European Journal of Applied Sciences – Vol. 13, No. 01
Publication Date: February 25, 2025
DOI:10.14738/aivp.1301.18305.
Dukiya, J. J. (2025). Application of Remote Sensing and Geographic Information System in Counter Terrorism in Sub Saharan Africa. European Journal of Applied Sciences, Vol - 13(01). 376-396.

Application of Remote Sensing and Geographic Information System in Counter Terrorism in Sub Saharan Africa

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ABSTRACT

That Sub-Saharan Africa is threshing floor for human blood is not an overstatement. Terrorism of divers nomenclature is everywhere, and they seem to be operating with impunity under a failed state. This review paper focuses on the capability of remote sensing and GIS in counter terrorism in Sub Saharan Africa with the epicentres at Gulf of Guinea and the Horn of Africa (Somali). To this end, the paper reviewed case studies in use of multi-temporal HSR-5M satellite imagery and ARCGIS that carry out area surveillance of elected area. While SASTRA resource search engine was used to access secondary data on Big Data, remote sensing, and GIS applications in security. The review finds out that Big-Data in GIS environment and sensors bearing Unmanned Area Vehicle (UAV), and natural birds are veritable tools for modern enemies' surveillance and logistic supply for troops. The paper therefore recommended that all the African countries should invest more in the security agencies capacity development, remote sensing and GIS hardware and software for effective territorial security and defence.

Keywords: Big Data, GIS, Remote Sensing, Sub Sahara Africa, Terrorist, UAV.

INTRODUCTION

The continuous rise in terrorism trend is one of the greatest challenges faced in the 21st century in the world. Cities and villages in particular across developed and developing countries have had their fair share of the attack in various degrees. Unfortunately, African countries are becoming the host of rebels and religious fanatics that has bred a large scale of humanitarian crisis ranging from loss of lives and properties, and Internally Displaced Persons (IDPs) at large scale. According to Chou (2017) 3.6 million people have lost their lives in the Sub Saharan Africa due to terrorism and Somalia and Nigeria top the list. In fact, in the global report on Internal Displaced persons (IDP) of 2018, Sub Saharan Africa recorded about 5.5 million victims as a result of the Al-Shabab, Boko Haram and the subsets of Al-Qaeda and ISIS armed groups activities in the region (Feldstein, 2018).

Twenty years after the September 11, 2001 series of airline hijackings and suicide attacks; by 19 militants associated with the al-Qaeda Islamic extremist group targets the world trade centre in the United States, the global jihad terrorist groups are expanding their war of terror in large portions of different continent. Insurgency and terrorism in all its forms have persistently arouse regional rejoinder co operations to eliminate all its menaces. For example, EU member states adopted the regional coalition approach in the form of Counter-Terrorism and Counter Insurgency (CT-COIN). Also around the Lake Chard Basin, the Multi-National Joint Task Force (MNJTF) was revitalized to crush cross-border terrorism (Alexandre, 2021; Vanda

et al, 2017). Although, this same task force according to Bashir and Usman (2021). has been undermined by the regional negative peculiarities.

Problem and Background of the Study

The issues of terrorism in Sub Sahara Africa have been on the increase more than a decade. In fact, from the Armed Conflict Location and Event Data Project (ACLED) record, from the year 2010, about 381 attacks that led to 1,394 fatalities occurred involving civilians, and by the year 2020, the figure rose to 7,108 attacks and 12519 fatalities (Mroszczyk.and Abrahms, 2021). In the global report of Verisk Maplecroft, seven out of the top ten terrorist counties are in Africa (Raleigh, et al 2010; Brown 2010).

Big Data is currently seen as a panacea to effective crime control globally. The advancement in Information Technology (IT) has resulted in the present global Big-Data model and all forms of algorithms that are used in conjunction with RS and GIS for combating terrorist attack. Most Big Data tools like Integrate.io, Atlas.ti, Analytics, Microsoft HDInsight, Skytree, and Talend have no spatial attribute data for geo-coding and 3D as in Geographical Information System (GIS) software like ArcGIS, MapInfo, Ilwis, Idrisi etc.

