Report
Integrating Remote Sensing into Household Economy Analysis

Overseas Tech

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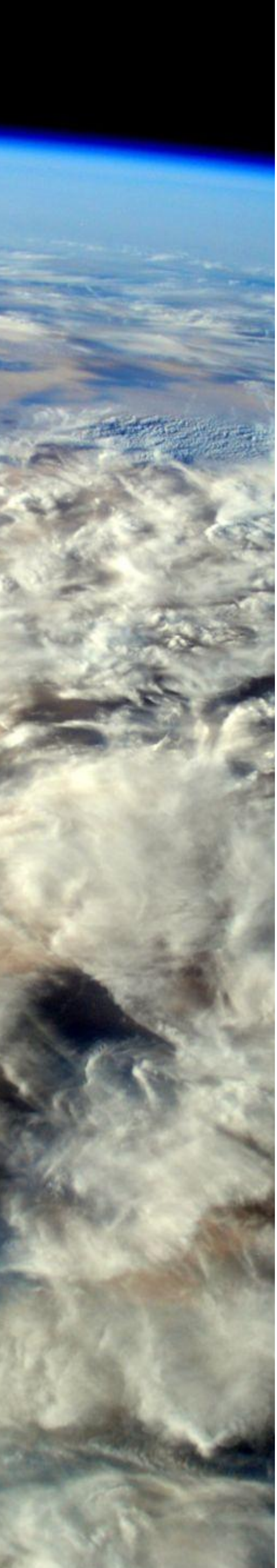
21 Dec 2021



Introduction

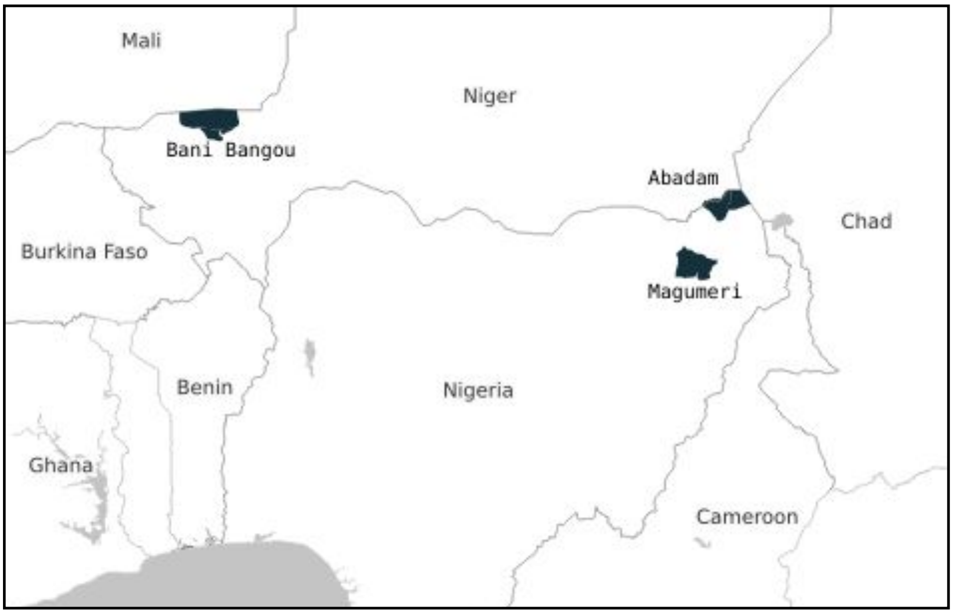


Figure 1: Map of the study area

This study focuses on the department of Bani-Bangou in Niger and the LGAs of Magumeri and Abadam, as shown on Figure 1. These areas were selected by the HEA staff at SCs Regional Office due to their insecurity and relative inaccessibility for humanitarian staff to collect in-person HEA data.

Objectives

1) **Remote sensing data inventory for HEA**
    a) List of satellite data currently used by the humanitarian food security sector in the Sahel and what relation they could potentially have to the HEA.
    b) This is partially expanded upon in section "Overview of remote sensing and HEA" but more fully in Annex 1
2) **Remote sensing analysis applied to OA for the study area**
    a) Analyze changes in cultivated surfaces and biomass availability
    b) Provide data usable in the context of the OA
3) **Reproducibility and learning**
    a) Write a step-by-step guide to reproducing the analysis created in objective 2 (Annex 2)

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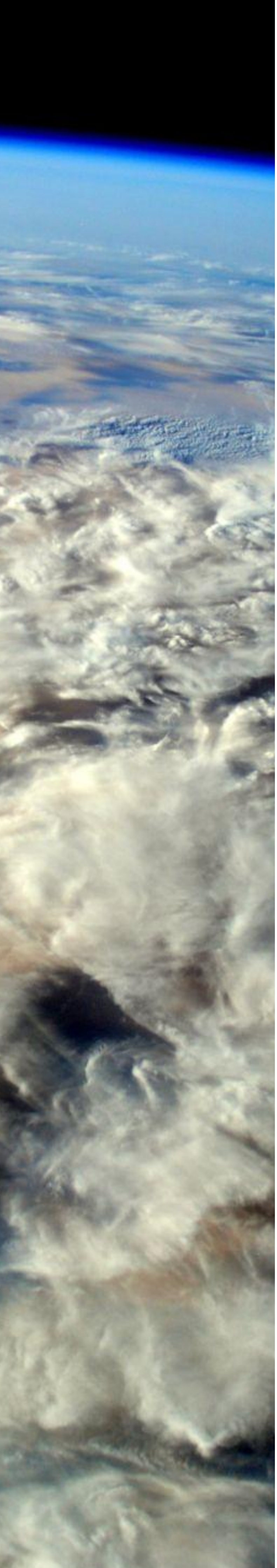
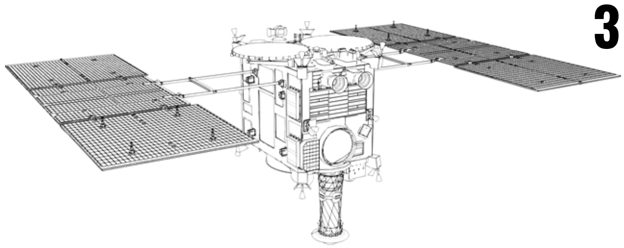
Annex 1: Remote Sensing Data Inventory for HEA
Annex 2: User Guide: cultivated surfaces analysis using open source GIS



Introduction

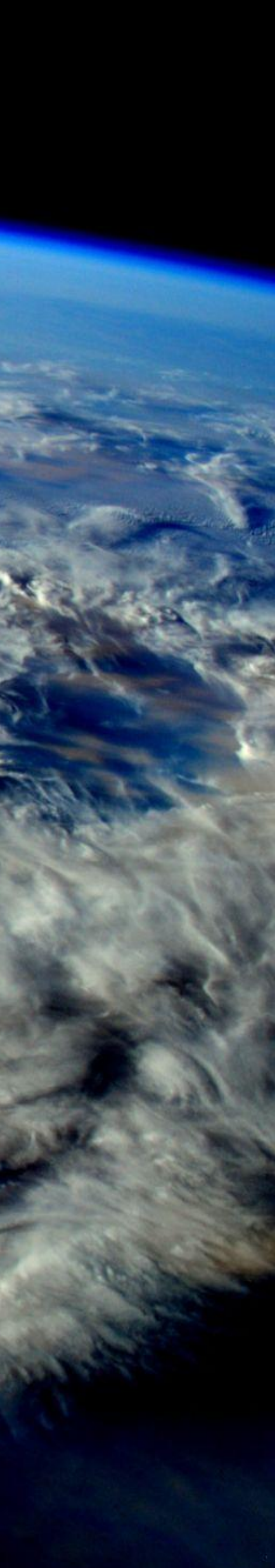


This study was commissioned by Save the Children regional office in West Africa to examine the possibilities of integrating Remote Sensing (RS) data into the Household Economy Analysis. HEA is a livelihoods framework that determines whether households have the food and cash they need to invest in their children's well-being. It is a unique approach for quantifying and predicting needs; and identifying and understanding the most economically deprived households. This study examines the possibility of including RS data in the outcome analysis (OA) phase of the HEA. The OA consists of an analysis of 4 key parameters: 1) Agricultural Yield, 2) Herd Size, 3) Market conditions and 4) All other sources of income that is typically collected by primary data. Where primary data is unavailable, inferences are made through secondary or contextual data.

Remote sensing (or satellite-derived imagery) has undergone a renaissance over the past two decades. The proliferation of open imagery and open source software has greatly increased the accessibility of remotely sensed imagery and its potential applications to real-world problems. Access to data on climate, water, weather and our environment has never been greater or easier. However, in spite of this revolution in data, uptake of RS data within the humanitarian community has been glacial, with the only significant movement occurring in the past decade. While RS data allows for new possibilities in detecting drought, monitoring agriculture, forecasting the weather or examining natural disasters, humanitarian programming has only seen a limited integration with these data.

RS data also allows for the possibility to monitor changes in the natural environment without field visits, greatly improving the possibility to monitor inaccessible places. It is within this logic that this study was built.

