World Journal of Research and Review (WJRR)
ISSN: 2455-3956, Volume-17, Issue-1, July 2023 Pages 01-07

The Effect of Insurgency on the Spatial Landscape of North Eastern Nigeria

Aliyu Mustapha, Mansir Aminu, Ihenacho Nnaemeka M., Imhanfidon Justin, Muhammad Bala A., David Ebunu, Ezeanya Princess, Oluyomi Olubunmi, Okwenna Nkeiruka, Umar T. Kura

***Abstract*— The insurgency in the northeastern Nigeria has adversely affected land uses and land covers in the area. The aim of this research is to evaluate land uses and land covers variations caused by over a decade insurgency in the North Eastern part of Nigeria. Landsat ETM+, Landsat 8 and sentinel-2 imageries acquired in 2008, 2014 and 2020, were used for the study. Pixel-based supervised classification using maximum likelihood algorithm was utilized. Eight land cover classes that include bare surface, wetland, water body, urban, tree cover, grassland, cropland and scrubs cover were identified for classification. The classification accuracy for the three temporal periods were evaluated from the Error matrix of the classified images with an overall accuracy of 75.8%, 80.2% and 84.1% respectively. The classification accuracy results yielded Overall accuracy of 75.8% 80.2% and 84.1% for 2008, 2014 and 2020 images respectively. The quantitative analysis of changes expressed in land area coverage reveals a significant change in the land uses and the land covers. The built up area was 197.87km^2 in 2008. It increased to 231.28km^2 in 2014 and to 588.57km^2 in 2020. This reveals continuous increase from 0.114% of the total area in 2008 to 0.134% in 2014 and 0.342% in 2020. The area put to crop farming was 105,867.4km^2 in 2008, which was 61.11% of the total area. It increased to 108,192.10km^{2,} i.e. 62.85% in 2014, but later decreased in 2020 to 91,478.77km^2, which is 53.14% of the total area. This shows that there was decrease in agricultural activities in the area in 2020. The natural vegetation cover, which includes grassland, shrubs and tree covers, were 37,808.65km^2, 16,867km^2, and 7,041.59km^2 respectively in 2008. These represented 21.82%, 9.736% and 4.065% of the total area respectively. The shrubs increased to 16,866.6km^2 in 2014, which was 9.798%, and to 16,978.07km^2 in 2020 i.e. 9.863% of the total area, while grassland reduced to 35,493.28km^2 i.e. 20.62% and 28,145.49km^2 i.e. 4.055% respectively. The tree cover vegetation in the area reduced to 6,980.07km^2 i.e. 4.055% of the total area in 2014. Meanwhile, it raised high to 25,526.17km^2 i.e. 14.83% in 2020. This findings reveal that the total natural vegetation in the area i.e. grassland, shrubs and tree covers, that was 35.625% in 2008, reduced to 34.471 in 2014. Interestingly, it rose to 41.041% of the total area in 2020. Bare surfaces was 1,099.00km^2 i.e. 0.634% of the total in 2008, but reduced to 1,243.30km^2 (0.722%) in 2014 and 5,976.64km^2, which was 3.472% of the total area in 2020. It has been obtained from this study that the area put to cultivation, rose to 62.85% of the study area in 2014, but later decreased in 2020 to 53.14%. This revealed that there was decrease in crop cultivation in that period hence goal two of the SDGs, which is to ensure food security, was threatened in that year.**

***Index Terms*— Landscape, Insurgency, land use land cover and Pixel-based classification.**

Aliyu Mustapha, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Mansir Aminu, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Ihenacho Nnaemeka, M. Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Imhanfidon O. Justin, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Egbunu David, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Muhammad, Bala A, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Enzeanya Princess, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Oluyomi Olubunmi, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Okwenna Nkeiruka, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria
Umar T. Kura, Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria

I. INTRODUCTION

National security is the state of the capability of a nation to overcome the multi-dimensional threats to the apparent well-being of its people and its survival as a state at any given time, by balancing all instruments of state policy through governance (Paleri, 2008). National security threat can be said to be anything, be it substantial or otherwise that threatens the physical well-being of the population or jeopardizes the stability of a nation's economy or institutions (Eastern Kentucky University, 2021). Every nation faces one threats or another. These threats can come in form of aggression from a neighboring country, infiltration from a terrorist group or global economic trends that compromise the nation's welfare. Certainly, threat of any kind, challenges a nation's power and disrupts its well-being.

