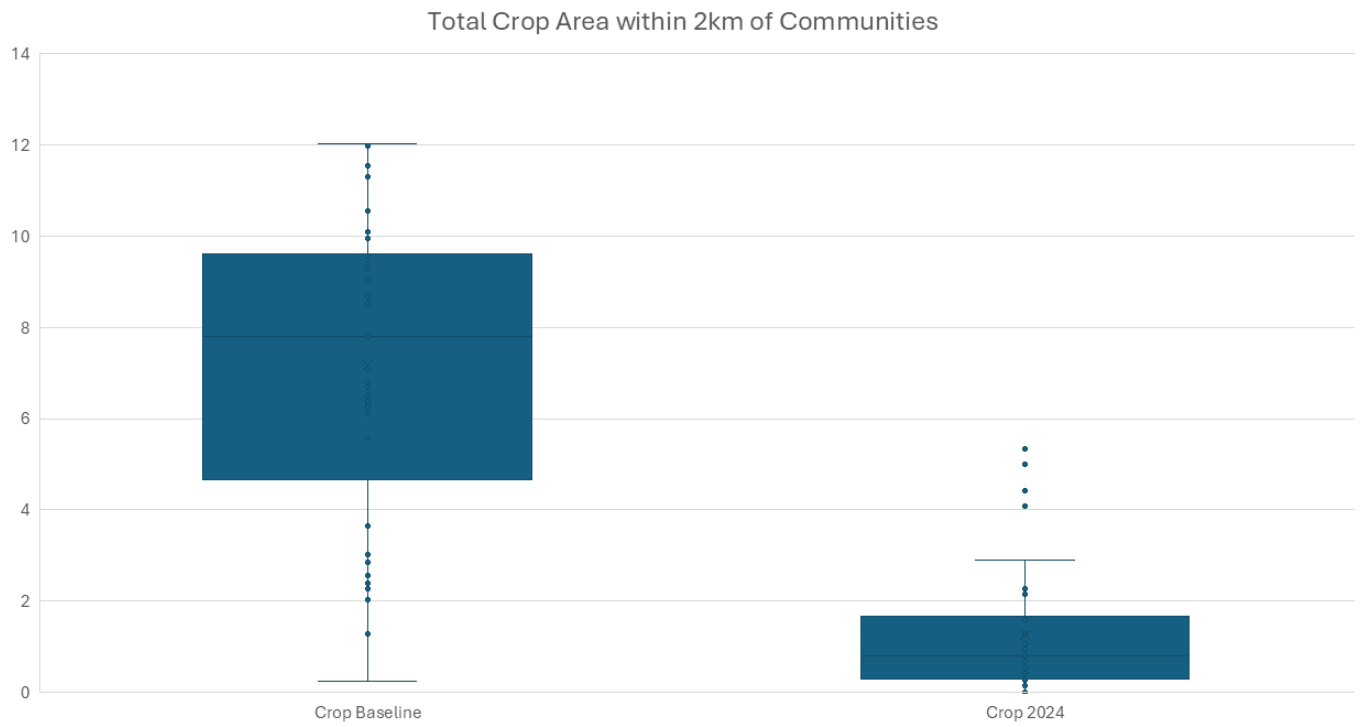


Figure 13. *The average estimated crop area near a razed community was 1.25 square-kilometers in 2024, which is a decrease from an average area of 7.16 square-kilometers at baseline (2019-2023).*

