ANALYSIS OF RECENT LOCUST INVASIONS ON NORTHERN KENYA'S RANGELANDS

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ABSTRACT

In the recent past, the Horn of Africa has witnessed an upsurge in desert locust invasions. In Kenya, the invasions raised major concerns over massive food insecurity, socioeconomic impact and livelihood loss caused by the recurring invasions. The aftermath of these infestations has been particularly detrimental to the pastoralist communities of Northern Kenya, who are reliant on rangelands for their livestock sustenance. This paper describes a study that was geared towards tracing desert locust movement patterns from 2020 to 2021 and determining the vegetation damage using remote sensing techniques; MODIS and Sentinel 2 imagery was used. The analysis therein utilized Google Earth Engine (GEE) to compute the Normalized Difference Vegetation Index (NDVI) for the counties studied. The NDVI values were used to assess vegetation cover changes that occurred throughout 2020 and early 2021 when northern Kenya was hit by its first and second wave of desert locust invasions. Using Turkana, Marsabit, Wajir, Mandera, as the study counties, the NDVI analysis indicated a general decline of vegetation before and after invasion. To establish a baseline for comparison, NDVI values from 2018, when climatic conditions closely resembled those of 2020, were used as a reference. The results demonstrate a clear correlation between locust invasion events and vegetation degradation, underscoring the substantial impact on grazing lands which are key to the livelihood of the pastoralists of northern Kenya. The study concludes that NDVI analysis is a scalable methodology for monitoring past desert locust invasions and the damage caused as a result. The study recommends the need for collective responsibility across bordering countries and increased surveillance in order to more effectively document future locust invasions and their effects.

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1.Introduction

The Desert locust(DL)is a migratory pest that causes significant damage with a character of changing habits and behavior when they aggregate in a group and this habit is catalyzed by different environmental factors (Shrestha,2021). Fluctuations in soil moisture, climatic conditions and semi arid areas receiving less than 200mm of annual rainfall provide a suitable habitat for their reproduction (Barasa *et. al*, 2023). Desert locusts have the ability to quickly reproduce and migrate to greener areas. A group of desert locust can fly a distance of 150km (Chen *et.al*, 2020). According to the United Nations Food and Agriculture Organization (FAO) a large swarm covering a square kilometer can consume 200 tons of vegetation in a day causing severe impacts and destroying vital vegetation cover (FAO, 2020-1). In recent years, Kenya has experienced a series of invasions caused by desert locusts, with the 2020 outbreak being the most severe and prolonged in decades. As a result, livestock production and associated products in the affected areas declined sharply, leading to increased food shortages, economic strain, and national panic over response strategies (Kimathi *et al*., 2020). This study seeks to delve deeper into understanding the damage caused in Northern Kenya on rangelands which led to food and financial insecurity and other related factors.

2.Problem statement

Locust invasions are great threat to food security and the country's economy: there is therefore need to study these invasions and to determine their effect on rangelands.

3. Objectives

3.1 General objective

To assess the damage caused by desert locusts on rangelands in Turkana, Marsabit, Wajir and Mandera in the period 2020 to 2021.

3.2 Specific objectives

- To map the locust swarm movement between 2020 and 2021.
- To assess the resulting damage on rangelands using NDVI analysis.
- To compare vegetation cover before and after invasion.

4.Literature review

The desert locust, Schistocerca gregaria, is the most destructive herbivory migratory pest in the world. It is highly mobile and feeds on large quantities of any kind of green vegetation, including crops, pasture and fodder. It is therefore a threat to agricultural production and has been associated with starvation in Africa and Western Asia for many years (Steedman, 1990).

Desert locusts were observed in larger swarms in Kenya after unusually heavy rains following a prolonged drought that occurred in March, April, and August. The large desert locust swarm coincides with the locust breeding reported between 2019 and 2020 in Eritrea, Somalia, and Yemen, which was attributed to unusually heavy rainfall after prolonged drought (UNEP, 2020). It has been reported that when there are heavy rains after a long period of drought, the soil becomes moist and supports a large quantity of lush vegetation, which is the perfect condition for the rapid breeding of desert locusts (Dong *et al*., 2023). The locusts begin to produce rapidly and become even more crowded together, leading to a lack of food, causing migration in search of food (Usman *et al*., 2022). Although it is widely believed that the same scenario is present in Northern Kenya, a large incidence of desert locust is believed to have come from elsewhere, especially along the dry horn of Africa, where reports of large swarms of desert locusts were reported earlier than in Kenya (Dong *et al*., 2023).