Nigeria, being the most populous black nation on earth, issues as regards insecurity is bound to arise (Oluwadiya, 2012). Since the transition of Nigeria from military to democratic rule in May 1999, various governments have failed in its responsibility to ensure the security of its citizens (Iregbenu and Chinecherem, 2015) which has gradually undercut any hope for the sustainable development, stability and peace of the nation (Aleyomi 2020). This is characterized by the levels (forces) of insecurity, categorized from state security to human security, which is largely attributed to extreme poverty, political violence and assassination, electoral violence, sectarian, ethnic, religious and communal conflicts, armed robbery, kidnapping, socio-economic agitations, boundary disputes, organized crimes, criminality amongst others, that have been prevalent in the nation. This is in addition to the widespread series of systematic terrorist attacks by the Niger Delta militants, Boko Haram, separatist groups amongst other civil banditries (Abang, 2014; Aborisade, 2018; Aleyomi, 2020). Bankong-Obi (2012) further emphasized Nigeria's intractable security challenges to government's apathy towards exterminating the terror group and inefficiency on the part of the security agencies. Thus, the joy and excitement that once culminated the transition to democracy has been overshadowed by the myriads of glitches and frustration faced by the citizenry and the nation at large.

There are few reviews of literature on researches employing the use of remote sensing and GIS in analyzing plethora of challenges faced in tackling insecurity. Beck (2003) informed the use of band-ratio satellite image mapping of the Kurram Group of the eastern Afghanistan region combined with the public national imagery and available databases as provided by the United Nations (UN). This was aimed to confirm the location of a terrorist, Zhawar Kili, around the Kurram Group rocks. The results were confirmed and were subsequently, forwarded to the U.S. government in October 2001. The information forwarded were instrumental to the successful triumph over a large number of terrorists bases and ammunitions at Zhawar Kili in November 2001 and January, February, and April of 2002. Adeniran et al (2013) employed the use of Garmin handheld Global Position System (Garmin CP76) in the collection of location data of facilities using Jos metropolis as case study, while secondary data from Google earth and documentations from the international crisis group were used. Series of spatial analysis was employed to demonstrate the effectiveness of GIS in joint military operations such as network analysis, spatial selection amongst others. Nte et al (2020) researched on the relevance of geospatial intelligence as a tool in conducting effective strategy in tackling terrorism, using the north-eastern part of Nigeria as case study. Sampling was employed due to the large population size of the study area between 2015 and 2018. Primary and secondary data were utilized in the research, such as questionnaires administered physically and electronically via emails while, secondary data came from published books, journals, articles, lecture guides, videos etc. These acquired datasets were subjected to statistical methods, employing simple percentage and chi-square statistics. Statically, results revealed strong correlation between geospatial intelligence and counter terrorism in Nigeria.

From previous researches, it can be deduced that although statistical methods amongst other approaches had been used, space-based technologies, in particular GIS and remote sensing technology have not been fully employed in their studies, especially with regard to probable areas of migration from affected areas of conflict. Hence, this paper aims to explore the role, which Geographic Information Systems (GIS) and remote sensing can play in combating insecurity challenges in the North Eastern Region of Nigeria. This is for both activities designed to prevent terrorist events from occurring in the first place and activities designed to deal with the aftermath of a terrorist event. This is of great benefit as there has not been much utilization of such in assisting the security forces and agencies in combating insecurity, terrorism in particular, within the north east region of the country. The aim of this research is to evaluate the effect of over a decade insurgency on the land use and land cover features as well as its consequences on infrastructure and service delivery in the North Eastern Nigeria.

The objectives of this research are to;

- Assess the land cover features for 2008, 2014 and 2020.
- Examine changes in the land cover features.
- Assess impact of insurgency on the landscape of the area.

II. PROBLEM STATEMENT

Nigeria is a country blessed with diverse resources. However, the country has not attained proportionate physical and socioeconomic developments due to incessant insecurity challenges. The most recent uproars in the country include the vicious actions of militants in the Niger Delta, secessionists groups in the South East, insurgents in the North East, kidnappers in the North West and North central Regions. Despite the effort put in by the Federal and States Governments to control the situation, the resultant effect seems ineffective due to persistence of the mayhem. Lack of adequate use of modern space technology is among the major issues frustrating security efforts in the country. This inefficiency has led to inaccuracies in locating precise conflict sites, as well as poor surveillance of the neighborhood by security agencies. In addition, most of the personnel were not effectively trained on how to use modern space technology to monitor crime and other related events in Nigeria.