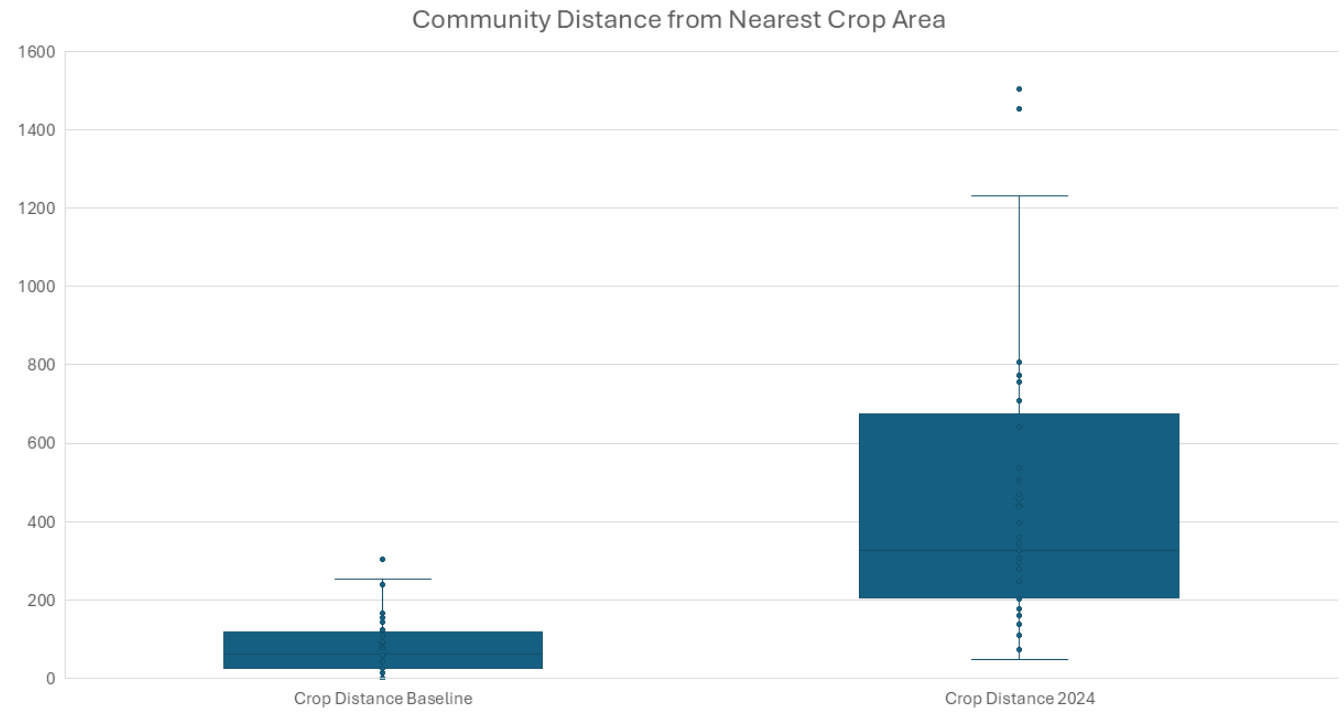


Figure 14. *The average distance from a razed community to the closest crop area increased by approximately 456% or 368.08 meters from baseline to 2024 (80.67 meters to 448.75 meters, respectively).*

V. Strengths & Limitations

Limitations

Due to limited land use/land cover data availability in North Darfur, Dynamic World was used to assess changes in identified crop area. The Dynamic World classifier can be error prone regarding climate in North Darfur which may cause misclassification and omissions.[40] Dynamic World does not use temporal information for classification and instead segments and classifies individual images.[41] The pixel size was multiplied by the total number of pixels classified as crop for baseline and 2024 crop area to assess the area if identified as crop area. This method can be error-prone and may lead to noise when calculating spatial area of an identified LULC class.

VIIRS and MODIS data have different uses and measurements. Both VIIRS and MODIS detect active fires and thermal anomalies, which may miss smaller fires or fires that may not be at high enough temperatures to be detectable to the sensor due to a coarse resolution of 375 meters and 1 kilometer, respectively.[42] If the same fire burns over several days, it may register as multiple detections. Thermal detections using VIIRS and MODIS are sensitive to cloud cover and recapture time, which may limit collection. This analysis did not assess the confidence of thermal detections nor systematically confirm the presence of thermal activity with satellite imagery beyond cross-referencing confirmed community razing. Yale HRL did not investigate or attribute possible cause to individual thermal detections from VIIRS and MODIS sensors outside the razed communities.

Abnormally heavy rainfall caused flooding during the 2024 rainy season (typically from June to September), likely causing planting delays. This is likely not the sole factor in observed change in identified crop area using Dynamic World or reduced agricultural activity visible in VHR satellite imagery. Although absolute changes in NDVI specifically within crop areas were not quantified, abnormal overgrowth of vegetation in most agricultural areas near communities was visible in satellite imagery. Yale HRL assessed the relationship between overall rainfall in El-Fasher locality with changes in NDVI within the communities and found that rainfall could not be determined as the only driver of the sharp increase in vegetation seen within communities (***Figure 9***).

This report does not measure agricultural yield or estimate the scale of future agricultural production. It aims to connect intentional razing events and their impact on food security within and surrounding El-Fasher. This report demonstrates how the fusion of VHR satellite imagery, other remote sensing data sources, and open source data can support food security assessments and provide additional context on the humanitarian situation in areas with limited to no humanitarian access.

Strengths

This analysis is one of the first of its kind to assess the impact of armed conflict on the food security of communities around El-Fasher over time using multiple remote sensing methodologies. First, it documents intentional razing of communities. Then this analysis demonstrates each communities' subsequent lack of pattern of life as well as contraction of agricultural activity as seen in VHR satellite imagery and identified crop area using Dynamic World's LULC classifier.