The scourge of desert locusts may be most effectively mitigated through an integrated strategy that includes element such as early warning and surveillance, community involvement, government preparedness and international collaboration. This study is related to the element of surveillance in which remote sensing and GIS have become invaluable tools for surveillance of locust movements, paving the way for targeted interventions such as ground spraying of the affected areas. (*Latuzkaite and Kimathi, 2024)*

5.Methodology

5.1 The study area

The study area for this research work involved 4 counties in Kenya, i.e., Turkana, Marsabit, Wajir and Mandera. The area of study is situated in Northern Kenya lying between latitudes 2°N and 5°N and longitudes 34°E and 42°E. This region was selected because it was the most affected by the waves of invasion in 2020 and 2021. The region shares a border with Ethiopia, Somalia and South Sudan which were entry points for the migratory DLs.

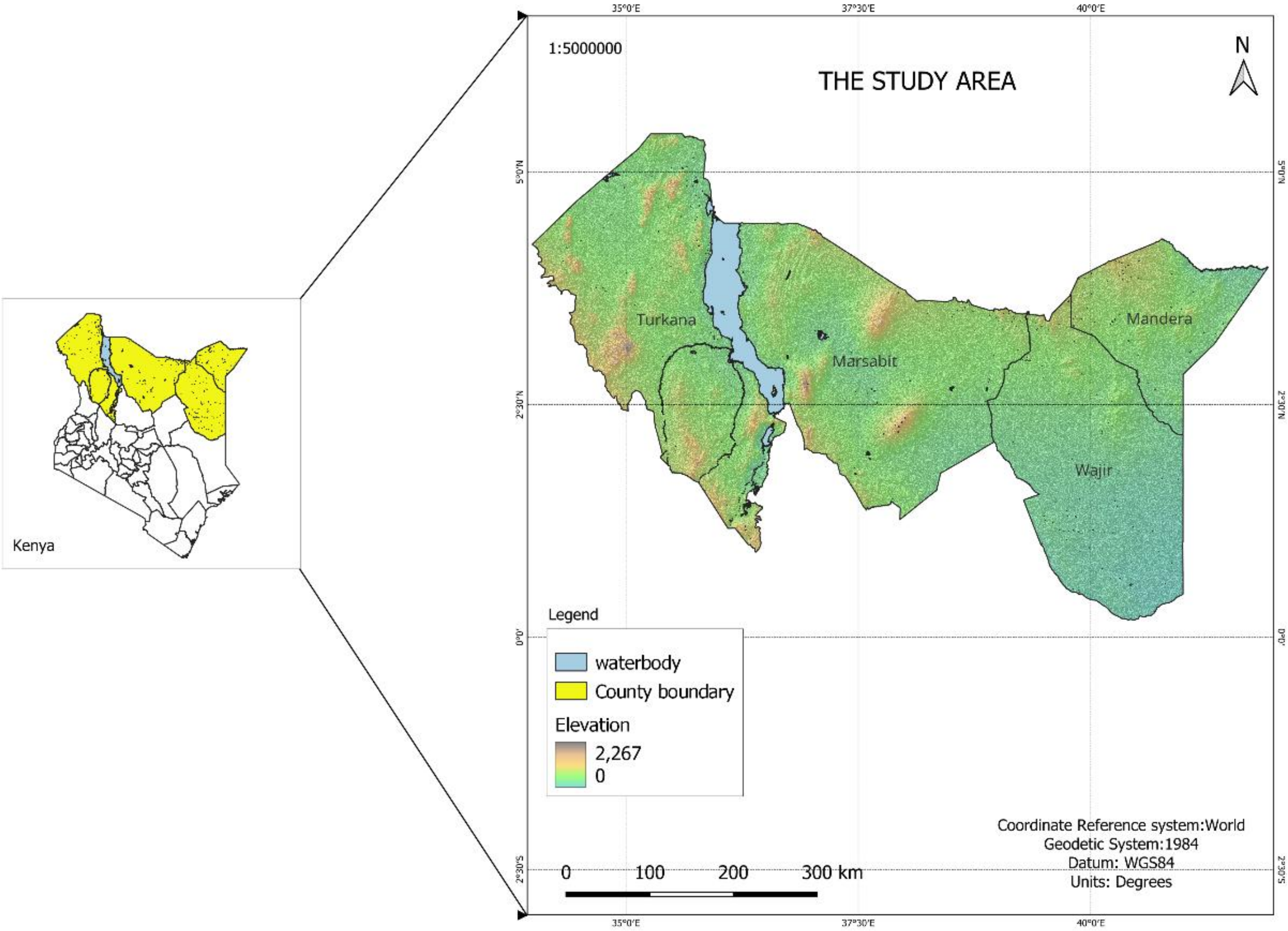

Figure 1: *A map showing the study area (Turkana, Marsabit, Wajir and Mandera)*

5.2Methodology overview

A summary for the methodology used for this study is shown in Figure 2.