Insurgency, which distresses the North East region can be attributed to the spread of weapons, transnational terrorism from the four Sahelian nations, and illegal border crossing. All these pose threats to the region. The region's poverty status and Human Development Index (HDI), high mortality rate, abysmal illiteracy, abandoned and ungoverned forest reserves, and adverse climatic conditions, are among the apparent drivers that promote disconcerting insecurity in the area.

III. MATERIALS AND METHOD

A. STUDY AREA

The North East region is one of the six geopolitical zones in Nigeria. It is composed of the following states: Adamawa, Borno and Yobe. It occupies slightly less than one-third of Nigeria's total area and had a projected population of 14,663,200 people in 2022, which is 13.5% of the country's population. The inhabitants are mainly Fulani. Only Borno state has Kanuri people as majority. There are more than 100 minority ethnic groups.

The area houses a large national park called Gashaka Gumti National Park and the Mambilla Plateau which covers significant part of Taraba state. The Mambilla Plateau has an average elevation of 1,600 meters. The study area has relatively humid weather. Annual rainfall ranges between 700 and 1500 mm with 140-150 rainy days. Temperature range is between 15-200c during harmattan i.e. December to February, while in the hot dry season (March to May) the temperature is 32-38C. Major crops grown are maize, sorghum, cowpea, groundnut and vegetables. The livestock reared in the area include cattle, sheep, goats, pigs and poultry.

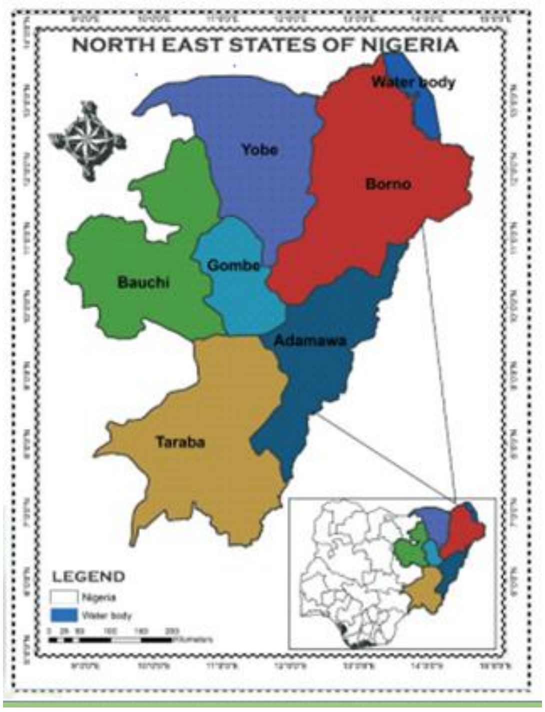

Figure 1: Map showing the North Eastern States.
Source: NASRDA, 2022

B. DATA REQUIRED

The table below shows the specific dataset used.

Table 1: Specifications of Dataset

SN	DATA	YEAR	FORMAT	SCALE/ RESOLUTION	SOURCE
1	Landsat Satellite ETM+	2008	Raster	30m	https://glovis.usgs.gov
2	Landsat Satellite 8 (OLI)	2014	Raster	30m	https://glovis.usgs.gov
3	Sentinel-2	2020	Raster	10m	https://glovis.usgs.gov

Source: Author, 2021

C. METHODS

In this study, data processing and analysis procedures follow these four steps discussed in their sequential order of operation. The steps are:

i. Pre- processing activities.

ii. Data classification/creation land cover maps for 2008, 2014 and 2020 and Accuracy assessment.

iii. Computation of change detection using post classification method and analysis of land cover change.

IV. PREPROCESSING OF DATA SETS

Data processing was carried out in ERDAS IMAGINE Software. Figure 2 shows the data processing workflow. Pre-processing includes atmospheric correction and geometric correction. It is computational efficient, simple to use and yield accurate spectra collection. Thereafter the images were rectified, mosaicked and area of interest was subset for further processing.