Although the analysis outlined in this report may not fully capture the complete scale of impacts to the agricultural production in the El-Fasher area, it does provide greater certainty that there were declines in agricultural production and pattern of life in affected farming communities. Time and use of a more comprehensive methodology will uncover the true scale of conflict's impact on agricultural activity around El-Fasher.

This method represents an advancement in the development and utilization of remote sensing data to assess food security in non-permissive environments. In communities where conflict and limited freedom of movement severely restrict humanitarian access, remote sensing data may be the only persistent and systematic window into a community's food security landscape. Although this report represents a step forward in using remote sensing data to support food security assessments, the development of standardized indicators and datasets that may be used for more rapid assessments in non-permissive environments must be developed. Standardized indicators must be sensitive to change over time, protect the safety of data collectors, minimize the burden of collection, be accessible and feasible for non-permissive environments, and interoperable across a wide range of environments and agricultural practices.

Remote sensing is a critical, often underutilized resource for documenting the food insecurity and violence civilians experience during conflict. This report demonstrates the role of remote sensing in assessing food insecurity in non-permissive environments, specifically active conflicts, in which remote sensing represents one of the only available sources of near real-time data. Moreover, this report combines remote sensing methodologies to create a novel fusion approach by utilizing earth observation to monitor conflict-related burning of communities, land use land cover (LULC) classification of crop, and abnormal vegetation overgrowth within communities. Together, these methods provide an otherwise unavailable capability for understanding the relationship between conflict patterns and food security resulting from attacks on civilian communities.