The increasing number of terrorist attacks has however prompted the need for the acquisition of real-time information in a dedicated format that can help in effectively countering terrorist threats (Ingber, 2019; Gartenstein et al, 2020). The information needed by security operatives exists in multiple forms and formats, cutting across different geographical location, physical, socio-economic, institutions, and organizations. The socio-political undertow in sourcing and integration of data from these different sources by security operatives often require huge resources and time using traditional methods (Coskun *et al*., 2008). Remote Sensing (RS) and GIS have proven to be very effective in filling the gap created by thetraditional methods in analysing big data. In fact, Artificial Intelligent AI is now being deployed to predict future terrorism at both national and global levels ((Uddinet al, 2021; Python et al, 2021; Buffa et al, 2022; Voukelatou et al, 2022). It is against this background that this paper examines the inter-operability of RS, GIS and Big-Data deployment in terrorist attack mitigation in Nigeria and Sub Saharan Africa countries.

RELATED LITERATURE AND CONCEPTUAL FRAMEWORK

Technology generally according to Wolfendale (2021) simply means any human made artefact, including everything from basic tools, specific invented devices, to complex socio-technological systems that involve a range of concepts and associations that may not be explicit, but shape our moral thinking, mediate moral decisions that instill norms. Therefore, many recent researchers accomplished the spatio-temporal assemblage capacity using spatial on-line analytical processing (SOLAP) systems (Gonzalez and Gonzalez, 2013; Ahmed, 2008) as a data cube thereby extracting the needed data from the huge dataset. In extracting data with some geographic features to identify or tag the targeted areas of interest like terrorist camps monitoring, multi-temporal and multispectral high resolution RS image data are processed in GIS laboratory (Lizhe et al 2016; Lizhe et al 2017; Weitao et al 2018).

The Syria civil war is another good example where satellite data was used to target and destroy archaeological site around the Abbasid Palace, while RS techniques were used to estimate the

oil production of ISIS in resource-rich regions for geopolitics and energy security (Moision and Harle 2006; Benítez 2007; Hagenlocher 2012; Hu and Ge 2013; Casana and Laugier 2017; Do et al 2018; Xu et al 2018; Hansen-Lewis 2018)

Yassine et al (2021) opined that the Spatial-feature Remote Sensing Data Cube (SRSDC) often used in conflict regions is a data cube that is aimed at providing scalable multi-dimensional data analysis for large scale RS data. SRSDC as GIS Software has the potential of storing, retrieving, managing and translating features that are amenable to information query operations. The long time-series in the RS techniques helps in performance evaluation of feature data cube for regional distribution.

Remote Sensing (RS) Technology

RS can be defined as the measurement or acquisition of information of a phenomenon or an object of interest by a recording device without physical contact with the object (Coskun, 1995) cited by Coskun et al, (2008). The use of RS can be traced back to 1950s when camera and electronic sensors were mounted on spacecraft to capture imageries for military operation purposes. RS system is made up of sensors that may be active (generating their own radian energy line Radars) and passive (natural light dependent sensors) in operation. These sensors operate in different regions of the Electromagnetic spectrum from the ultraviolet to microwave with the capacity to collect large amount of information about the earth's surface daily (Malgorzata, 2010; Dukiya, 2014). The uniqueness of this technology includes the following:

a) Collection of real-time data and information extraction;
b) Effective for direct electro-transmission to action locations and receiving stations;
c) Low-cost comparative advantage over large area coverage;
d) High potential for day and night operations via thermal infrared and microwave sensors.
e) Repetitive and synoptic coverage of study areas.

