

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 resulting vegetation damage using remote sensing techniques; MODIS and Sentinel 2 imagery were 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 and 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 suggest a 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.

Keywords

Desert Locust, Rangelands, Northern Kenya

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 [1]. Fluctuations in soil moisture, climatic conditions and semi-arid areas receiving less than 200 mm of annual rainfall provide a suitable habitat for their reproduction [2]. 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 [3]. The locusts begin to reproduce rapidly and become even more crowded together, leading to a lack of food, causing migration in search of food elsewhere [4]. Desert locusts have the ability to quickly reproduce and migrate to greener areas. A group of desert locust can fly a distance of 150 km [5]. 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 [6]. It is therefore a threat to agricultural production and has been associated with starvation in Africa and Western Asia for many years [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 [7]. Desert locusts were observed in large 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 [4]. 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 [8].

2. Methodology

2.1. The Study Area

The study area for this research work consisted of 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, as shown in **Figure 1**. 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 desert locusts.

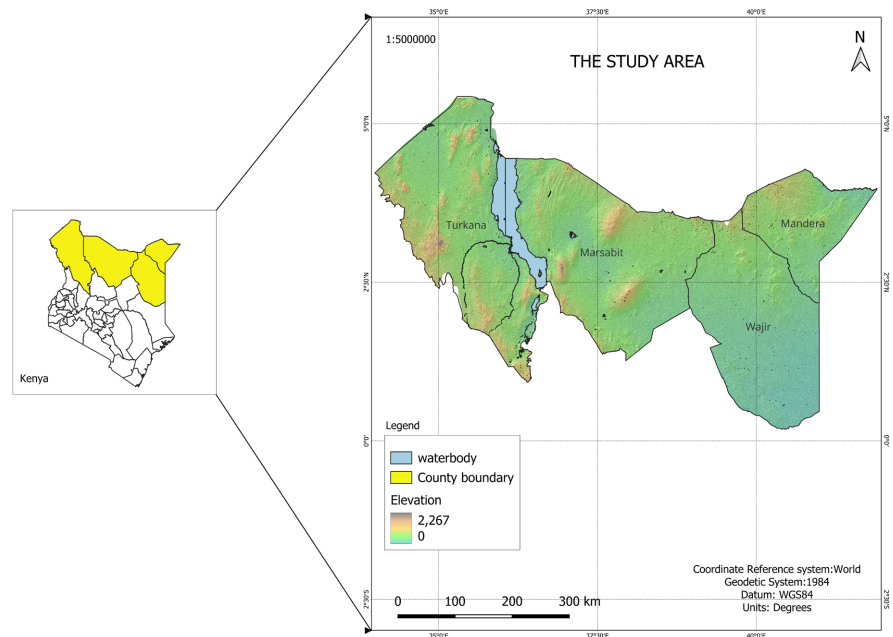


Figure 1. A map showing the study area (Turkana, Marsabit, Wajir and Mandera Counties).

2.2. Methodology Overview

The methodology used was summarized in **Figure 2**.