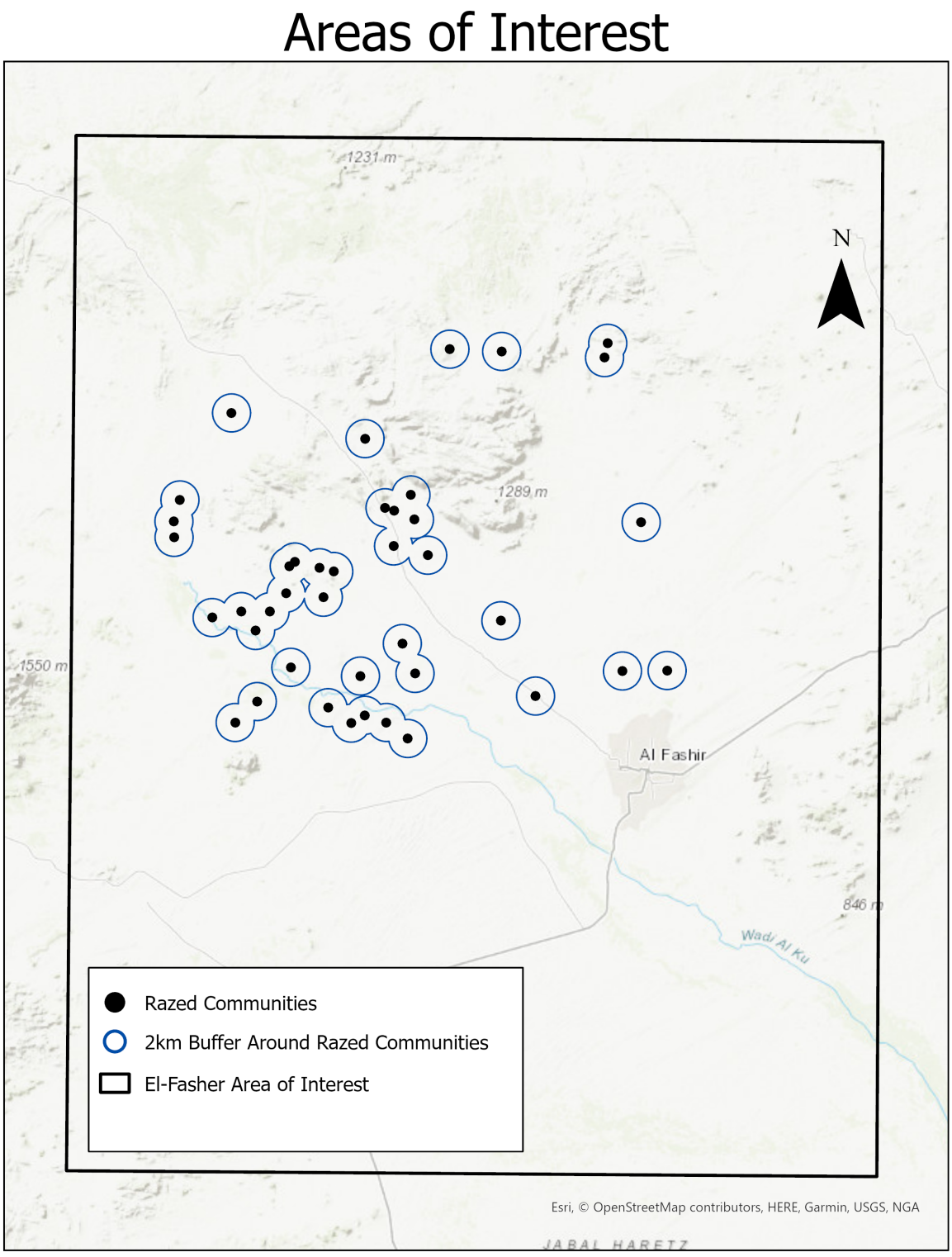
VI. Conclusion

The disproportionate impact of armed conflict on civilians and long-term effects on farming communities is apparent after RSF's intentional razing of 41 farming communities surrounding El-Fasher. Most of the analyzed communities experienced damage to civilian dwellings and livestock corrals followed by no or low pattern of life, which indicates that civilians living in these communities were killed, forcibly displaced, or otherwise fled these communities. At least 24 percent of these communities were razed more than once between 31 March to 12 June 2024, suggesting the intentional destruction of farming communities that support the food security ecosystem of El-Fasher. This analysis corroborates reports that RSF allegedly induced famine conditions in El-Fasher by systematically targeting these communities to remove the most critical food resources, including farmers and farming infrastructure. The shock caused by the attacks on farming communities and livelihoods is further worsened due to lack of cash, limitations on freedom of movement, and lack of humanitarian access in El-Fasher and surrounding areas. This, coupled with major conflict events occurring after the period of analysis, including the intentional burning of Zamzam IDP camp beginning in April 2025, the construction of an over 75-kilometer earthen wall around El-Fasher, and reported mass killings in El-Fasher after the city's capture in October 2025, continue to contribute to catastrophic food insecurity.

Together, these findings demonstrate the impact of the RSF's targeted razing of farming communities, subsequently impacting the food security environment around El-Fasher. The methods shown in this report support documentation and accountability measures related to alleged violations of International Humanitarian Law and support food security assessment in conflict settings.

VII. Appendices

A. Areas of Interest



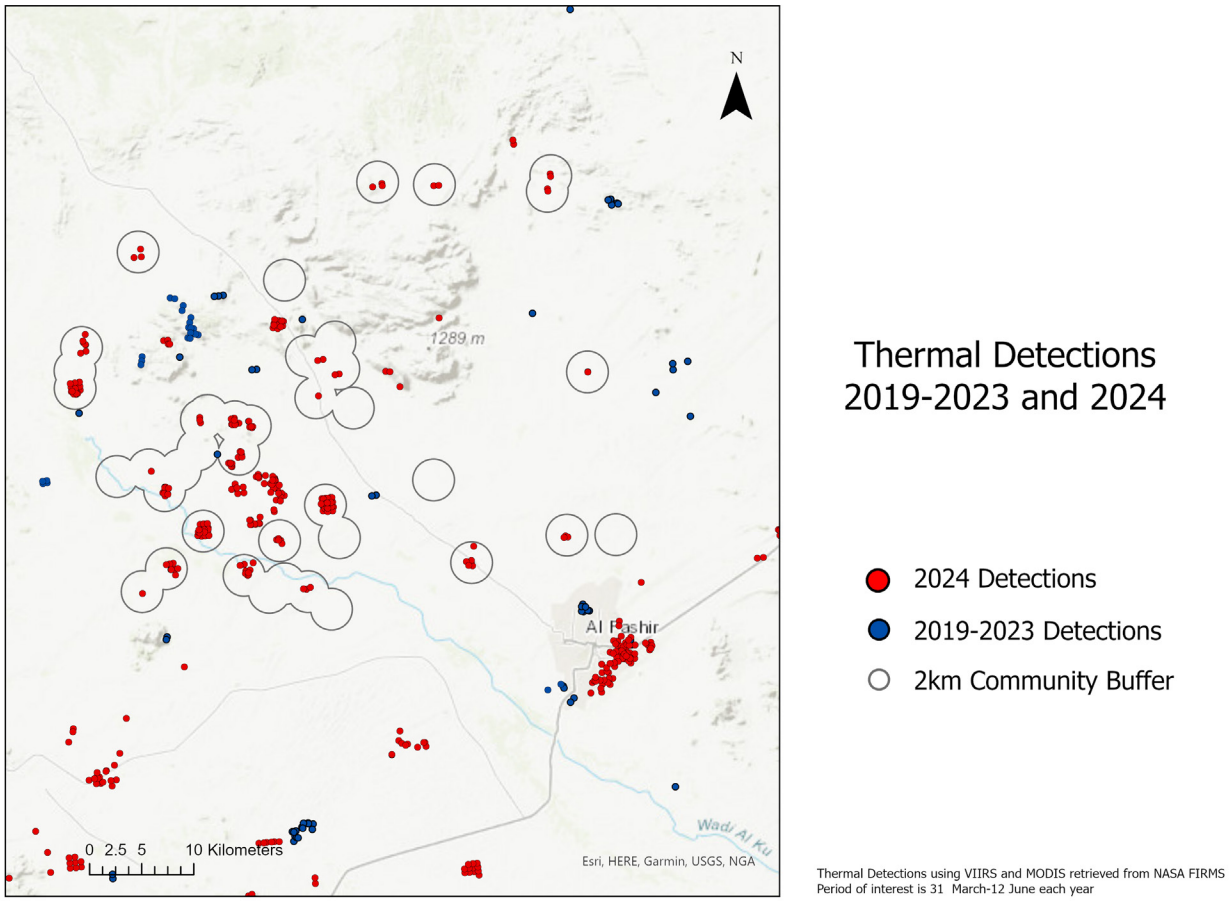
Areas of interest outlined in this report include: (1) the area within a two-kilometer buffer around each of the razed communities and (2) the El-Fasher Area of Interest.