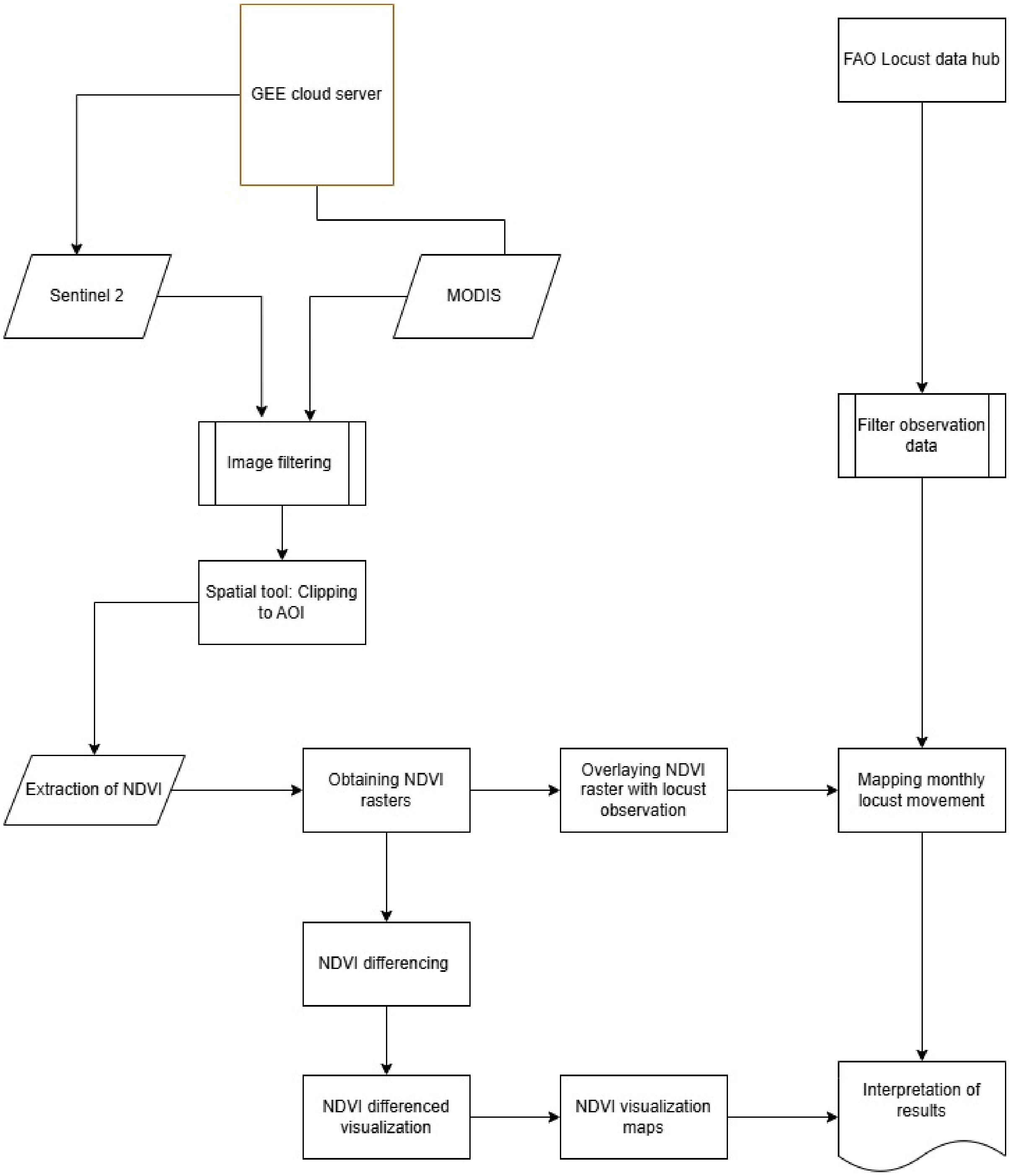

Fig 2: *Overview of methodology chart*

5.3Data acquisition

The data used to execute this project were obtained from multiple sources, as outlined in Table 1.

Table 1*:* *Data sources*

Data	Characteristics	Source
Desert locust observation data	CSV files	FAO website
Satellite imagery	Raster	Google earth engine
County boundaries	Shapefiles	IEBC

5.4 Data processing and Analysis

The data used in this project included Sentinel-2 imagery, MODIS imagery and DL occurrence data. Data processing was performed using Google Earth Engine. Google Earth Engine was also used to obtain satellite imagery because it is a powerful processor with high computational capabilities. Sentinel-2 images were chosen because of their high spatial resolution covering up to 10m by 10m. However, this was not used throughout the analysis. Sentinel-2 has a five-day revisit time and captures data across 13 spectral bands ranging from the visible to the shortwave infrared regions of the electromagnetic spectrum. Only band 4(red) and band 8 (near-infrared) were used to calculate NDVI which is a proxy for showing vegetation change over time. The image processing involved masking the images to remove cloud cover which would otherwise cause errors in the deduction of results.

For this study, MODIS Terra data was also used, which offers 16-day composites at a 250-meter resolution. The use of MODIS data enabled the tracking of vegetation trends and anomalies over longer time frames, complementing the finer-scale but less frequent Sentinel-2 observations. This was particularly useful in understanding the progression and recovery of vegetation in response to locust invasions across the four counties in Northern Kenya. The supplementation of this was because Sentinel-2 gave data gaps when it came to calculating daily mean NDVI values necessary for this study. The study provided a thorough understanding of locust impacts on pastoral landscapes by combining Sentinel-2 and MODIS data, which allowed it to capture both the smaller spatial details and the larger temporal patterns of vegetation change.

The data about desert locust observation was obtained from the FAO DL hub website. The data consisted of bands, swarms, hoppers and adults. For this particular study, only adult DLs were used since they cause severe damage as compared to their other stages of development.

For this project, NDVI was computed during peak seasons for a particular county in 2020. NDVI, which is an indicator of vegetation greenness was used and is usually computed as;

NDVI = NIR-RED/ NIR+ RED

Its values ranges from -1 to 1 with values close to 0 indicating rocks and bare soil, negative values indicating water and clouds, sparse vegetation consisting of shrubs and grassland are indicated by values 0.2 – 0.3 and values above 0.4 indicating healthy vegetation.

NDVI rasters were generated and these were overlaid with locust occurrence observations for each county studied. The resulting maps would then show the DLs movement over different regions and the resulting change in vegetation monthly.