This study proposes to integrate RS data into the HEA's OA phase. An inventory of RS data relating to food security in the Sahel has been assembled for this purpose in annex 1. To pilot the integration of this data, 2 data sets from the inventory have been analyzed to the context of the HEA. The first is the cultivated surfaces dataset, which is being applied to the first OA Key Parameter, Agricultural Production. The second is biomass production, which is being applied as contextual information to the pastoral situation of the study area, rather than as a direct input to a Key Parameter. Finally, this report also provides a brief guide for reproducing the analysis of cultivated surfaces and biomass production.



Methodology- Cultivated Surfaces

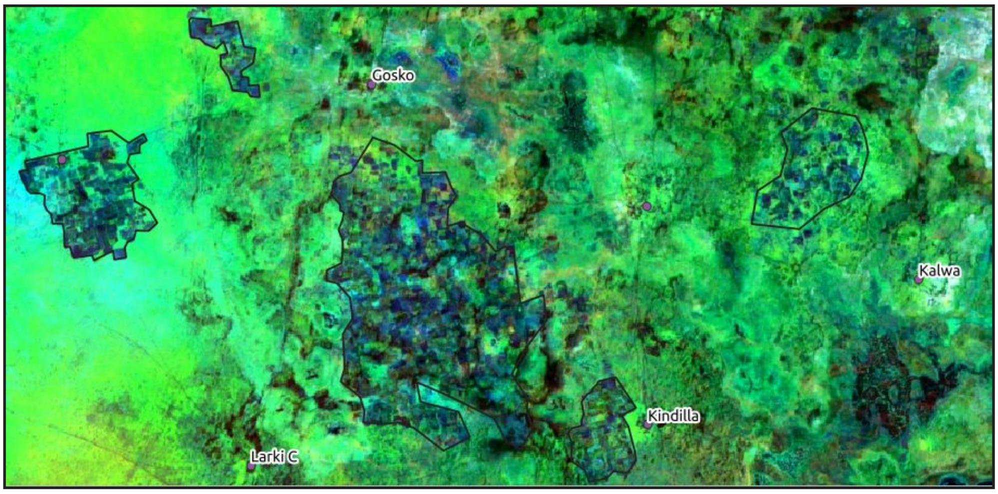


Figure 2: Cropland identified by 3 Period Timescan Method

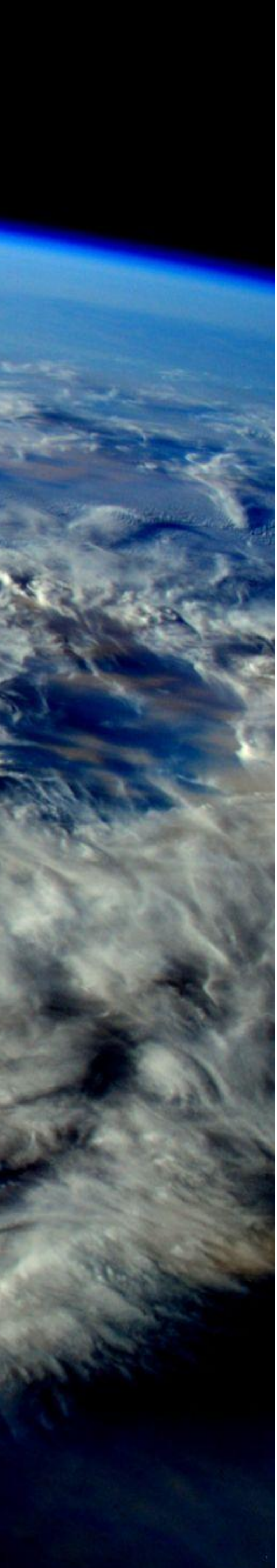
In order to measure the changes of cultivated surfaces, the “3 Period Timescan” (3PTS) method was employed, using images captured from the Sentinel 2 satellite of the European Space Agency. 3PTS is built from The Normalized Difference Vegetation Index (NDVI). NDVI is commonly used in remote sensing as an indicator of live green vegetation presence. It is calculated from the values of the red and near-infrared imagery bands of satellite images. For the present analysis, Sentinel-2 images acquired during the agricultural season (15th June till 15th October) were processed into yearly composite maps for the present year (2021) and the year of reference for our study area (2016,2017). The composites of these images allow to chart the change in vegetation across the growing season for each individual pixel of an image.

Because of Sentinel 2’s relatively high resolution ($10m^2$), a temporal profile can be visualized for a very specific area, allowing to single out different land cover types, and so to identify croplands. A more detailed technical explanation of 3PTS can be found by consulting Boudinaud and Orenstein (2021) and Boudinaud (2020).

An image above showing the results of a 3PTS image in Abadam, Nigeria. The cropland can be clearly seen as dark blue squares distinct from the surrounding natural vegetation, which is coloured green. The polygon shapes around the cropland were drawn manually.

The code for the 3PTS was executed on Google Earth Engine (GEE), an online platform which combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. As GEE is hosted in the cloud, it allows for a much faster turnaround time in creating images and executing analyses.

By comparing the 3PTS composite maps for 2021 and a baseline year (2016 or 2017), the status of crop change could be visually determined for every populated area within the zone of interest.



Methodology- Cultivated Surfaces

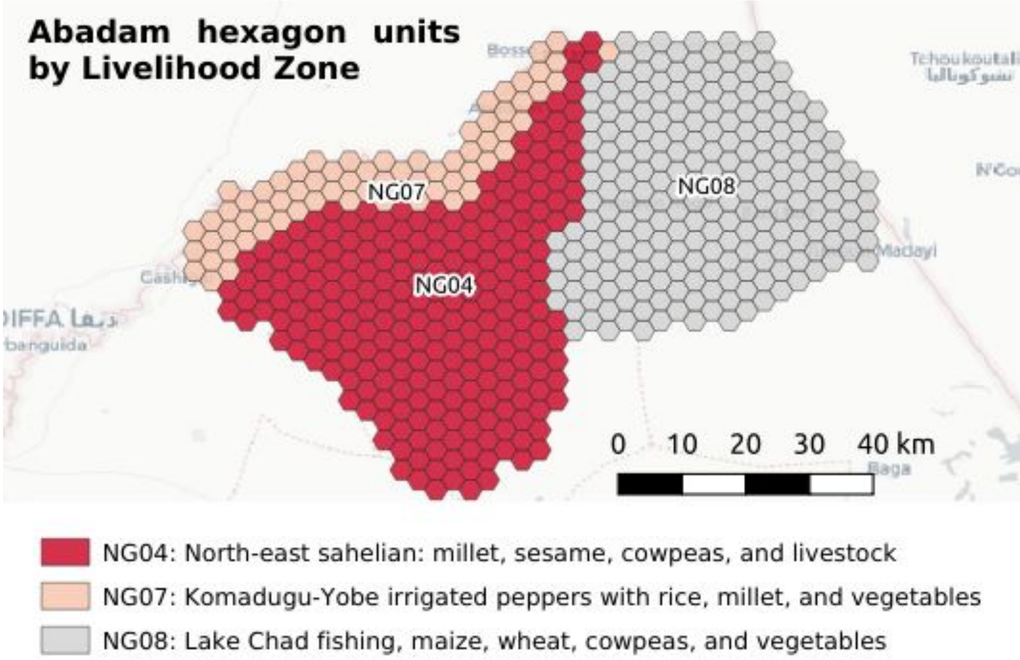


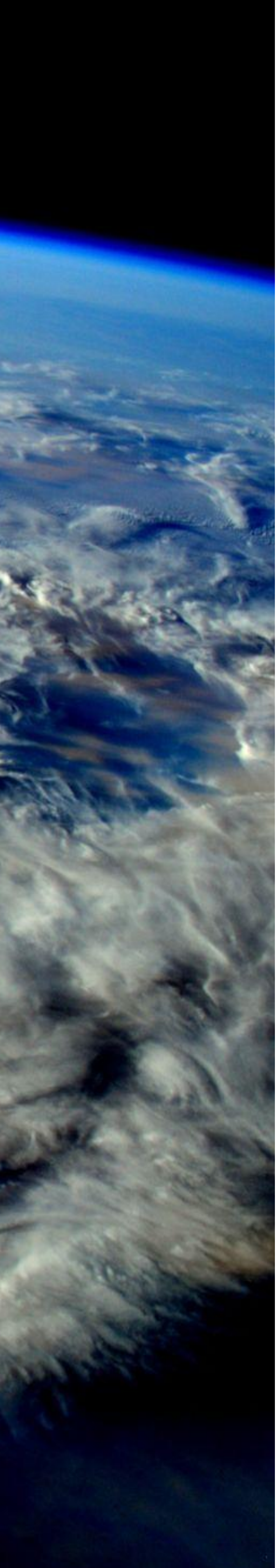
Figure 3: Hexagonal analysis zones in Abadam, classified by livelihood zone

The zone of interest is further divided into equally-sized hexagons with a diameter of 3.5km. The use of these hexagons creates equal sized areas for analysis, allowing for complete uniformity and minimizes spatial subjectivity in the analysis. Above is an image of the Abadam study area, subdivided into hexagons, classified by livelihood zone.

Once analyzed, hexagon is thus placed within a “fourchette” based on a comparison of it’s 2021 and 2016 images. The table below offers a description of each fourchette and its associated category. The use of these fourchettes creates clear and concise categories for each possible situation. The 3PS Methodology does not allow for machine learning in classifying the changes from one year to another. As a result, the use of these fourchettes allows for categories to be quickly assigned by visual analysis and human interpretation.