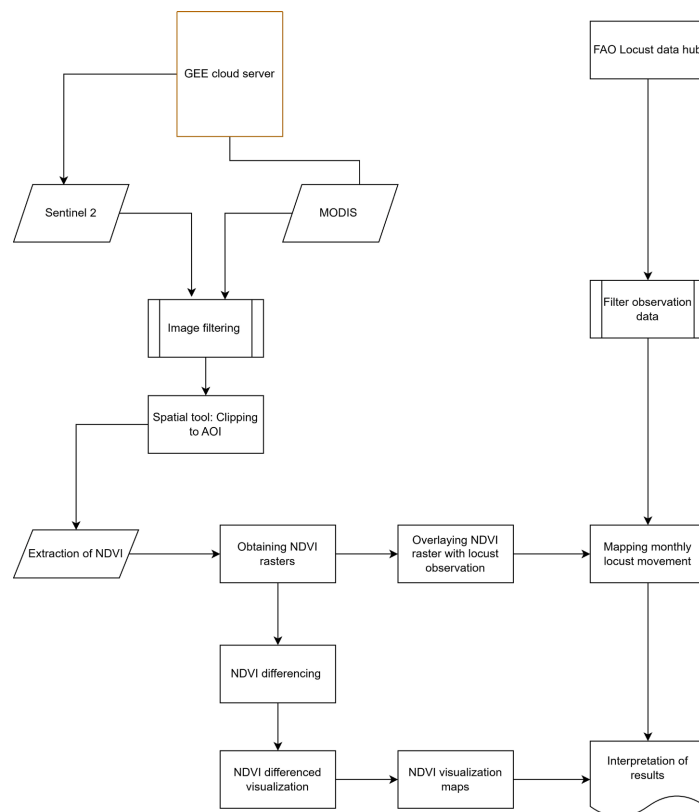


Figure 2. Methodology flow-chart (after [9]).

3. Data 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

3.1. 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 were 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. Direct pixel-level comparison between the datasets was not done since Sentinel-2 and MODIS imagery had differing spatial resolutions. Rather, mean NDVI statistics were used to aggregate NDVI measurements at the county level so that vegetation conditions throughout the study counties could be compared over time. The study provided a good 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 observations was obtained from the FAO DL hub database, which covered the period from the year 1985 to 2021. The original dataset consisted of bands, swarms, hoppers and adults. For this particular study, only adult DLs were used because they are highly mobile and cause severe vegetation damage across large areas as compared to their other stages of development. The desert locust observations were first grouped by year necessary for this study,

2020 and 2021, and then categorized monthly. The observations were further filtered spatially to retain records for the study counties of Turkana, Wajir, Garissa and Mandera. The filtered observations were subsequently overlaid on NDVI maps to examine the spatial and temporal relationship between locust occurrence and vegetation greenness across the counties studied.

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

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Its values range 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 desert locust movement over different regions and the resulting change in vegetation monthly [2]. In this paper, vegetation damage is defined as a significant decline in NDVI values between the periods before invasion and after invasion. Monthly mean NDVI was used to assess vegetation condition and compare temporal changes.

The year 2018, prior to the desert locust invasion, was selected as a baseline reference because rainfall and seasonal vegetation condition across the study counties were comparable to those observed in 2020. This was based on CHIRPS rainfall data patterns.

3.2. Results

The maps in **Figures 3-6** show desert locust movements across the counties when it was worst hit. Turkana and Marsabit were the worst hit in May, June and July of 2020. Wajir was the worst hit in December 2020 and January 2021. Mandera was hit in December 2020.