6. Results

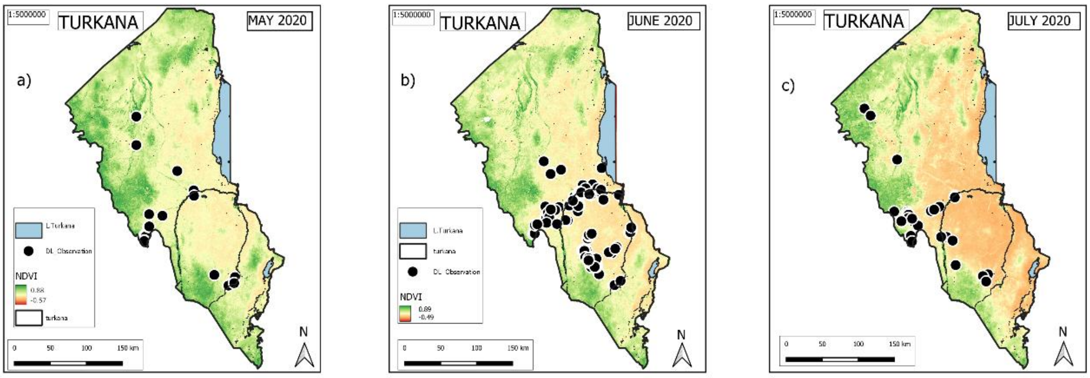

Fig 3: Turkana county; desert locust observation in the month of a) May, b) June and c) July

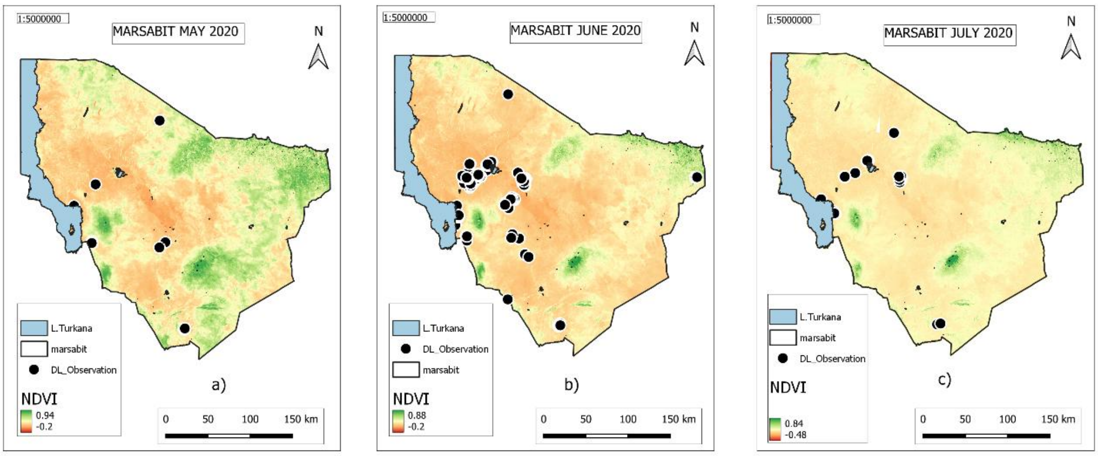

Fig 4: Mandera county; desert locust observation in the month of a) May, b) June and c) July 2020

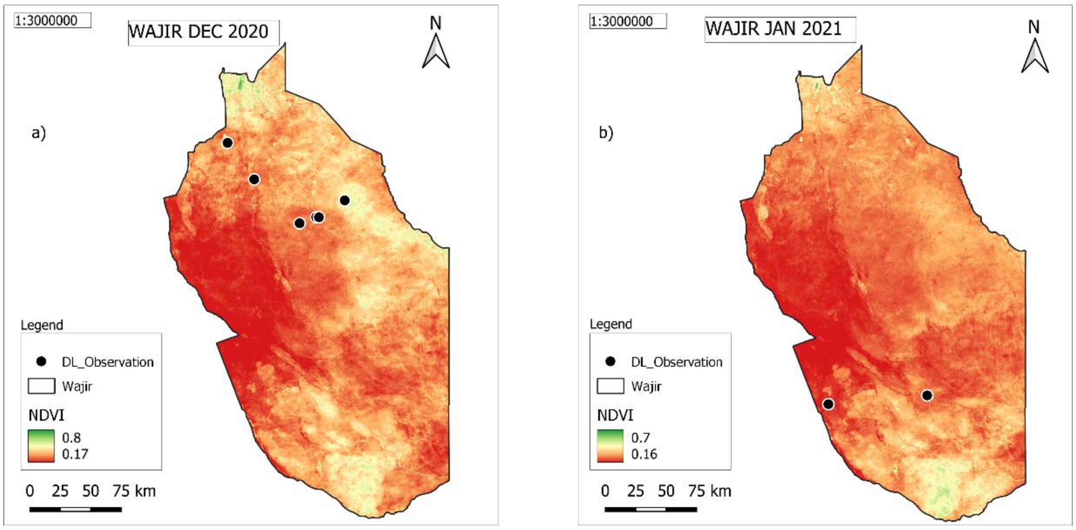

Fig 5: Wajir county ; desert locust observation in a) Dec 2020 and b) January 2021