Generally, the usability and application of imageries acquired through an aerial or satellite platforms :(Radar or Lidar optic sensors) depends on the following three parameters (Prata et al 1995; USGS, 2019):

1. Pixel values of surface features refer to the spatial resolution that ranges from 300m to tens of centimetre
2. Electromagnetic regions of sensor operation refer to the spectral resolution (from blue to infrared); and
3. radiometric resolution that refer to the ability to recognize feature brightness variations (from 256 to 64000 level)

Arockia and Subhashri (2017), identify three main stages in RS operation which are: as a) Remote Sensing Acquisition Unit (RSDU), b) Data Processing Unit (DPU) and c) Data Analysis Decision Unit (DADU) as illustrated in Fig. 1. Technological advancement in RS and GIS applications includes satellite TV for PC photo analysis, gradient and side detection, and gradient intensity for effective intra prediction (Tsai et al, 2008; Paul et al, 2010; Dugane and Raut, 2014).

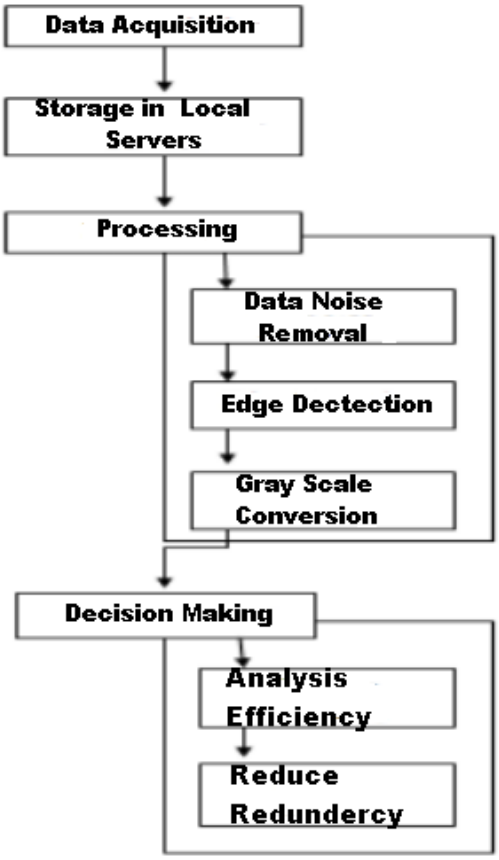

Figure 1: Remote Sensing Big Data Architecture.
Source: Arockia and Subhashri (2017).

There are wide variety of satellite imageries from different countries' platforms; that ranges from France SPOT, US Landsat series, Ikonos, Quick birds, SRTM, NigeriaSat-X and many others. The space satellites acquire images that are downloaded at the countries ground receiving station as illustrated in Fig 2.