B: Assessments & Datasets

ASSESSMENT	SOURCE	INDICATOR	DATES	AREA TESTED	DERIVED INFERENCES
Intentional razing of communities	Vantor, Planet Labs	VIIRS, low, moderate, and very high-resolution (VHR) satellite imagery	31 March to 12 June 2024	Area north-northwest of El-Fasher, North Darfur	Forty-one communities were razed between 31 March to 12 June 2024. Twenty-four percent (10) of communities were attacked more than once. One village was attacked as many as seven times.
Active Fires and Thermal Anomalies	NASA Fire Information Management System (FIRMS)[43]	Visible Infrared Imaging Radiometer Suite (VIIRS) & Moderate Resolution Imaging Spectroradiometer (MODIS) sensors[44]	31 March to 12 June of each year within AOI	Within two kilometers of each razed community and across the same area of interest used to assess attacks on communities. This area of interest spans 9270 km^2 across the wider El-Fasher area.	Detect thermal anomalies and fires. Dataset was developed to compare "normal" fire activity from 2019-2023 near communities to the period during the razing of communities in 2024.
Rainfall	United Nations Humanitarian Data Exchange (HDX)	Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)[45]	2019 to 2024, rainfall estimates aggregated by month	El-Fasher Administrative Level 2	Rainfall alone was not a contributing factor in the sharp increase of vegetation detected with NDVI within the communities.