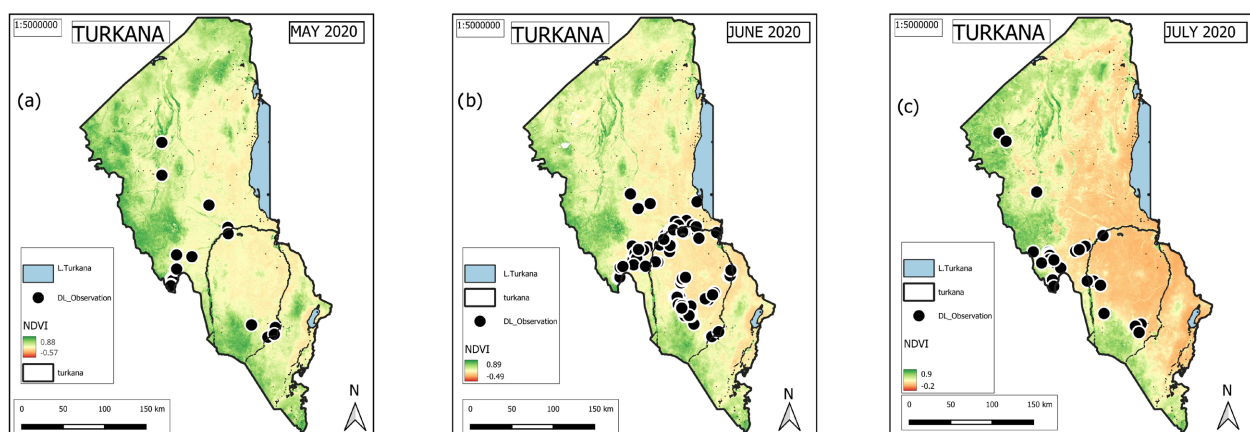


Figure 3. Turkana County; desert locust observation in the months of (a) May, (b) June and (c) July.

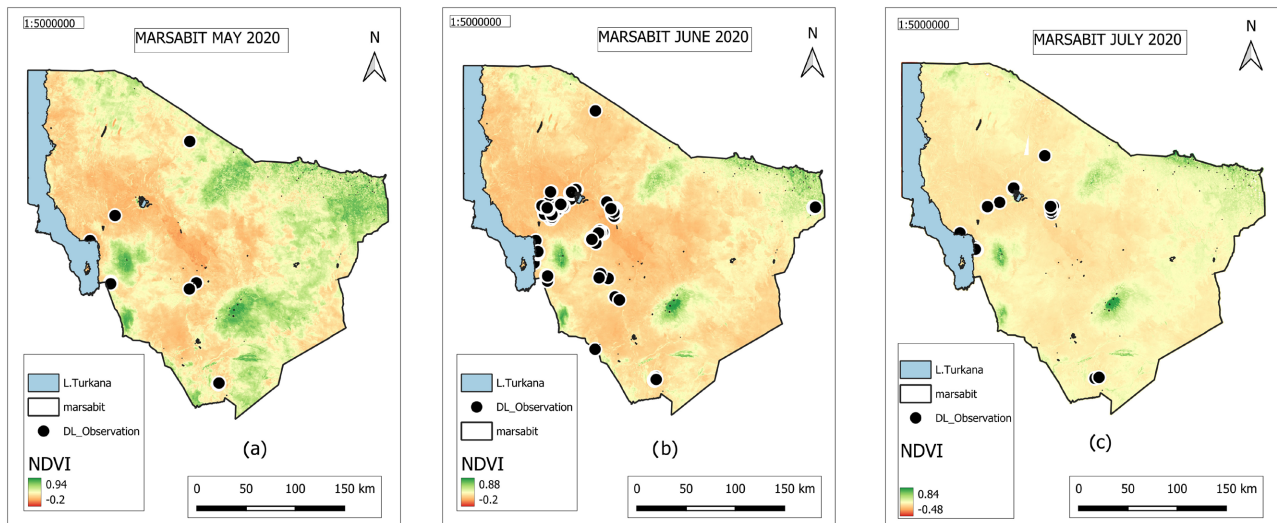


Figure 4. Mandera County; desert locust observation in the month of (a) May, (b) June and (c) July.

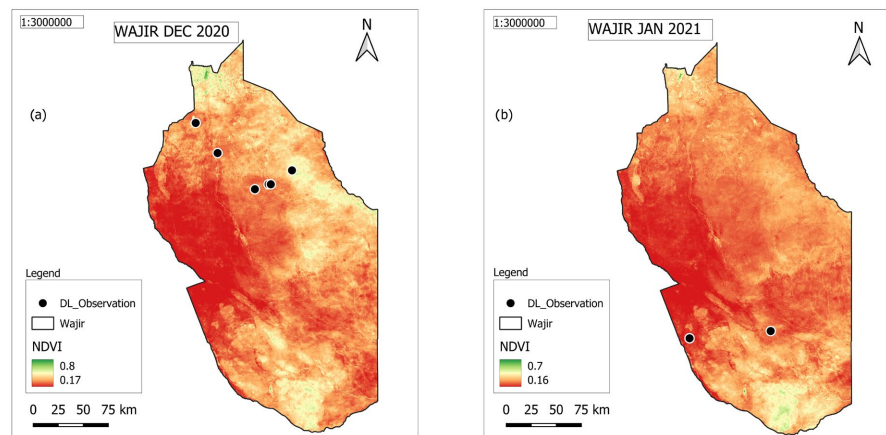


Figure 5. Wajir County; desert locust observation in (a) December 2020 and (b) January 2021.