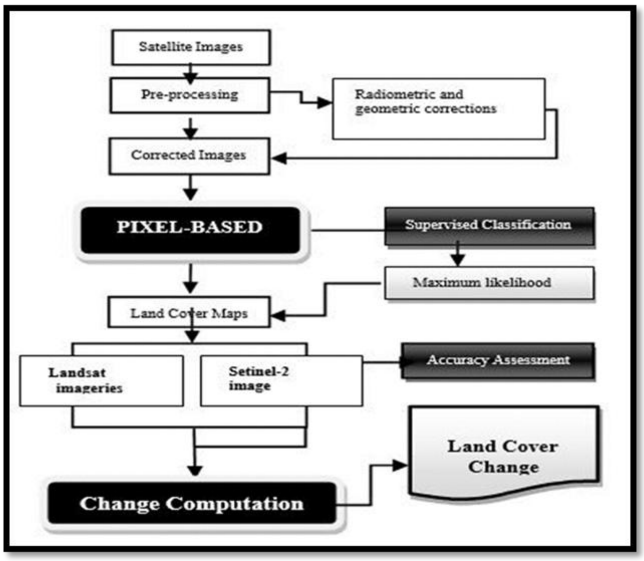

Figure 1: Methodology Flowchart

V. DATA CLASSIFICATION, ACCURACY ASSESSMENT AND CREATION OF LAND COVER MAPS

Several classification algorithms had been developed and employed to extract land cover information and monitor change. Supervised and unsupervised pixel-based classifications have been widely used and documented in several studies. In this study supervised pixel-based classification was utilized using maximum likelihood algorithm in Erdas Imagine software. Eight land cover classes: bare surface, wetland, water body, urban, tree cover, grassland, cropland and scrubs cover were identified for classification. In doing this, training polygons were selected and digitized on-screen as representative of each class. Google earth was used for the identification of features. RGB color composition of images and elements of visual interpretation such as color, shape etc., observed on the images of the study areas guided features' identification.

The accuracy of the classified map was assessed using confusion matrix. Accuracy assessment involves statistical estimates obtainable from remote sensing classification output and an independent reference dataset in order to measure the probability of error for the classified map. Accuracy assessment was carryout for 2008, 2014 and 2020 classification maps produced from Landsat 7 ETM+, Landsat 8 and sentinel-2 data. Due to lack of reference data for the study area as ground truth data, it was difficult to carry out accuracy assessment with independent data. Alternatively, stratified random sampling design was adopted with sample points generated and their locations chosen to represent the eight land cover classes considered in the area. The three classified images were used as input data to detect the pattern of change in land use land cover within the study area.

VI. COMPUTING CHANGE USING POST-CLASSIFICATION COMPARISON

Many change detections based on image classification of remotely sensed data have been reviewed. One of the most commonly used change detection method is post-classification, which is a method that determines the difference between independently classified images for each of the dates in question. Post-classification comparison algorithm allows the type of land cover changes that have occurred within the time frame to be recognized and quantified.

The technique is selected because it minimizes the impact of geometric and radiometric differences and the most suitable where data from different sensors are involved as in this case. The only drawback of the method is that the result obtained depends on the accuracy of the individual classifications, hence the need to be more careful during classification operation. Quantitative analysis of class change is presented on the table and percentage bar scale.

VII. RESULTS AND DISCUSSION

The satellite image of the following epoch years (2008, 2014 and 2020) of the study area were classified. The classification accuracy for the three periods of 2008, 2014 and 2020 were evaluated from the Error matrix of the classified images with an overall accuracy of 75.8%, 80.2% and 84.1% respectively as shown in table 1. Eight feature classes of built up, vegetation, bare surface, cropland, water body, scrubs, tree cover and grassland were extracted from the satellite images. These are shown in figure 3. The area coverage of each feature classes is shown in table 2.

Table 1: The Overall Accuracy, Producer and User Accuracy of Land cover classes (2008, 2014, 2020).