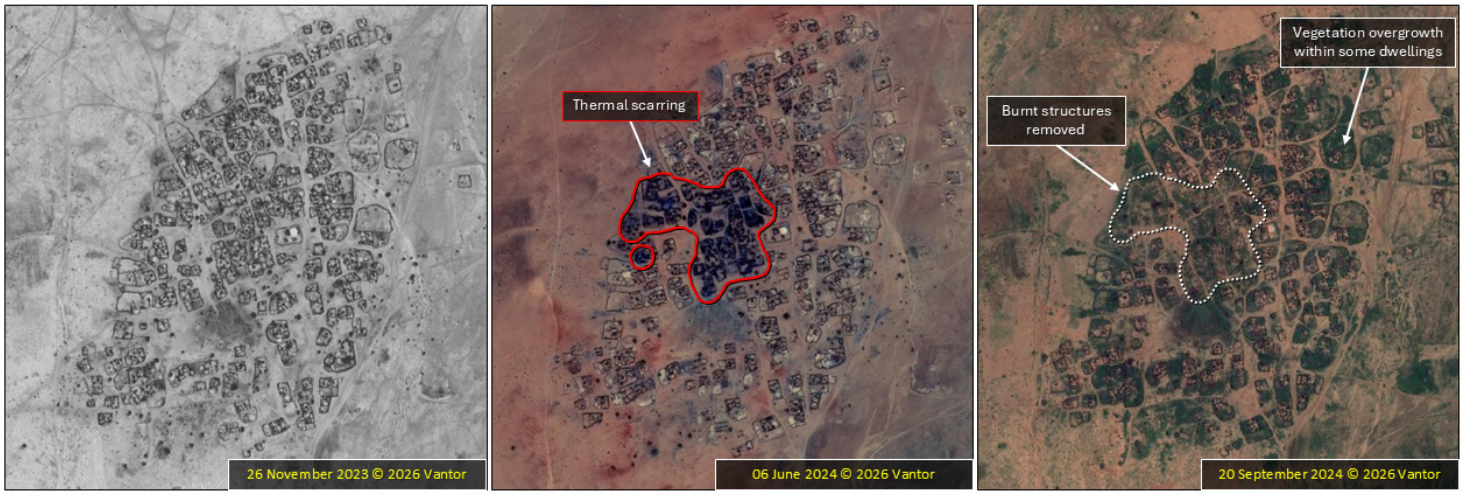
ASSESSMENT	SOURCE	INDICATOR	DATES	AREA TESTED	DERIVED INFERENCES
Pattern of Life (Satellite Imagery Analysis Component)	Activity within community, corral damage assessment, Agricultural activity outside Community Vantor, Planet Labs, Airbus DS	Very-high resolution and moderate resolution satellite imagery, Vantor, Planet Labs, Airbus DS	Multitemporal change detection **Period post razing:** included the most recent imagery available from 22 July 2024 to 11 November 2024 **Period of razing:** 31 March to 12 June 2024 **Historical imagery during similar post-razing period**: All locations used historical imagery collected between August and November. Available imagery for most locations was 8 October 2023 and 12 October 2023, while some locations included historical imagery from August to November due to imager availability.	The 41 communities of interest and the area immediately surrounding the communities.	**Village POL:** Twenty-eight Communities (68.3%) have no visible pattern of life between August to November after the communities were razed between 31 March to 12 June 2024. Five communities have seen a reduced pattern of life. Eight communities have normal pattern of life **Corral Damage:** Twenty communities showed corrals damaged partially or entirely between 31 March to 12 June 2024. **Agricultural activity:** Thirty-three communities showed no or reduced (29 no and 4 reduced) agricultural activity including fallow or barren fields. Eight communities showed similar agricultural activity when compared to historical imagery.
Pattern of Life (NDVI Component)	Sentinel Hub, Google Earth Engine,[46] Harmonized Sentinel-2 MSI: Multispectral Instrument, Level-2A	Normalized Difference Vegetation Index (NDVI)	1 August to 30 September from 2019 to 2024	Within drawn community boundaries	When comparing the change on baseline between 2019-2023 to 2024 NDVI values, 40 of 41 communities experienced an increase in NDVI change while one village showed a decrease. The mean NDVI change was 0.273. The baseline NDVI mean was 0.288 while in 2024 the mean was 0.561, suggesting a sharp increase in abnormal vegetation within the communities.
Identified Crop Assessment	Dynamic World[47] and Google Earth Engine	Changes in "Crop" Land Use Land Cover (LULC) class	1 August to 30 September from 2019 to 2024	Within two kilometers of community center point	Assess changes in area classified as crop proximate to razed communities to infer change in agricultural activity after the razing event.

C: Thermal Detections



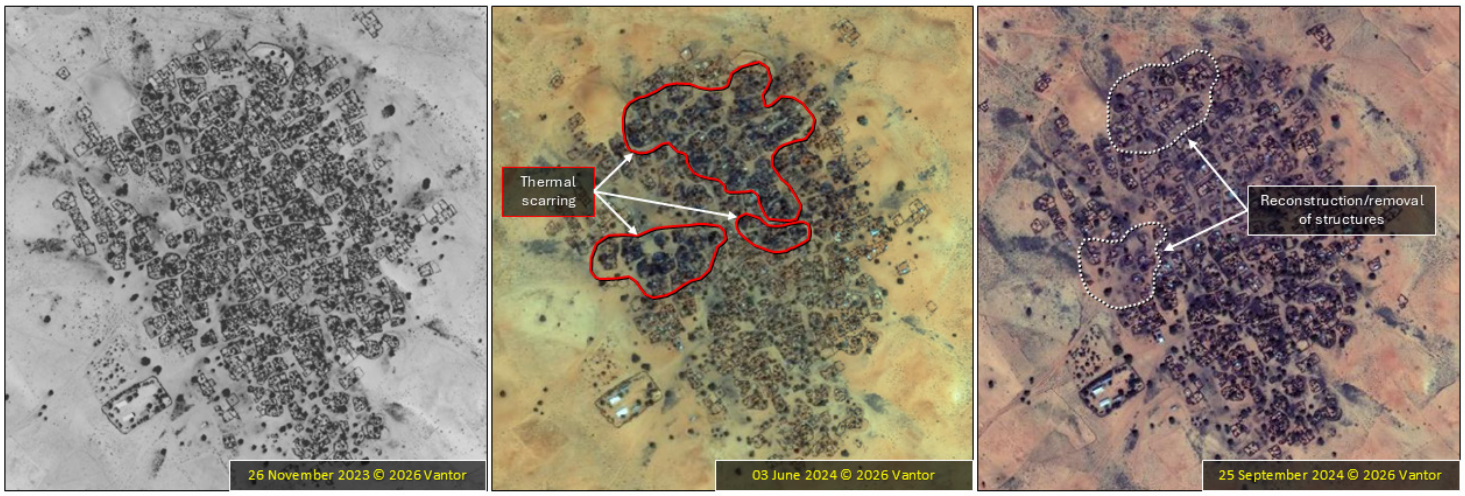
Active fires and thermal detections from 31 March to 12 June, 2019-2023 compared to 2024.