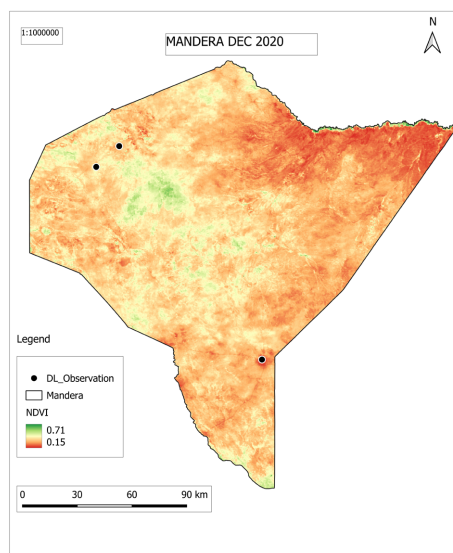


Figure 6. Desert locust observation in Mandera County in December 2020.

NDVI VALUE TRENDS

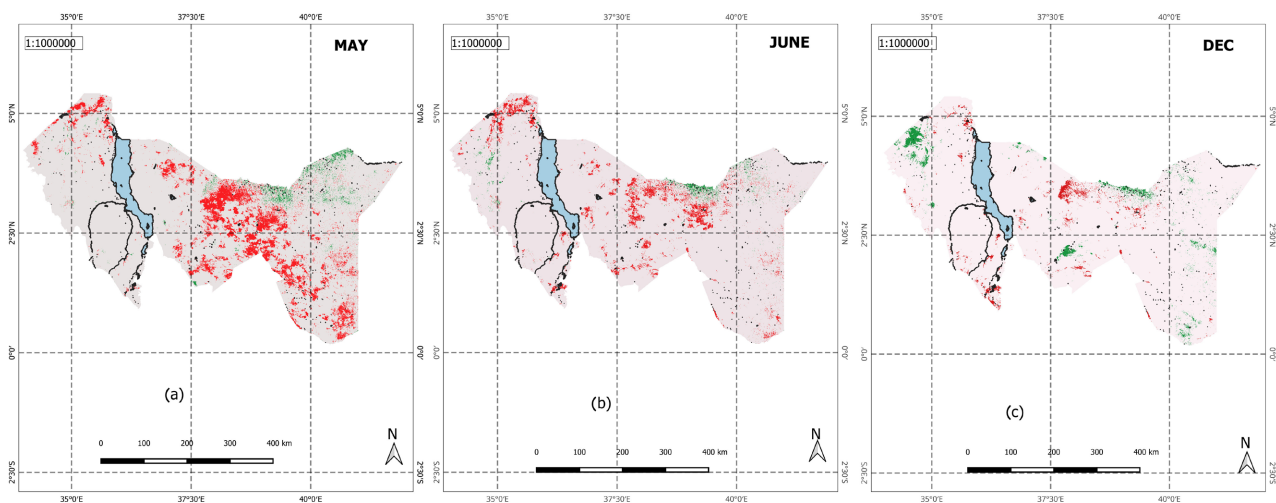
In Turkana, May generally showed some degree of greenness as compared to the following months, June and July. The NDVI values ranged from highest 0.4 to lowest 0.2. In June, however, the lowest value recorded was a 0.05 with massive dips in the NDVI values. In July, the same trend was observed. Its highest 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. In January 2021, the county experienced a sharp decline of NDVI values in the beginning of the last week.