Category	Fourchette	Description (compared to ref. year)
Total loss	0%	Total loss of agriculture- may indicate the total abandonment of a village
Severe loss	1-50%	Less than half of cultivated surfaces
Moderate loss	50-80%	Cultivated surfaces over half of what was observed in ref. year
No change	80%-120%	Approximately the same as the ref. year
Moderate increase	120%-150%	Noticeable increase in cultivation
Significant increase	+150%	Large growth in cultivation (either previously uncultivated surfaces or a return to previously abandoned fields)

Table 1: Fourchettes



Methodology- Cultivated Surfaces

The image below shows the same Hexagon in Abadam, Nigeria from 2016 to 2021, falling into the “moderate increase” fourchette. The cropland can be seen as the blue shaded pixels, which contrast well against the green-colored natural vegetation. A moderate increase in the surface of cropland can be seen in 2021, especially in the two south-western clusters of cropland.

Once every hexagon has been classified, a map is drawn showing the classification of each hexagon, allowing for conclusions to be drawn across the entire zone of interest. As indicated in the hexagon map of Abadam, it is also possible to subdivide the zone by livelihood zone. This allows for the results of the analysis to be tailored to specific livelihood profiles.

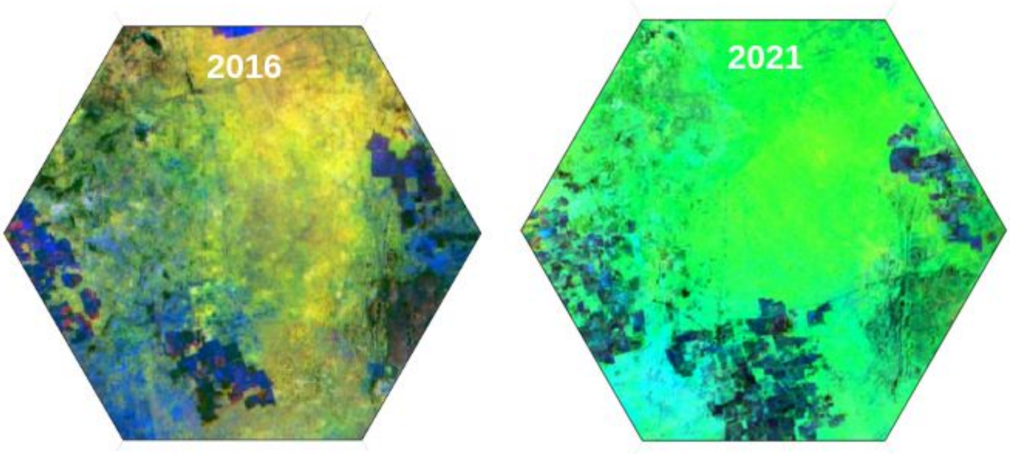


Figure 4: Hexagons comparing cropland between current and reference years

FIgure 5 offers an additional example, by comparing a 3PTS image and Very High Resolution satellite image from Google Earth of the same area. The zones identified as cropland by the 3PTS (bordered in yellow) can clearly be seen as cropland in the right-hand image (this is best viewed zoomed in on a computer screen).

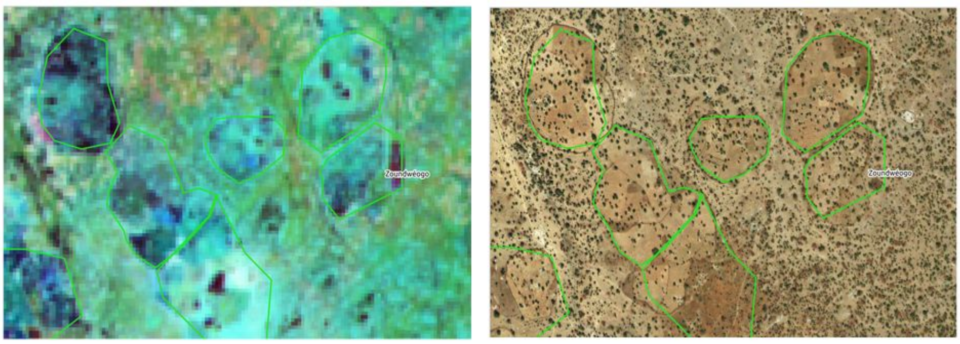
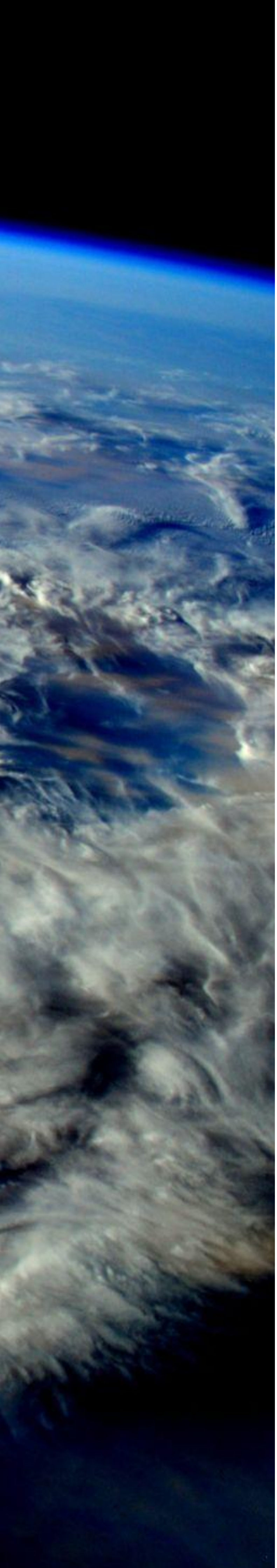


Figure 5: Cropland seen on a 3PTS image and Google Earth

Boudinaud, Laure & Orenstein, S. (2021). ASSESSING CROPLAND ABANDONMENT FROM VIOLENT CONFLICT IN CENTRAL MALI WITH SENTINEL-2 AND GOOGLE EARTH ENGINE. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLVI-4/W2-2021. 9-15. 10.5194/isprs-archives-XLVI-4-W2-2021-9-2021.

Boudinaud Laure (2020)"Satellite Imagery in conflict-affected areas", World Food Programme
https://www.wfp.org/publications/wfp-mali-satellite-imagery



Methodology- Population

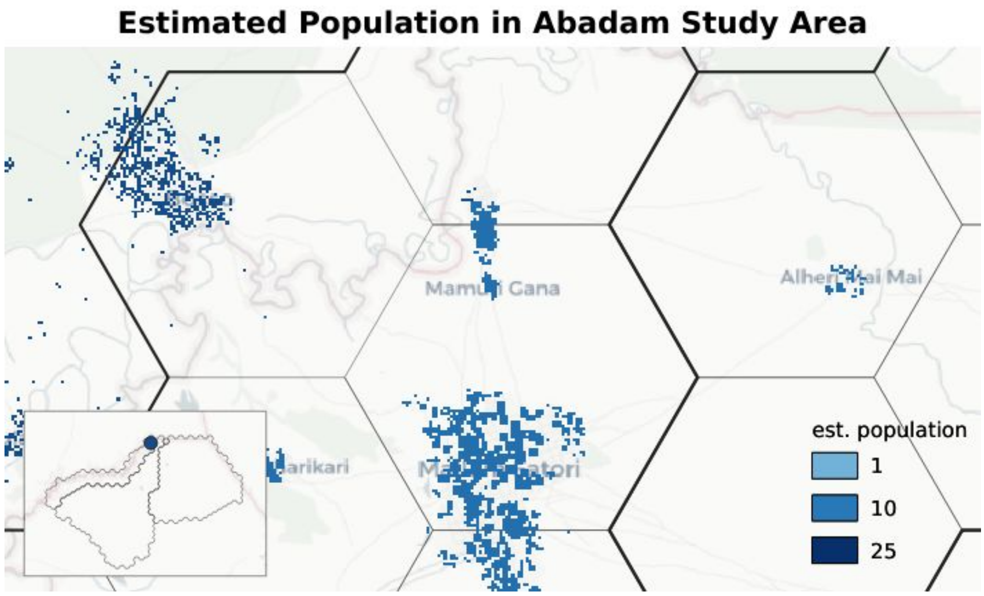


Figure 6: Population density visualized by the HRSL Dataset in Abadam

The final step in the analysis is to attach population estimates to each hexagon, allowing for the method to estimate the population living in zones falling into each "fourchette". This is done using the High Resolution Settlement Layer (HRSL), first developed by Facebook in 2017 (Tiecke et Al). This dataset is built from a series of satellite images and machine learning algorithms designed to model the density of human habitations. It provides a global estimate of population density at a very high resolution (30m) as shown in figure 6. As a result, determining the population of each hexagon is a simple question of counting the total population estimates within the boundaries of a hexagon.