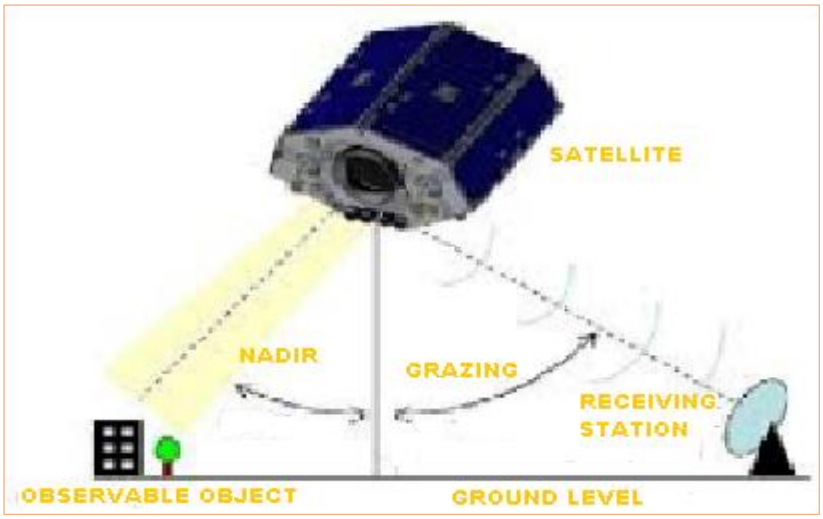

Figure 2: Remote Sensing system

On a small scale, as part of RS activities, unmanned area vehicle (UAV) are used by researchers and security agents to carrying out reconnaissance survey of enemy territory, forces fly over war zones, drop supplies to troops, and release bombs over enemy zone. (Microsoft Encarta, 2009). UAV are used to carry sensors for aerial surveillance of enemy locations and activities since they are unmanned, while modern researches have leverage on the life birds and made them to bear sensors that image enemy territory unaware as illustrated in Fig. 3a, b. The use of drones as a means of killing suspected and known members of Al Qaeda and other terrorist and militant organisations began under the Bush administration, expanded under the Obama administration (Kaag and Kreps, 2014), and expanded further under the Trump administration where as of May 18, 2020, 40 air-strikes had been launched against Somalia (Wolfendale, 2021).

Figure 3: Sensor bearing UAV and Birds for RS operations.
Source: Kaag and Kreps (2014) www.dronepoweredsolutions.com

The advancement in RS technology has helped security operatives achieved a highly favourable and decisive decision in all their operations. For example, in the 1991 Gulf War, RS was vital to the operation desert storm's (US Army) success in defeating the enemies. According to the US Army's Geographic Unit, RS satellites were constantly used in providing infrared and microwave visual data to its troops (NOAA, 2017). Alharith and Samak (2018) assert that, land and air commands of the US military relied on information from geostationary satellite for reconnaissance mission, spatial decision support system for ammunition selection, troop's reorientation, and movement of equipments. This example revealed that the integration of RS technology into the operations of the military would go a long way to curtail the activities of terrorist organisation within the Sub Saharan Region.

Geographic Information System (GIS) in Combating Terrorism

Terrorist groups make use of different technology and tools to support their operation (Furnell and Warren, 1999). Alharith and Samak (2018) opined that part of the tools used by terrorists is the internet. In curtailing the activities of terrorist there is a need to employ the use of GIS because of its ability to harness the power and versatility of the internet. GIS can be defined as a multilevel computer system that is capable of capturing, storing, analysing, and displaying geographically referenced information (Prata et al, 1995; USGS, 2019). This implies that GIS has the ability to identify data on the earth's surface in relation to its location, (Dukiya**,** 2011). In the fight against terrorism, GIS can be applied in four stages that is, monitoring/surveillance, Preparedness, Response and Mitigation (Deogawanka, 2015; Michael, 2021). The GIS operations depend on referenced geographical and attribute data for spatial analysis queries

and predictions as illustrated in Fig. 4. GIS applications are generally for environmental analysis and decision making in disaster management and sustainable development.

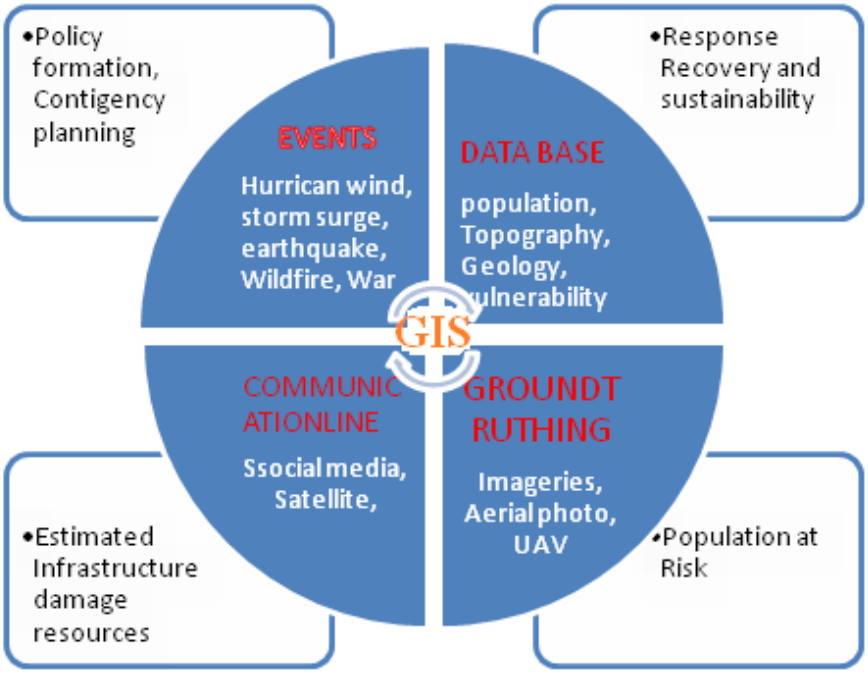

Figure 4: GIS model.
Source: After Abbas, and Fasona (2012)