D: Community 23



Progression of vegetation growth following razing in Community 23 from baseline (left, to observed thermal scarring (center) then to reduced pattern of life (right). The baseline image of Community 23 from 26 November 2023 precedes the thermal scarring. The middle image, dated 6 June 2024, shows thermal scarring consistent with intentional razing. The right-most satellite image from 20 September 2024 shows vegetation overgrowth in the months following the razing of Community 23, with reduced pattern of life in the community.

E: Umm Dalil



Minimal progression of vegetation growth following razing in Umm Dalil from baseline (left, to observed thermal scarring (center) then to normal pattern of life (right). The baseline image of Umm Dalil from 26 November 2023 precedes the thermal scarring. The middle image, dated 3 June 2024, shows thermal scarring consistent with intentional razing. The right-most satellite image from 25 September 2024 shows no vegetation overgrowth as well as reconstruction and removal of structures in the months following the razing of Umm Dalil, with normal pattern of life in the community.

F: Communities Assessed

Period of interest for VIIRS and times hit was 31 March to 12 June 2024, the period of interest for NDVI and identified crop analysis was –30 September 2024. Finally, multitemporal change detection analysis was used to assess pattern of life (POL) and agricultural (Ag) activity by comparing historical imagery prior to the razing events, imagery depicting thermal scarring from razing, and comparing to imagery from August and November 2024.