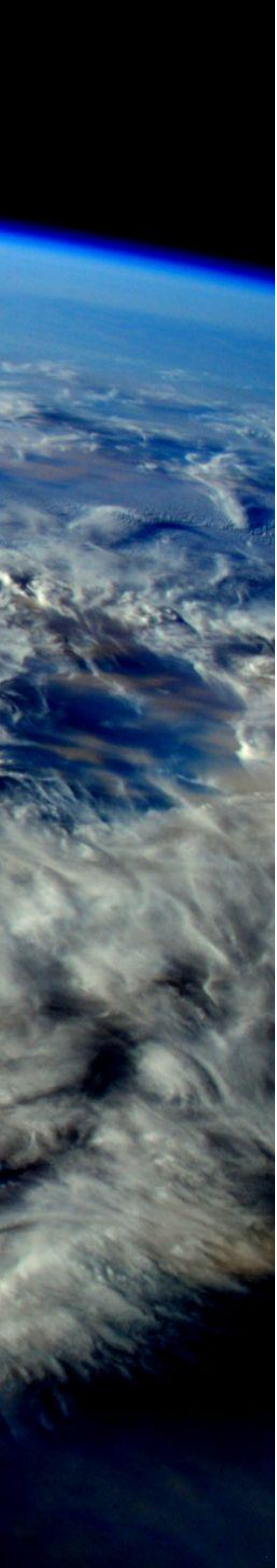
In the final analysis in section 4, the results are presented in terms of percentage of population rather than numbers of people. This is because the HRSL, while highly precise, is not an official estimate of population. Likewise, population estimates may differ from those used by the HEA OA. The strength of the HRSL is in its capacity to visualize relative density, rather than population numbers. Thus it is preferable to present the data in terms of percentages, allowing HEA practitioners to apply the percentages to their own population estimates.

This study compared 2018 HRSL estimates for all 3 study areas against their official 2018 population projections. For each instance, the error was inferior to 10%, indicating that the dataset is reliable for the purposes of this study.

	Official 2018 Projection	2018 HRSL	HRSL Error
Abadam	150,614	143,400	5.03%
Magumeri	211,138	192,361	9.76%
Bani Bangou	87,185	80,661	8.09%

Table 2: Population totals for the study areas from HRSL and official projections

Mapping the World Population One Building at a Time
Tiecke, Tobias G., Liu, Xianming, Zhang, Amy, Gros, Andreas, Li, Nan, Yetman, Gregory, Kilic, Talip, Murray, Siobhan, Blankespoor, Brian, Prydz, Espen B., and Dang, Hai-Anh H.
Other papers. December 2017



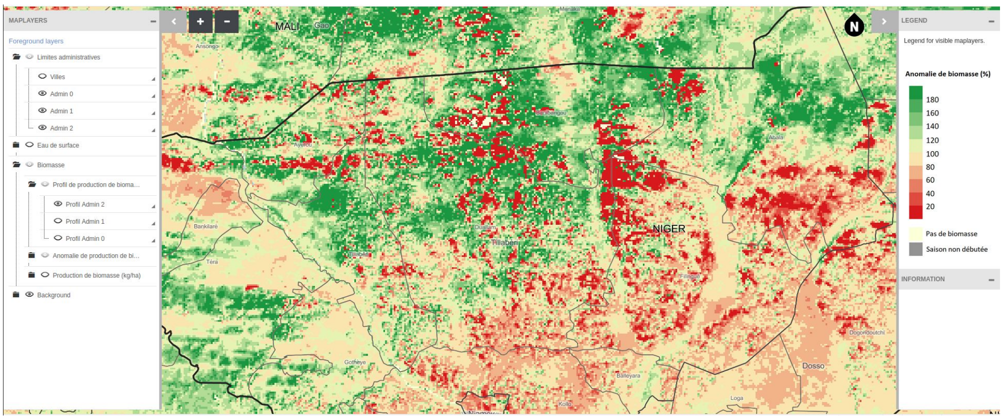


Figure 7: Biomass Anomaly map of Tilabery, Niger generated from Geosahel.Info

The biomass anomaly (the production of this year over the long-term average) has been used as a proxy for understanding pasture availability in the Sahel for decades. These analyses, typically produced by Action Contre la Faim (ACF), have been used to inform the HEA for a number of years on the situation of pasture availability. Unlike the data for cultivated surfaces, the biomass data do not have a direct relationship to the HEA OA Key Parameters in the same sense as the cultivated analyses do. Nonetheless, the inclusion of biomass is important for understanding the situation of pastoral zones which would be excluded by only focusing on agricultural production.

The Biomass profiles of the study areas were drawn from ACF's Biomass datasets. These data are created from the BIOGENERATOR algorithm and show the annual biomass production of the entire Sahel, expressed in Kilogrammes of Dry Matter per Hectare. More information on the BioGenerator and ACF's methodologies can be found by consulting Fillol and Bernard (2021) or instructional materials available on the www.sigsahel.info platform.

Within QGIS, a shapefile of the study areas was used to extract the biomass data for the administrative areas. This was then compared to the long-term average (1998-2021) to create the anomaly, presented as a percentage. It is also possible to reproduce this analysis using ACF's interactive platform, www.GeoSahel.info, which allows users to show temporal biomass production profiles for any administrative area in the Sahel.

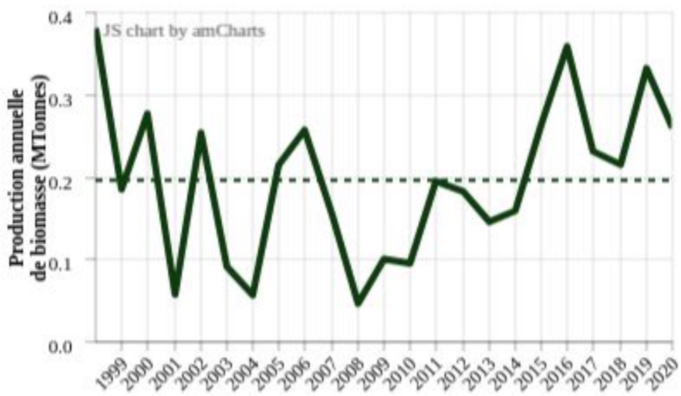


Figure 8: Annual Biomass Production in Bani Bangou, Niger

Overview of Remote Sensing and HEA

A wide range of remotely sensed data can be applied to food security contexts (See Annex 1 for more details). However, the range of pertinent data becomes far more restricted when looking at the specific context of HEA's OA Key Parameters (KPs). No remote sensing datasets can be directly plugged into a KP or used as a substitute for primary data. The specificity and asset-heavy focus of the KP does not allow for any direct substitution with environmental data (which is what remote sensing can typically offer to a food security analysis). What remote sensing can instead offer, are secondary datasets or proxy measurements to understand food insecurity in zones where field visits are not possible. The four key parameters of the HEA OA are listed below with an explanation of how remote sensing can fit within their analytical framework.

Crop Yield

Among all the OA Key Parameters, this is the only one that can be directly associated with a remote sensing dataset. In the case of this study, the Cultivated Surfaces dataset. These data cannot be used to estimate yields so cannot be used as a substitute for field data. However, they can show changes in cultivated surfaces compared to a reference year which can help provide experts with contextual information to understand potential changes in local food availability.

Livestock herd size

There is no remote sensing data that can substitute for this indicator. Satellite imagery cannot estimate herd sizes with confidence. Open source imagery is not available at the resolution needed to identify cattle. Even the prohibitively expensive Very High Resolution imagery does not have the coverage necessary to cover vast pastoral zones and the time needed to identify and count the cattle would not be possible within the scope of any reasonable project.

Even if the resource constraints could be overcome, it would be impossible to distinguish between sedentary and transhumant herds or to discern whether clusters of cattle were individual or grouped herds.

While counting cattle is not possible, understanding pastoralists' access to resources can be done through remote sensing. Pasture availability in particular, can be measured through widely available biomass data. While this does not translate into herd size, it can indicate whether or not sedentary herds are at a higher risk of animal mortality, or whether transhumant herds are likely to depart earlier.

Market Prices

Much like herd size, market prices cannot be directly substituted with remote sensing data. There is a large corpus of literature around modelling the relationship between cereal prices and meteorological data. However, it is not possible to model a direct relationship within the confines of the HEA. While a decrease in agricultural production (as indicated by the Cultivated Surfaces dataset) may reduce availability of locally produced cereals, it is not possible to model this as a price change without accounting for subsidies, external trade and market dynamics.

Other income sources

This key parameter is not a fixed indicator but rather a catch-all designed to account for diverse incomes of different livelihood zones. As a result, no specific remotely-sensed indicator can be applied to it.