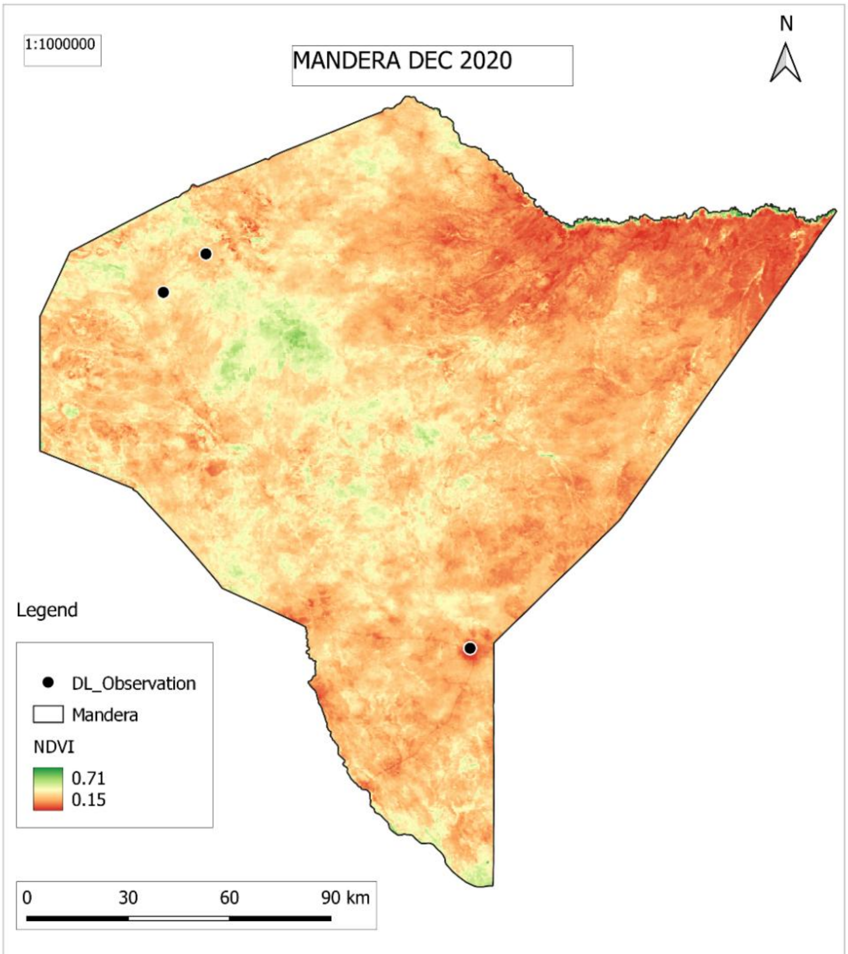

Fig 6: Desert Locust observation in Mandera county in December 2020

The maps above show desert locust movements across the counties when it was worst hit. Turkana and Marsabit were worst hit in May, June and July of 2020. Wajir was worst hit in December 2020 and January 2021. Mandera was hit in December 2020.

NDVI VALUE TRENDS

In **Turkana**, May generally showed some degree of greenness as compared to the following months, June and July. The NDVI values ranged from highest 0.4 to lowest 0.2. In June however, the lowest value recorded was a 0.05 with massive dips in the NDVI values. In July, the same trend was observed. Its highest NDVI value being 0.4 and lowest at 0.03.

In **Marsabit**, May experienced a general greenness compared to the month of June. Its highest recorded NDVI value was 0.4. In June the lowest NDVI recorded value was -0.02.

In **Wajir**, December 2020, the lowest recorded values were 0.05 at the beginning of the second week and the third week. January 2021, the county experienced a sharp decline of NDVI values in the beginning of the last week.