Land cover Class	2008		2014		2020	
	Producer Accuracy	User Accuracy	Producer Accuracy	User Accuracy	Producer Accuracy	User Accuracy
Wetland	78.0	76.5	84.0	77.8	84.0	87.5
Water body	63.8	77.3	68.8	82.1	78.6	82.1
Urban	80.0	82.1	92.5	75.5	92.5	82.2
Tree cover	84.3	71.1	88.6	78.5	94.3	82.5
Grassland	81.3	74.7	81.3	80.2	81.3	81.3
Cropland	71.3	76.0	78.8	76.8	78.8	85.1
Bare surface	85.0	72.3	72.5	78.4	82.5	80.5
Scrubs cover	71.3	79.2	80.0	90.1	85.0	90.7
Total						
Overall accuracy	75.8%		80.2%		84.1%	

The total area was said to be 172,144.8 km^2. The built up area was 197.87km^2 in 2008. It increased to 231.28km^2 in 2014 and to 588.57km^2 in 2020. This reveals continuous increase from 0.114% of the total area in 2008 to 0.134% in 2014 and 0.342% in 2020. The area put to crop farming was 105,867.4km^2 in 2008, which was 61.11% of the total area. It increased to 108,192.10km^{2,} i.e. 62.85% in 2014, but later decreased in 2020 to 91,478.77km^2, which is 53.14% of the total area. This shows that there was decrease in agricultural activities in the area in 2020.

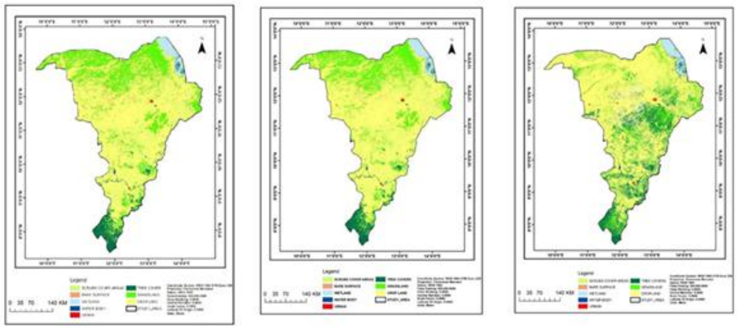

Figure 2: Classified image (Landsat 2008; Landsat 2014; sentinel-2 2020)

The natural vegetation cover, which includes grassland, shrubs and tree covers, were 37,808.65km^2, 16,867km^2, and 7,041.59km^2 respectively in 2008. These represented 21.82%, 9.736% and 4.065% of the total area respectively. The shrubs increased to 16,866.6km^2 in 2014, which was 9.798%, and to 16,978.07km^2 in 2020 i.e. 9.863% of the total area, while grassland reduced to 35,493.28km^2 i.e. 20.62% and 28,145.49km^2 i.e. 4.055% respectively. The tree cover vegetation in the area reduced to 6,980.07 km^2 i.e. 4.055% of the total area in 2014. Meanwhile, it raised high to 25,526.17km^2 i.e. 14.83% in 2020. This findings revealed that the total natural vegetation in the area i.e. grassland, shrubs and tree covers, that was 35.625% in 2008, reduced to 34.471 in 2014. Interestingly, it rose to 41.041% of the total area in 2020.

Table 2: Area covered by the Land cover Classes in the study area

Land cover Class	2008 km²	2014 km²	2020 km²
Wetland	3645.44	2422.62	2543.51
Water body	716.79	715.55	907.55
Urban	197.87	231.28	588.57
Tree cover	7041.59	6980.07	25526.17
Grassland	37808.65	35493.28	28145.49
Cropland	105867.4	108192.1	91478.77
Bare surface	1099	1243.3	5976.64
Scrubs cover	16867	16866.6	16978.07
Total	172144.8	172144.8	172144.8

Bare surfaces was 1,099.00km^2 i.e. 0.634% of the total in 2008, but reduced to 1,243.30km^2 (0.722%) in 2014 and 5,976.64km^2, which was 3.472% of the total area in 2020. It has been obtained from this study that the area put to cultivation rose to 62.85% of the study area in 2014, but later decreased in 2020 to 53.14%. This revealed that there was decrease in crop cultivation in that period, hence goal two of the SDGs, which is to ensure food security, was threatened in that year. This is contrary to Arowolo and Deng (2018) who found conversions to cultivated land dominated the land use/land cover change processes. However, Arowolo and Deng (2018)'s study area covers the country. This study also obtained that the total natural vegetation in the area i.e. grassland, shrubs and tree covers (forest), that was 35.625% in 2008, reduced to 34.471% in 2014, but interestingly rose to 41.041% of the total area in 2020. This was probably due to the insecurity in the area, because the farmers among the inhabitants of the area would have avoided hideout of the insurgents. This is also contrary to the findings by Arowolo and Deng (2018) who found that the conversions to cultivated land was largely at the detriment of the natural vegetation i.e. grassland, shrubs and forests.