Results- Abadam Cropland

Abadam		NG04		NG07		NG08		Abadam	
		Affected Pop	Zones	Affected Pop	Zones	Affected Pop	Zones	**Affected Pop**	**Zones**
No cultivation	NA	40%	52%	47%	46%	35%	67%	**42%**	**58%**
Total loss	0%	14%	5%	26%	23%	1%	6%	16%	7%
Severe loss	0 - 50%	4%	2%	3%	6%	8%	4%	**4%**	**3%**
Moderate loss	50 - 80%	5%	3%	7%	6%	2%	1%	**5%**	**3%**
No change	80 - 120%	19%	14%	17%	17%	31%	12%	**20%**	**13%**
Moderate increase	120 - 150%	12%	17%	1%	3%	10%	8%	**8%**	**12%**
Significant increase	>150 %	6%	6%	0%	0%	13%	1%	**5%**	**4%**

Table 3: Population and zones by fourchette and LHZ

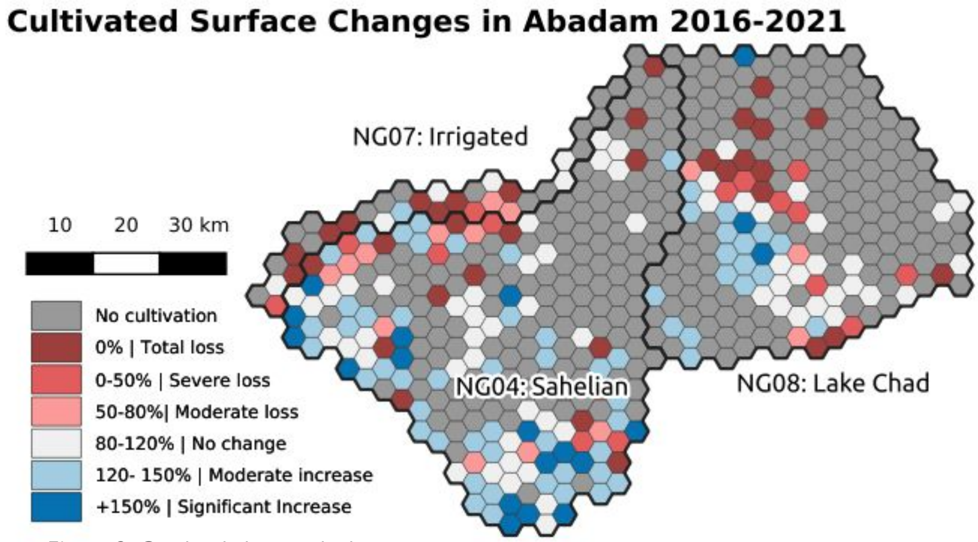


Figure 9: Cropland changes by hexagon

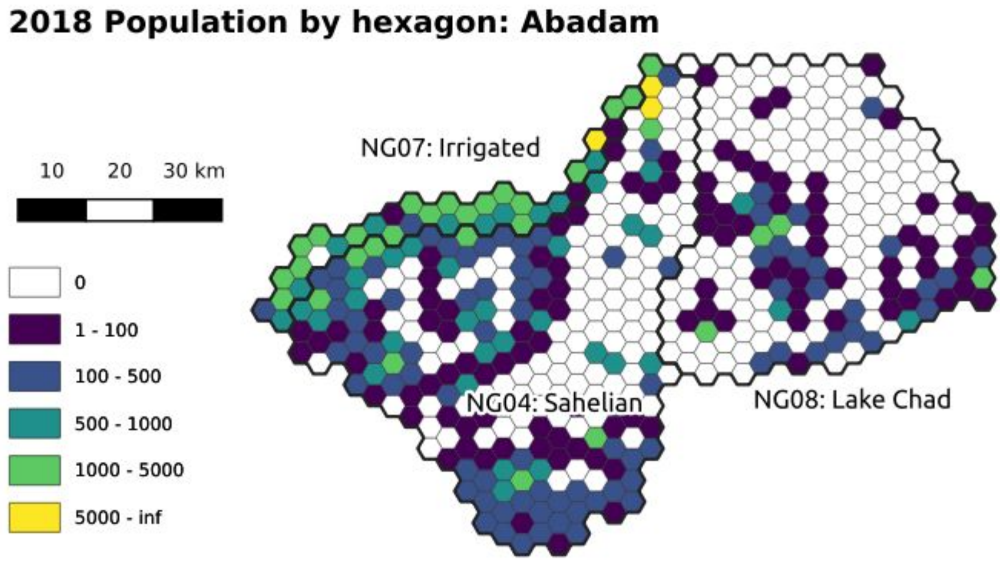


Figure 10 : Population by hexagon

Results- Abadam Cropland

An analysis of cropland changes from 2016-2021 shows mixed results with deterioration in the irrigated zones and relatively stable situations in the other two LHZ. However this deterioration is not uniform across the zone. Of the 212 zones containing cultivated surfaces (290 hexagons had no crop landcover whatsoever), 81 saw an increase in cropland since 2016, whereas 64 saw a loss. Among those 64 zones, 34 had a complete loss of all cropland. While at face value, this seems to indicate an improvement in food security outcomes, this is no longer the case when population is accounted for. Analyzing the hexagons by their population (see figure X), a much larger share of the population can be found in areas experiencing cropland losses. An estimated 25% of the population can be found in areas with cropland losses, and 16% of them are in areas with a total loss of cropland. Only 13% of the population lived in zones with increased cropland. 20% of the population lived in zones with stable/unchanging cultivated surfaces.

It is also worth noting that 42% of the population were found in zones with no cultivation whatsoever. For many, this indicates that they were unengaged in significant agricultural activities- this hypothesis is reasonable, considering the significant population concentration in the towns of Abadam and Mallam Fatori (around 22% of the population) and the significance of fishing and livestock herding in the area. That said, it is reasonable to assume that a number of the people living in zones with no cultivation are farmers who live a long distance from their fields, which is a common occurrence. Thus a number of people in the area may live in a different hexagon from their fields.

Since a majority (58%) of the zones are not cultivated at all, a different story is told when only looking at cultivated areas. The chart below (table 4) analyzes the data in the same way as table 3. However, non-cultivated areas are removed and only the zones, not the population are included. This is more suited to understanding agricultural changes. When this is taken into account, the proportion of total losses becomes considerably more substantial, at 16% across the entire LGA.

Abadam- Cultivated Zones Only					
	Change	NG04	NG07	NG08	**Abadam**
Total loss	0%	11%	42%	18%	**16%**
Severe loss	0 - 50%	5%	11%	12%	**8%**
Moderate loss	50 - 80%	7%	11%	4%	**7%**
No change	80 - 120%	29%	32%	36%	**32%**
Moderate increase	120 - 150%	35%	5%	25%	**29%**
Significant increase	>150 %	13%	0%	4%	**9%**

Table 4: Hexagons in each fourchette (non-cultivated areas removed)

Results- Abadam Cropland

Among the 3 LHZ in Abadam, the one with the most significant deterioration was NG07, the irrigated zone. Only a single hexagonal zone saw an increase in cropland since 2016. Whereas 34% of zones saw a decrease and 23% saw a total loss of all cropland. When looking only at cultivated areas in Table 4 the difference becomes even starker. **63% of those zones saw a loss in cropland and only 5% saw an increase.** Likewise, 36% of the population was found in areas with a decrease in cropland. It is important to note that as indicated in the methodology section, this analysis only covers rain-fed agriculture. Irrigated fields are usually not detected by the algorithm employed in this study. However they do represent an important livelihood contributor for this area.

In the other 2 LHZ the situation seems more stable. In NG04, the Sahelian zone, the portion of cultivated zones (again subtracting non-cultivated zones from the total) experiencing loss was lower than those showing an increase (23% to 48%), however the proportion of the population living in the areas with decreasing cropland was relatively smaller than those in areas of increased cultivation (11% to 23%).

In NG08, cultivated hexagonal zones showing an increase in cropland are roughly equal to those showing losses (34%-30%). Likewise, when population is taken into account,the proportion is roughly equal. However, it should be noted that **18% of these zones saw a total disappearance of cultivation.** That said, only 1% of the population was found to occupy these zones. While the situation is far from clear, the disappearance of nearly ⅕ cultivated zones indicates a deterioration in cultivation.

Key points for HEA Outcome Analysis

- Significant deterioration in NG07 significantly impacted at least 36% of the population in that LHZ.
- A somewhat stable situation in NG04, with more areas of cultivation increases than decreases.
- A less clear situation in NG08. Most likely a deterioration with a significant number of areas showing a total loss of cropland but a significant number of increases as well (nearly 30%).

Results- Abadam Biomass

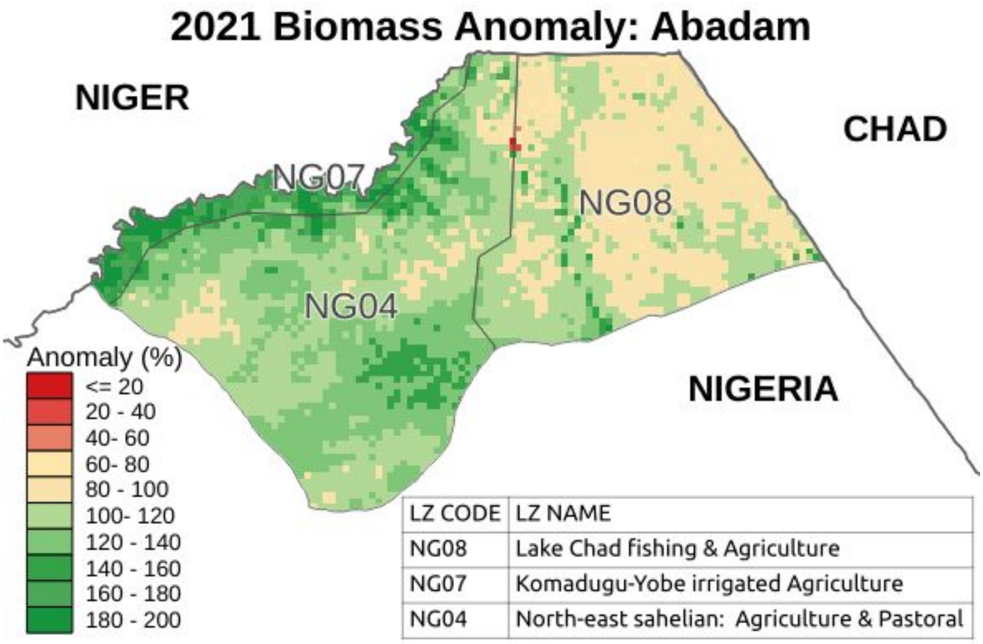


Figure 11: Biomass Anomaly Map of Abadam (calculated against average of 1998-2021)

Biomass conditions in Abadam are generally favorable, indicating positive pasture availability. The chart below, showing interannual biomass growth indicates that 2021 was favorable both compared to the reference year of 2016 and the long term average. Furthermore, an analysis of the biomass map indicates no significant pockets of deficit areas (normally coloured red), showing a favorable spatial distribution of biomass production across all livelihood zones. Significant positive anomalies can be found in the agro-pastoral zone (LHZ NG04) in the west of Abadam, indicating a positive situation for pasture.conditions seem positive and natural fodder shortages are unlikely to be a problem until the onset of the dry season. However, cattle conditions may deteriorate due to insecurity. Likewise, it is not possibly to gauge the accessibility of pastoral resources from satellite imagery alone.