NAME	LATITUDE	LONGITUDE	VIIRS WITHIN 2KM	RAZING FREQUENCY	POL	CROP BASELINE	CROP 2024	CROP CHANGE	NDVI BASELINE	NDVI 2024	NDVI CHANGE	BASELINE CROP DISTANCE	2024 CROP DISTANCE	CROP DISTANCE CHANGE	AG ACTIVITY
Janjounat	13.68776955	24.97436921	8	1	No	11.97	2.28	-9.69	0.31	0.54	0.23	0.00	74.23	74.23	None
Baraka	13.72057704	25.00674958	20	1	Reduced	10.16	1.65	-8.51	0.31	0.63	0.32	0.00	306.77	306.77	None
Tikailat	13.71283004	25.07458572	5	2	No	9.35	2.14	-7.20	0.30	0.69	0.39	0.00	537.71	537.71	None
Turkniya	13.67553316	25.07920115	1	3	No	6.25	1.27	-4.99	0.31	0.73	0.42	52.48	469.30	416.81	None
Jaranga	13.66887191	25.10006756	3	1	Reduced	6.38	2.90	-3.48	0.24	0.61	0.37	48.91	443.80	394.17	Reduced
Muqrin	13.65378105	25.12109824	0	1	Reduced	6.10	2.27	-3.83	0.23	0.34	0.12	141.28	295.62	154.34	Reduced
Ammar Jadid	13.74405471	25.11503824	37	5	No	6.69	0.70	-5.99	0.23	0.61	0.38	152.75	708.07	555.32	None
Community 1	13.78750201	25.03778706	11	1	No	8.68	0.43	-8.25	0.28	0.53	0.24	97.29	504.89	407.61	None
Community 3	13.81551928	25.03403569	17	1	No	9.63	0.68	-8.94	0.30	0.60	0.30	51.62	362.91	311.29	None
Community 2	13.81208526	25.04775689	17	1	No	10.10	0.99	-9.11	0.30	0.58	0.28	42.21	251.12	208.91	None
Umm Suneita	13.7553627	24.9722384	11	1	No	2.86	0.26	-2.60	0.32	0.73	0.41	32.46	394.64	362.17	None
Community 6	13.82080954	25.00980106	3	1	No	9.29	0.95	-8.33	0.24	0.52	0.28	58.50	760.60	702.09	None
Community 7	13.8168851	25.00437025	3	1	No	9.03	0.80	-8.23	0.28	0.60	0.32	77.32	326.55	249.23	None
Kosa	13.66768275	24.95307922	1	1	Reduced	12.02	2.33	-9.69	0.52	0.72	0.20	0.00	159.77	159.77	Reduced
Fag	14.01750704	25.30984763	4	1	Yes	2.57	0.00	-2.57	0.29	0.35	0.07	130.28	1506.17	1375.89	Same
Community 11	14.03114008	25.31284556	4	1	Yes	2.39	0.00	-2.38	0.30	0.31	0.01	93.35	1233.06	1139.71	Same
Community 10	14.02442815	25.15911913	3	1	Yes	3.72	0.14	-3.58	0.23	0.29	0.05	118.20	774.01	655.81	Same
Tawazin	13.77337883	24.98607922	0	1	No	5.59	1.60	-3.99	0.37	0.67	0.30	0.00	256.02	256.02	None
Community 9	13.79108843	25.00151933	0	1	No	9.46	0.60	-8.86	0.28	0.56	0.27	26.51	205.73	179.22	None
Kobbei	13.87888371	24.89744619	7	7	No	9.29	0.15	-9.14	0.30	0.47	0.17	116.53	246.21	129.68	None
Community 14	14.02264546	25.20955006	2	1	Yes	2.04	0.02	-2.02	0.25	0.29	0.04	165.24	278.13	112.90	Same
Kerkera	13.86108746	25.34664115	2	1	Yes	7.09	0.03	-7.06	0.27	0.35	0.07	56.89	311.70	254.81	Same
Community 15	13.83682551	25.10574695	1	2	No	10.56	4.43	-6.13	0.32	0.80	0.48	63.95	175.09	111.14	None
Community 21	13.8432469	24.89205919	15	3	No	9.94	0.53	-9.41	0.42	0.52	0.10	8.36	765.82	757.46	None
Wadi Kafod	13.85855361	24.89180726	11	4	No	9.57	0.04	-9.53	0.33	0.50	0.17	24.12	436.90	412.78	None
Community 17	13.96208748	24.94696628	3	1	Yes	7.89	0.02	-7.88	0.26	0.46	0.20	49.26	343.40	294.14	Same
Gileidit	13.7195041	25.32942332	3	1	No	1.27	0.33	-0.93	0.24	0.43	0.19	173.67	640.85	467.17	None
Community 23	13.72023743	25.37285398	0	1	Reduced	3.01	0.30	-2.71	0.18	0.30	0.11	253.05	756.74	503.69	None
Umm Dalil	13.6950852	25.24506221	6	1	Yes	0.25	0.00	-0.25	0.22	0.20	-0.02	303.15	1455.23	1152.08	Same
Jughmar	13.71573968	25.12761013	0	2	No	2.26	0.44	-1.82	0.25	0.68	0.43	3.97	808.10	804.13	None
Community 25	13.76728859	24.92979784	0	2	No	6.53	0.41	-6.12	0.41	0.88	0.48	12.14	814.53	802.38	Reduced
Community 26	13.77321037	24.95806336	1	1	No	6.17	0.85	-5.32	0.39	0.79	0.39	61.39	294.99	233.60	None
Balunga	13.87311709	25.09716416	2	1	No	8.52	1.08	-7.44	0.25	0.75	0.51	90.68	140.49	49.81	None
Shalakhna	13.87026459	25.10586228	2	1	No	10.02	1.68	-8.34	0.28	0.80	0.52	109.22	143.20	33.98	None
Community 27	13.76647629	25.2107904	0	1	No	3.65	1.65	-2.00	0.27	0.59	0.32	0.00	47.79	47.79	None
Community 28	13.82826735	25.13903613	0	4	No	9.40	5.34	-4.06	0.22	0.48	0.26	238.19	288.70	50.51	None
Community 29	13.93867293	25.07713419	0	1	Yes	6.82	0.32	-6.50	0.29	0.37	0.09	112.12	201.30	89.18	Same
Community 30	13.88546215	25.12229748	0	1	No	11.29	4.09	-7.20	0.29	0.74	0.45	34.75	73.41	38.66	None
Community 31	13.86215943	25.12592044	3	1	No	11.55	5.01	-6.54	0.24	0.70	0.45	96.33	109.61	13.28	None
Sarfaya	13.68248127	25.04331369	9	1	No	7.80	1.07	-6.73	0.25	0.61	0.36	87.88	359.03	271.16	None
Um Ashoush	13.66798171	25.06588938	0	1	No	6.50	1.59	-4.91	0.24	0.70	0.46	123.22	137.26	14.04	None

Endnotes

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