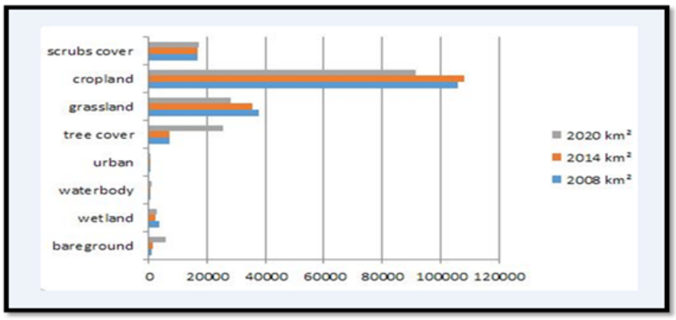

Figure 3: Comparison of Land Cover Changes for year (2008, 2014, and 2020)

Another issue of concern is the continuous rise of bare surfaces within these periods. This is because bare surface type of land cover is synonymous with desert encroachment. This feature class was seen to be 0.634% of the total in 2008, but rose to 0.722% in 2014 and 3.472% of the total area in 2020. The specific changes in Land cover classes for the study area between 2008, 2014 and 2020 are shown in table 3.

Table 2: Specific Land cover changes for the study area in 2008, 2014 and 2020

Land cover Class	**2008 and 2014**		**2014 and 2020**		**2008 and 2020**	
	Area Covered (Km²)	Area Covered%	Area Covered (Km²)	Area Covered %	Area Covered (Km²)	Area Covered %
Wetland	-1222.82	-20.03	120.89	+0.25	-1101.93	-2.24
Water body	-1.24	-0.02	192	0.40	190.76	0.39
Urban	33.41	0.55	357.29	0.74	390.7	0.79
Tree cover	-61.52	-1.01	18546.1	38.54	18484.58	37.56
Grassland	-2315.37	-37.93	-7347.79	-15.27	-9663.16	-19.64
Cropland	2324.7	38.09	-16713.33	-34.73	-14388.63	-29.24
Bare surface	+144.3	+2.36	+4733.34	+9.84	+4877.64	9.91
Scrubs cover	-0.4	-0.01	+111.47	0.23	+111.07	0.23

VIII. CONCLUSION

Nigeria has been beclouded with a myriad of security issues that has threatened us at every front. Various literature states the inefficiency of institutional architecture. The multiplicity of security challenges have overstretched the security infrastructure presently on ground, which if not improved, could lead to its breakdown. Although, these varied observations are widely disseminated, it seems there are no concerted efforts to develop a well-defined strategic model, to overcome the widespread security challenges in the country. It is of great importance that attention be directed to quell these security threats, which have been detrimental to the socioeconomic development of our dear country.

The contemporary advancement in space science and technology presents numerous opportunities to be benefitted as a nation. This study adopted the use of space based systems, in particular, remotely sensed imagery, to evaluate the effect of over a decade insurgency on the land use and land cover features as well as its consequences on infrastructure and service delivery in the North Eastern Nigeria. However, a desk review was conducted with the use of secondary materials largely sourced from government publications, academic journals and media reports. The various remotely sensed imageries used in the research were the Landsat 2008; Landsat 2014 and Sentinel-2 2020 for near-event data analysis and interpretation.

Although this study was conducted with meagre resources, the results revealed places that have been affected by the insecurity, due to the identified land use and land cover changes in the area. This was achieved due to effectiveness of space technology. Further studies are required with satellite imageries of very high spatial resolution in order to identify detailed features in the areas of the incidence, as well as places and assets that are of high vulnerability.

Providing an effective national security program requires identifying and assessing vulnerabilities from all types of hazards and threats. It includes developing capacity to prevent, protect from, respond to, and recover from catastrophic incidents. Maintaining continuous situation awareness is now generally accepted as the foundation for successfully maintaining national security (Van Leuven, 2011). This is among the prerequisite before any socioeconomic development can be achieved. Sustaining uninterrupted situation awareness can be efficiently achieved with the use of space technology.

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