Main HEA takeaway: While we cannot draw a direct relationship between herd size and pasture availability, it can be assumed that herds will not be affected by lack of pasture deficits before the lean season in Abadam as pasture seems abundant.

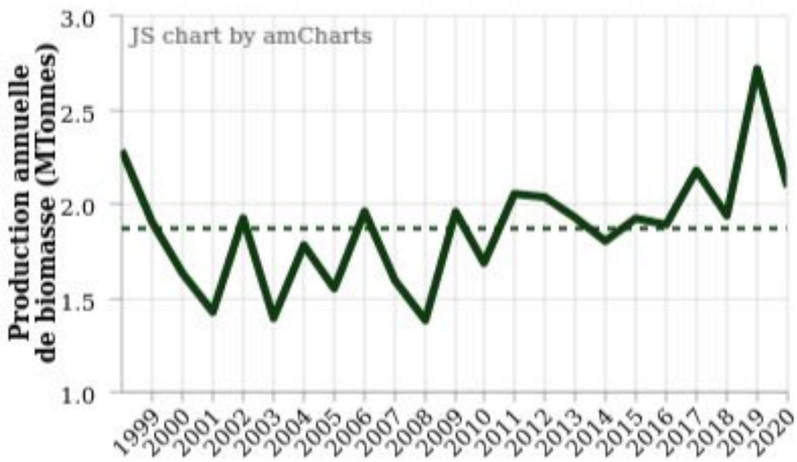


Figure 12: Annual Biomass Production of Abadam, Nigeria

Results- Magumeri Cropland

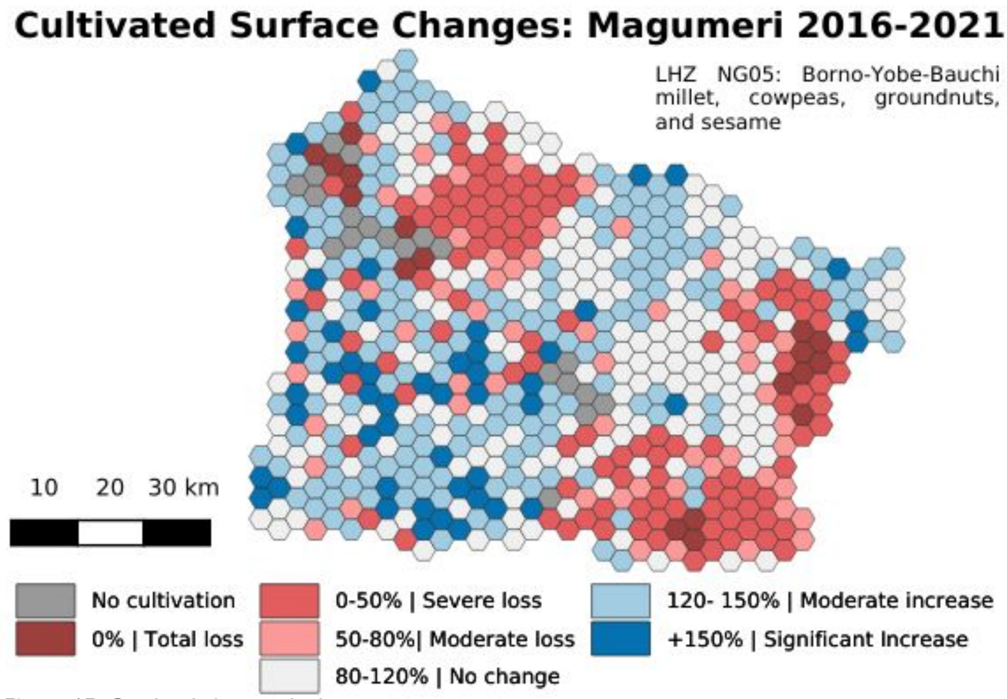


Figure 13: Cropland changes by hexagon

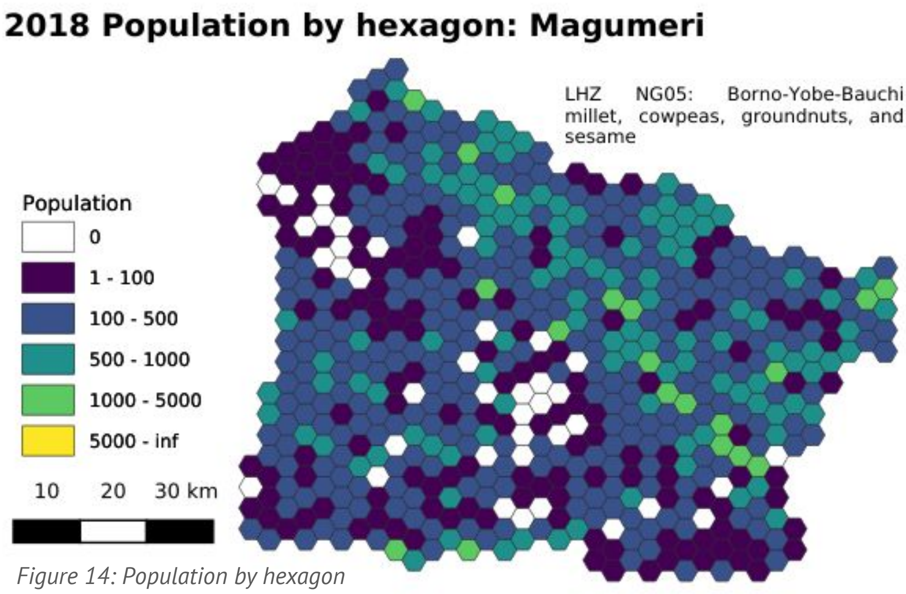


Figure 14: Population by hexagon

Fourchette	Change	Affected pop	Zones
No cultivation		0%	3%
Total loss	0%	**2%**	**3%**
Severe loss	0 - 50%	19%	19%
Moderate loss	50 - 80%	9%	10%
No change	80 - 120%	40%	28%
Moderate increase	120 - 150%	24%	29%
Significant increase	>150 %	6%	8%

Table 5: Population and zones by fourchette and LHZ

Results- Magumeri Cropland

An analysis of cropland changes from 2016 to 2012 in Magumeri shows a relatively stable picture, with pockets of noticeable declines in surface area. Unlike Abadam and Bani Bangou, Magumeri has only one LHZ, NG05 (Borno-Yobe-Bauchi millet, cowpeas, groundnuts, and sesame). Likewise, contrary to both other zones, Magumeri is considerably more agricultural as only 3% of zones (hexagons) were uncultivated. Because there are so few uncultivated areas in Magumeri, this study did not include a table only showing changes in cultivated areas (as was done for Abadam in table 4) - the percentage differences were not different when uncultivated areas were removed.