In GIS environment, data are gathered, processed and presented in maps either in raster or vector format, and risk assessment is done on the maps produced in order to analyse and determine potential targets spots/locations (Prakash, 2000; Temfli et al 2009; Mccartney, & Mehta, 2020). Data are shared in a simpler format for easy comprehension in preparation for the third stage (i.e, Responses), while prediction of activities; combat operation and execution are examined at the fourth stage (Mitigation). The stages in GIS implementation for counter-terrorism is as indicated in Fig. 5.

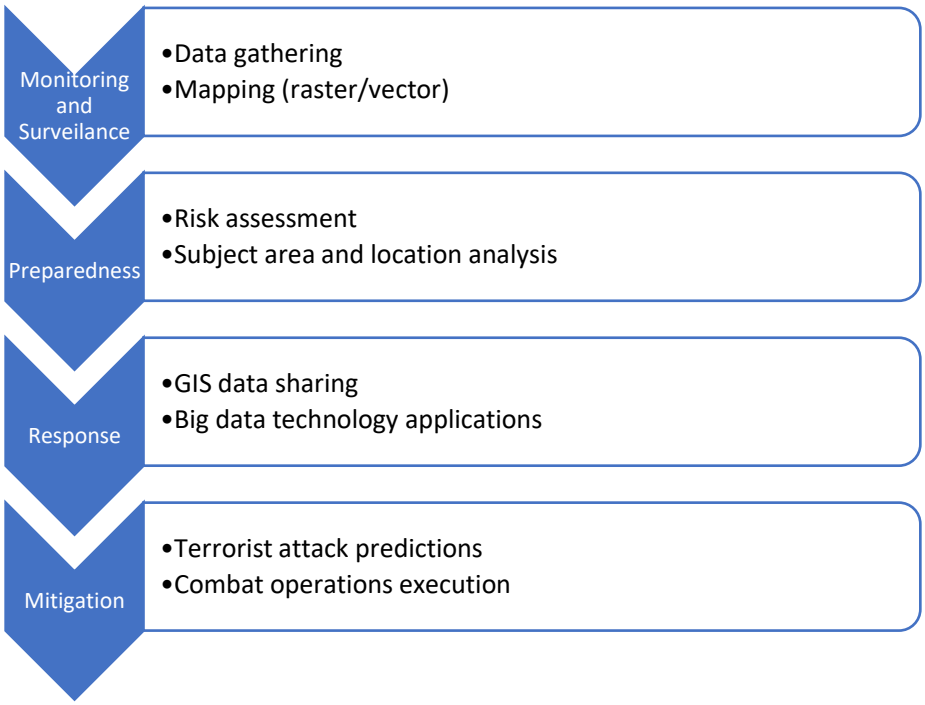

Figure 5: Counter-terrorism GIS architecture
Source: After Deogawanka, 2015.

The Concept of Big Data and National Security

Big Data can generally be referred to as structured and unstructured massive volumes of data that are multi-sourced and complex in nature emanating from the digital exhaust of web searches, credit card payments and mobiles pinging the nearest phone mast that are beyond the common database software (Snijders, Matzat, and Reips, 2012). While Gudiveda et al (2015) views it as 'data too large and complex to be acquire process and analyze using current computing infrastructure. The emphasis however is in the complexity and multi-source nature such as Google search index, database of Face-book user profiles, and Amazon.com products list requiring various tools, techniques and frameworks (Bello-Orgaz, Jung, and Camacho, 2016).