In **Mandera** County at the end of the first week in December 2020, there was a comparable drop, followed by a partial recovery and a further dip in the third week. Prior to a sharp and abrupt drop at the start of the third week.

NDVI change

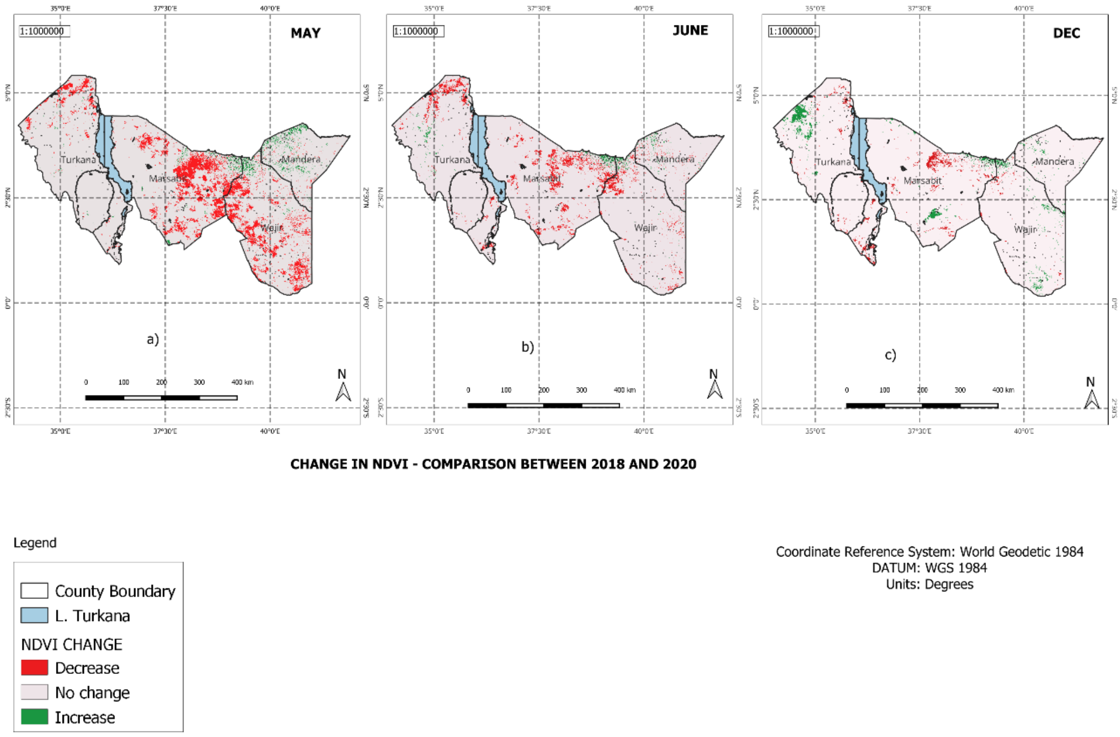

Fig 7: Comparison of vegetation loss between 2018 and 2020 in the months of May, June and December.

7. Discussions

The NDVI difference maps have shown that the impacted counties were experiencing widespread vegetative stress and showing the noticeable declines. These regions were also identified as major DL swarm hotspots during the 2020 invasion, demonstrating the correlation between vegetation analysis conducted using satellite imagery and on-the-ground observations.

This study demonstrated the use of satellite imagery as a reliable source for analysis of vegetation cover. Satellite imagery is subject to cloud cover which can make analysis difficult. Initially sentinel 2 imagery was used but it showed gaps in certain regions from the months of May, June, July and September. For this reason MODIS was switched to making the data more reliable and suitable for use.

8. Conclusions and Recommendations

8.1 Conclusions

The objectives of this study have been achieved and it is concluded as follows:

- The study has effectively tracked temporal and spatial patterns of locust swarms.
- There was large-scale vegetation damage due to DL invasion posing a significant threat to rangelands.
- There was a detectable change in NDVI before and during invasion.

8.2 Recommendations

From this study, it is recommended that:

- There's a need to establish a real-time desert locust monitoring system using satellite data and reports.
- The country can implement a regular NDVI-based rangeland monitoring to identify areas most impacted by invasions and to plan for post-invasion recovery.

9. References

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