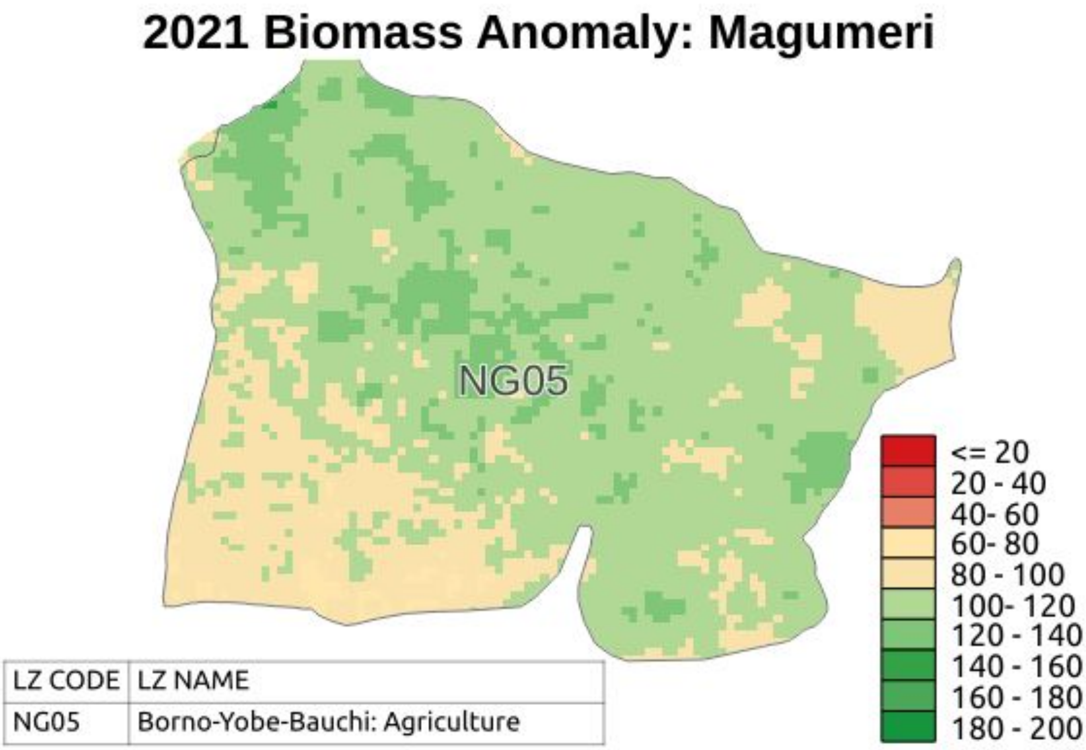
Importantly, **there were very few instances of total losses-** only 2% of the population could be found in areas experiencing a total loss of cultivated surfaces. The proportion of population in zones experiencing losses and increases is roughly equal (approximately 30% in each). **The largest population category ,at 40%, are those living in zones that saw no noticeable change** in cultivated surfaces between 2016 and 2021. When zones with no cultivation are removed from the analysis, the **proportion of zones experiencing growth is noticeably larger than those experiencing losses (roughly 40% to 30%).**

That said, Nearly ⅕ of the population (19%) were found in areas experiencing severe losses. A geographical concentration of zones experiencing these losses can be observed as occurring in 3 areas of Magumeri. 1) in the north near the border with Gubio LGA, 2) in the east surrounding the towns of Arari and Kuriari (this is also where the largest cluster of “total loss” areas can be observed) and 3) in the South-East corner of the LGA.

The reasons behind this clustering of losses should be investigated. An initial analysis of rainfall showed no relationship between rainfall patterns changes in cultivation from 2016 to 2021. It would be of interest to examine the locations of conflict incidences (from the ACLED dataset, for instance) to see if there is a relationship to the areas experiencing cropland losses.

Key Points for HEA Outcome Analysis

- 19% of the population in areas experiencing severe crop losses.
- The proportion of cultivated areas experiencing growth since 2016 was larger than those experiencing losses (40% to 30%).
- A noticeable geographical concentration of losses in 3 areas should be the subject of further investigation.



LZ CODE	LZ NAME
NG05	Borno-Yobe-Bauchi: Agriculture

Figure 15: Biomass Anomaly Map of Magumeri (calculated against average of 1998-2021)

Magumeri's livelihood zone is considerably more agricultural than pastoral. The entire LGA is contained within a single agricultural livelihood zone. As a result, the biomass data is less relevant for this zone. That said, biomass production during the 2021 rainy season was quite stable, with no visible major pockets of deficits in the area. Biomass production for this year exceeds both the long-term average and the 2016 reference year. While biomass is not lacking, it is not possible to determine how much of that biomass is accessible pasture (compared to enclosed areas or cropland).

Main HEA takeaway: With the caveat that a correlation cannot be drawn between herd size and pasture availability, we can make the assumption that any herds in Magumeri will not be affected by severe pasture deficits before the start of the lean season.

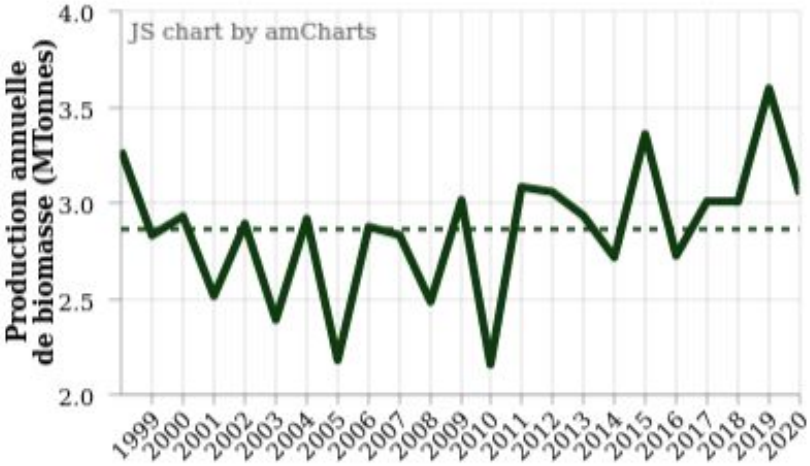


Figure 16: Annual Biomass Production of Abadam, Nigeria

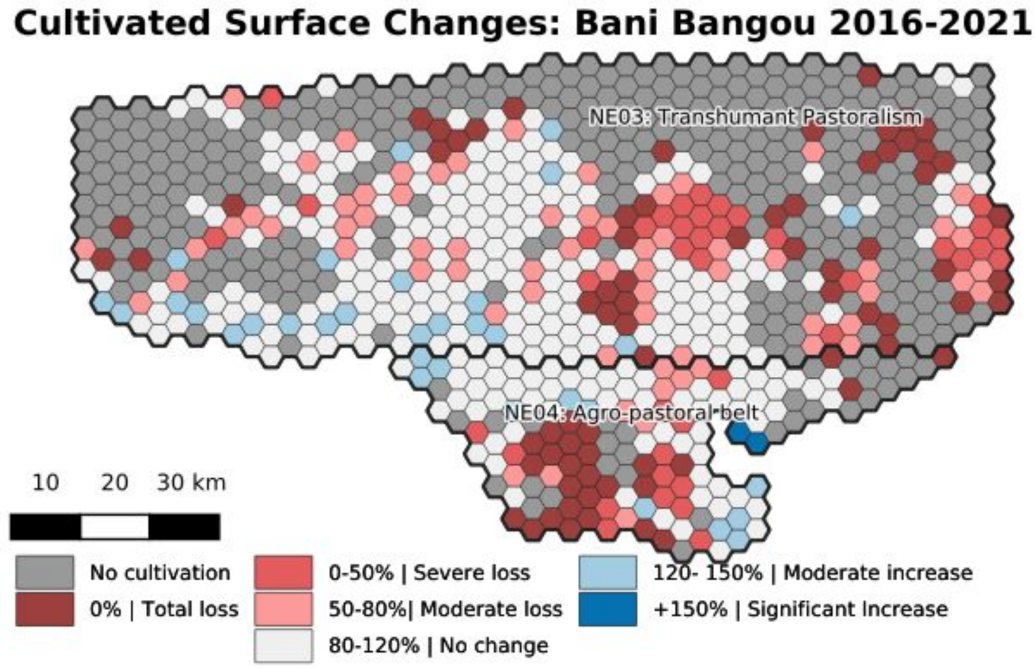


Figure 17: Cropland changes by hexagon

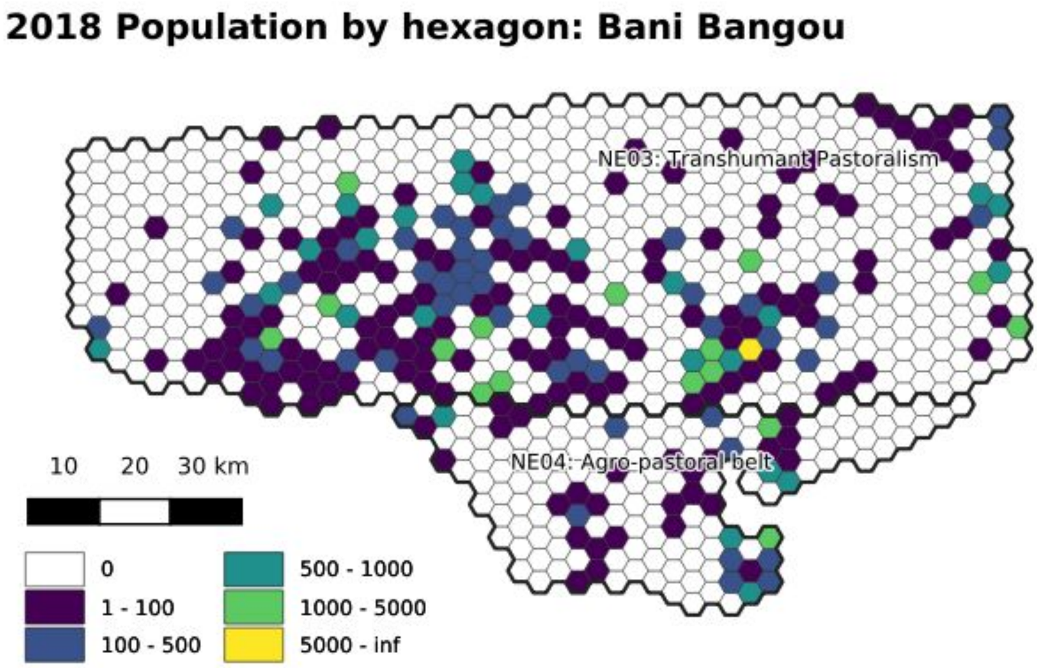


Figure 18: Population by hexagon

Bani Bangou	Change	NE03		NE04		Bani Bangou	
		Affected Pop	Zones	Affected Pop	Zones	**Affected Pop**	**Zones**
No cultivation		14%	46%	8%	20%	**14%**	**41%**
Total loss	0%	3%	7%	4%	17%	3%	9%
Severe loss	0 - 50%	5%	4%	1%	8%	**5%**	**5%**
Moderate loss	50 - 80%	12%	9%	4%	6%	**11%**	**8%**
No change	80 - 120%	56%	29%	55%	41%	**56%**	**32%**
Moderate increase	120 - 150%	9%	3%	27%	7%	**12%**	**4%**
Significant increase	>150 %	0%	0%	0%	1%	**0%**	**0%**