Venkat et al (2015) also opine that the issue of big data is not just the matter of the paralleled volume but velocity (the speed at which the data is generated as in phone calls), the variety that refers to its heterogeneity that is often comprised of unstructured, semi-structured, and structured data of disparate types. While the veracity focuses on the life cycle transformations the data goes through; that requires (data provenance) and tracing the history of such transformations to establish its dependability. Therefore, for big data to provide value and actionable information for organizations to justify investments in it, the collection, cleansing, transforming, storing, analysing, interpreting, visualizing, and querying must be seamless and cost effective.

Though Big Data are multi-sourced form: purchase history, social graphs, tweets, blog posts, scientific data, images and videos; many of its features are not new. But of major interest is that of earth observation (Radar, optical images and texts). Earth resources imagers depending on

their spatial resolution; contain multi-data on physical, socio-economic, cultural, and political. The inferential opinion mining values have appreciated since the early 2000, and what is now captivating is the cost-effective ways of analysing this heterogeneous huge data.

Government agencies tends to improvised in the deployment and harnessing big data analysis when managing urban crime, traffic congestion and addressing transparency issues (Bello-Orgaz, Jung, and Camacho, 2016). Big data integration has been found to be profitable in dealing with the following challenges:

1. Determining causes of failures and defects in real time operations,
2. Prompt computation and re-computation of risk portfolios, and
3. Dealing with pro-active fraud detection at all levels.

Major Sources of Big Data:

Generally, major Big data comes from environmental and economic, RS and social mediadata. The environmental and economic data are more discrete in nature and place specific. RS data is one of the voluminous, high frequency open data source for different project missions like the Sentinel-1 satellites (that has a return-time of 6 days at mid-latitudes) operated by the European Space Agency (ESA) and the Copernicus Programme (Corrigan, et al, 2012; Tanala, 2015). While social media comes from social media (Twitter, Facebook, Histagram, and WhatsApp) and news agencies (Reuters) for real-time detection of socio-political events, both in research and in industry (Bello-Orgaz, Jung, and Camacho, 2016). The extractions of metadata content do provide more information to abide by intellectual (Corrigan et al 2012; Tanala 2015).

Big Data Tools:

Big data tools refer to the hard and software infrastructure used for the storage, analysing, processing the huge complex data set (like Integrate.io, Atlas.ti, HDInsight, Skytree, Talend, Splice Machine, and Spark). The following are some of the factors that influence big data tool selection:

1. Software license cost (where applicable),
2. Customers' cooperation and support,
3. Institutional capacity development,
4. Levels of hardware and software requirements accessibility,
5. Programmers and vendors' support and update policy of the tool, and
6. The socio-political environment.

It is worthy of note that the deployment of big data operations is not without some socio-political implications that tends to cripple it growth globally and especially in Africa. Telecom big data sources are characterized with individual and corporate classified data that require high anonymity to preserve the integrity of those concerns. More so, underground marketing of stolen personal information by criminals is prevalence and must be control by law. It is not out of place for government intelligent services to be trailing and targeting personal, corporate, and government adversaries for espionage and rivalry (Freudiger et al 2014). This has become endemic in the resent cyber attacks against both government and commercial institutions (Freudiger et al 2014; Dong et al, 2015), resulting into the lost of millions of dollars and serious damages to the individuals and institutions (Gudivada et al 2015).

Big data analysis operations require modern protective algorithms like the current cryptography for dependability and investment justification. In fact, Confidentiality, Integrity, and Availability (CIA) are the three key security goals in big data operation. The confidentiality addresses the levels of sensitive data freedom from adversity attack and accessibility to wrong parties (Sheppard and Terveen 2011; Xu 2015). While the data integrity goal is to ensure that data are free from data modification traceability and freedom from unauthorized interferences at all stages to assure data veracity. Availability security deals with the problems irretrievability of stored data, adversaries should not be able to disable critical stored data stored at any point in time which is made possible by non-cryptography replications.