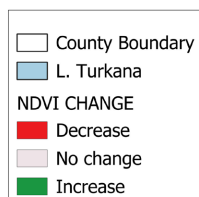
In Mandera County at the end of the first week in December 2020, there was a comparable drop, followed by a partial recovery and a further dip in the third week, prior to a sharp and abrupt drop at the start of the third week. These NDVI change trends are illustrated in **Figure 7**.

NDVI CHANGE



CHANGE IN NDVI - COMPARISON BETWEEN 2018 AND 2020

Legend



Coordinate Reference System: World Geodetic 1984
DATUM: WGS 1984
Units: Degrees

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

3.3. Discussions

The NDVI difference maps have shown that the impacted counties were experi-

encing widespread vegetative stress and showing the noticeable declines. These regions were also identified as major desert locust swarm hotspots during the 2020 invasion, demonstrating the correlation between the 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.

4. Limitation of the Study

Although declines in NDVI values coincided with the period in which locust invasion occurred, it is important to note out that vegetation greenness can also be influenced by other factors such as rainfall variability, temperature, seasonal vegetation cycles, grazing and other land use activities. Therefore, the observed NDVI declines should be viewed and interpreted as an indication of vegetation stress potentially associated with all other factors rather than solely attributed to the presence of desert locusts.

5. Conclusion

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

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Steedman, A. (1990) Locust Handbook. Natural Resources Institute, 204 p.
<https://www.scirp.org/reference/referencespapers?referenceid=3924782>
- [2] Barasa, B., Watsusi, C.W., Gudoyi, P.M., Lutaaya, N., Gumisiriza, L.T. and Magaya, J.P. (2023) Desert Locust Invasion in Uganda: Effects on Household Food Consumption and Effective Control Interventions. *Sustainability*, **15**, Article 14496.
<https://doi.org/10.3390/su151914496>
- [3] Dong, Y., Zhao, L. and Huang, W. (2023) Monitoring of Desert Locust in Africa and Asia. Springer. <https://doi.org/10.1007/978-981-19-7238-6>
- [4] Usman, M., Ijaz, M., Aziz, M., Hassan, M., Ahmed, A.M., Soomro, D.M. and Ali, S. (2022) Locust Attack: Managing and Control Strategies by the Government of Pakistan: A Review on Locust Attack in Pakistan. *Proceedings of the Pakistan Academy of Sciences. B. Life and Environmental Sciences*, **59**, 25-33.
[https://doi.org/10.53560/ppasb\(59-2\)718](https://doi.org/10.53560/ppasb(59-2)718)
- [5] Chen, C., Qian, J., Chen, X., Hu, Z., Sun, J., Wei, S. and Xu, K. (2020) Geographic Distribution of Desert Locusts in Africa, Asia and Europe Using Multiple Sources of Remote-Sensing Data. *Remote Sensing*, **12**, Article 3593.

<https://doi.org/10.3390/rs12213593>

- [6] Kimathi, E., Tonnang, H.E.Z., Subramanian, S., Cressman, K., Abdel-Rahman, E.M., Tesfayohannes, M., et al. (2020) Prediction of Breeding Regions for the Desert Locust *Schistocerca Gregaria* in East Africa. *Scientific Reports*, **10**, Article No. 11937. <https://doi.org/10.1038/s41598-020-68895-2>
- [7] Lazutkaite, E. and Kimathi, E. (2024) From Crisis to Innovation: Learning from the Previous Desert Locust Invasions. <https://www.icpac.net/news/from-crisis-to-innovation-learning-from-the-previous-desert-locust-invasions/>
- [8] Shrestha, S., Thakur, G., Gautam, J., Acharya, N., Pandey, M. and Shrestha, J. (2021) Desert Locust and Its Management in Nepal: A Review. *Journal of Agriculture and Natural Resources*, **4**, 1-28. <https://doi.org/10.3126/janr.v4i1.33197>
- [9] Bett, C. (2025) Analysis of Desert Locust Invasions on Rangelands in Northern Kenya's Project Report. Department of Geospatial and Space Technology, University of Nairobi, 32 p.