Table 6: Population and zones by fourchette and LHZ

Results- Bani Bangou Cropland

Bani Bangou Cultivated Zones Only				
	Change	NE03	NE04	**Bani Bangou**
Total loss	0%	14%	21%	**16%**
Severe loss	0 - 50%	8%	10%	**9%**
Moderate loss	50 - 80%	17%	7%	**14%**
No change	80 - 120%	55%	51%	**54%**
Moderate increase	120 - 150%	6%	9%	**7%**
Significant increase	>150 %	0%	2%	**0%**

Table 7: Hexagonal totals with non-cultivated areas subtracted

A deterioration in cultivated surface area can be observed in Bani Bangou between 2016 and 2021. Approximately 20% of the population can be found in areas experiencing a loss in cultivation and 40% of the cultivated zones have seen a loss since 2016. The situation was **somewhat stable for the majority of the population, as 56% lived in zones experiencing no noticeable change in cultivation** and 7% in areas showing a moderate increase in cultivation.

Since a large portion of the zones (41%) are not cultivated at all, a different story is told when only looking at cultivated areas. The chart below (table 7) analyzes the data in the same way as table 6. However, non-cultivated areas are removed and only the zones, not the population are included. This is more suited to understanding agricultural changes. More zones experienced losses than increases. When non-cultivated areas are excluded from the analysis, **nearly 40% of zones saw some kind of loss in cultivation and 16% of these areas saw a total loss in cultivation. Only 7% of zones saw any kind of increase in production.**

Of the 2 LHZ present in Bani Bangou, the Pastoral zone (NE03) and the Agro-Pastoral zone (NE04), the **losses are far more acute in the agro-pastoral zone, with 21% of the cultivated areas showing a total loss.** However in both NE03 and NE04, the total portion of zones experiencing a loss in cultivation is around 40%. A noticeable geographical concentration of the "total loss" zones can be observed as they are mostly clustered in the southern portion of NE04. An initial analysis of rainfall patterns detected no relationship between rainfall changes from 2016 to 2021 and changes in cultivated surfaces. It would be of interest to examine the locations of conflict incidences (from the ACLED dataset, for instance) to see if there is a relationship to the areas experiencing cropland losses.

Key Points for HEA Outcome Analysis

- Noticeable deterioration from 2016 as 40% of cultivated zones experienced a loss.
- 16% of cultivated zones saw a total loss of cultivation between 2016 and 2021
- 19% of the population were found in areas experiencing a loss in cultivated surface areas.

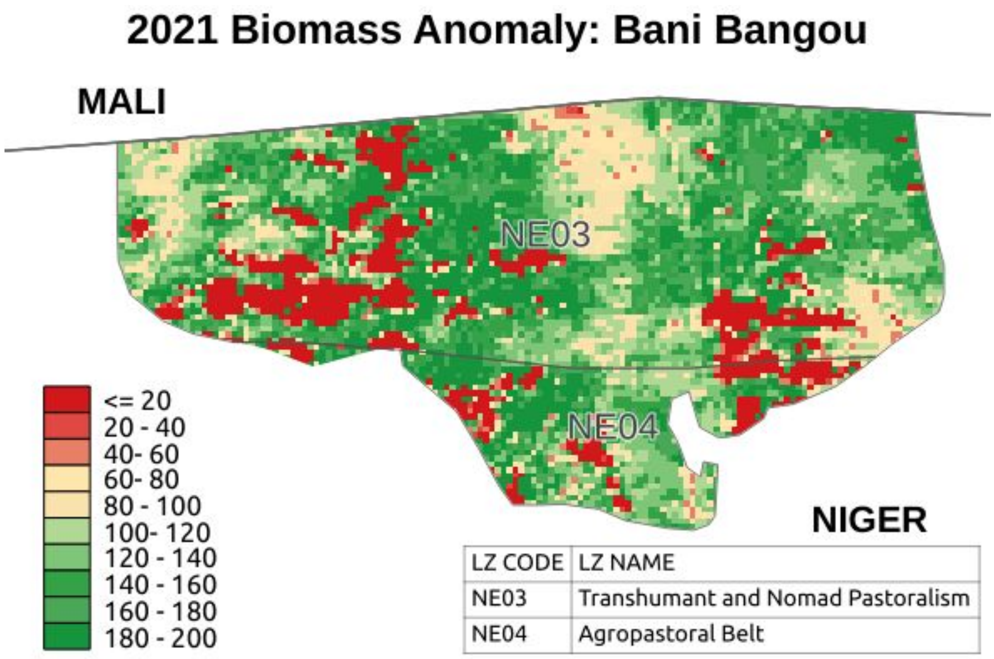


Figure 19: Annual Biomass Production of Abadam, Nigeria

Bani Bangou contains both a pastoral and agro-pastoral livelihood zone. The situation in both zones is mostly favorable as biomass production is in excess of the long term average (figure 20). It is inferior to the reference year of 2016, but it should be noted that 2016 recorded the highest biomass production since 1999. There are noticeable deficit pockets throughout both zones. However these pockets are immediately adjacent to areas of high production, indicating that herds should be able to easily move to areas of higher production. That said, unrestricted pastoral mobility will be necessary to move herds from deficit zones to areas of higher production. The ongoing insecurity in the area is likely to restrict pastoral movements and may deny herders access to areas of high productivity.

Main HEA takeaway: While it is not possible to estimate changes to herd size, herd dynamics should benefit positively from high biomass production. However, access to pastoral resources may be constrained by insecurity.

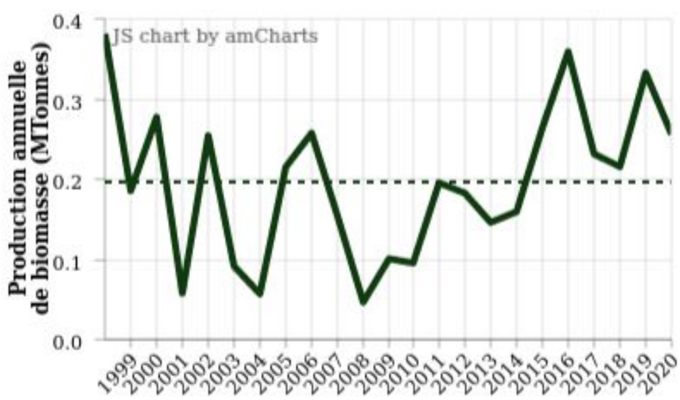


Figure 20: Annual Biomass Production of Abadam, Nigeria

Conclusion

This study offers a proof of concept for the use of remote sensing imagery to support HEA Outcome Analyses, especially in hard to reach areas. The use of biomass measurements and changes in cultivated surfaces offers HEA practitioners valuable contextual information for pastoral and agricultural conditions. Some main points for contextualizing this study are offered below:

Strengths

- This study offers a fully scalable, replicable methodology for visualizing potential food security outcomes through free and open-source data.
- Using population data allows for easily segmenting results into categories of “affected population” which is well-suited to the HEA toolkit.
- 2 levels of cropland analysis are offered, one that looks at the entire zone and another that subtracts non-cultivated areas (such as desert, wetlands or rangelands) from the analysis. The latter is helpful for understanding cropland changes in areas with significant non-agricultural land use.
- Employing hexagons as study units allows for modular areas of interest as hexagons can fit into any shape (LHZ, administrative boundary, etc) for future analyses of cropland changes.

Weaknesses/Limitations

- Satellite data can never replace reliable field data. Observing changes in cultivated surface from space may give a very general idea to conditions, however it cannot estimate agricultural yields since it cannot distinguish between crop types or provide information on the conditions of specific fields.
- The HEA OA Key Parameter for pastoral conditions is herd size. As a result, remote sensing cannot directly provide insights into herd size. The biomass indicator provided in this study may offer some contextual data but no direct information on herd sizes.

Opportunities for further research and scaleup:

- While it is possible to scale up this method to any area within the scope of HEA, local considerations must be taken into account such as seasonality, agricultural practices into any future study.
- In future studies, it would be beneficial to compare conflict occurrence data (notably from the ACLED dataset) against cropland changes to see a relationship between deteriorating cultivation could be the result of insecurity.
- The size of the hexagon/study unit may be changed for future studies. For this study, a small hexagon was chosen to provide high precision. However larger hexagons may reduce the time needed to perform the analysis/allow for larger areas to be studied. However it may lead to a reduction in data quality or precision.