Message Authentication Code (MAC) and Digital Signature have been the primary tools for ascertaining data integrity which helps to uncover any adversary activities on data. Precisely, MACs are the secret keys used to sign and verify the validity of data signature, and they both have the following protocols:

1. KeyGen - that is a generational algorithm key,
2. Sign (k, m) – signing 'k' algorithm and message 'm' used for object authentication, and
3. Verify (k. m) = b - signing key 'k' algorithm and message 'm' returning a Boolean 'b' value depending on the use of accurate key.

METHODOLOGICAL APPROACHES IN RS, GIS AND BIG DATA ANALYSIS

For RS data, high resolution multi-temporal satellite imageries of area of interest (AoI) is acquired from satellite image providers (like NASDAR in Nigeria) for image processing and analysis for land-use-land-cover change detection. This reveals formal and informal settlements in the area (criminal hideouts), that is comparable to experimental project envisaged by the EU satellite centre, the University of Athenss, and NCSR 'Demokcritos' in Fig. 6.

Figure 6: Big Data integration into GIS, and neural network for national security.
Source: The Big Data Europe and Societies pilot.
https://www.satcen.europa.eu/page/the_bigdataeurope_project

In Telecom Network data analysis, a Special Memorandum of Understanding (MoU) between the Federal Government and the network providers on all communication flow within the country (NCC, 2014; Nwanga et al 2015). The origin and destination of all Telecom calls have geographical coordinates that are stored in the data base of network providers which form the big data together with social media like WhatsApp, Twitter, and Face-book. The work-flow ingests satellite images to locate Area of Interest (AoI) which is then relate to the socio media

and news agencies' item for cross-validation. The social media and news agencies' information that serve as attribute data to the referenced data are overlaid on the maps where trending topics with geospatial connotation constitute an event that is localised in time and space as in Fig. 6. Relevant keywords on selected AoIs are acquired and processed. All the calls made by terrorist and kidnappers are geo-coded in the big data and analysed using neural network algorithm to track down their location for rescue response and spot clearance by the search and rescue operation agents (Nwanga et al, 2014).

CASE STUDIES AND DISCUSSION

According to Rob (2021), the major difference between counter insurgency (COIN) and counter-terrorism (COTE) is that insurgents operate with the local population's support, whilst terrorists are individuals or isolated groups without broad public support. Insurgence requires a 'hearts and minds' campaign, whilst counter-terrorism requires search and arrest or destroy tactics with less impacts on the population. Therefore, in trialling and tracking terrorist hideout, multi-temporal HSR-5M satellite imagery covering suspected terrorist dens around highly undulating terrain with landslide features and thickly forested zone was analysed. In fig 7 for instance, the January image interpretation has no traces of informal strange camp,. but in the March image, one informal camp in the north-eastern part was detected very close to the land slide, while that of June revealed twoinformal strange camps along the same path. The coordinates of these informal camps were auto determined, and the intelligent groundtruthing carried out together with telecom data analysis confirming them as terrorist base (Guo, Liao, and Morgan 2007; Medina, Hepner, and Siebeneck, 2011). It must be established that the word terrorist and banditry are politically nomenclatures that are virtually the same. Deep forest hunting and farming is becoming suicidal in countries like Nigeria. Remote sensing imageries as big data sources is the earliest specialized tool in use for security purposes in the 50s by the military even before the commercialization and general applications. Its real-time and panoramic view characteristic makes it the most versatile in dealing with geospatial issues. The migratory pattern of the terrorist can easily be monitored and counter attack can be launch with high precision (Nance. 2014).

Figure 7: Terrorist camp tracking on Using HSR-5M Imagery.
Source; after Pierre (2014)

Mustafa (2020), in analysing the spatial pattern of the nature of insurgency in Borno State, employed ArcGIS which revealed that suicide bombing was the most common insurgency in the

area with 505 incidences., and Maiduguri the state capital had the highest. Also, in assessing the impacts of bomb blast in the State, Buffering tool in ArcGIS was used to generate buffer map as a guide in evacuating residents within the trouble zones. Fig.8 shows a vulnerability buffer map indicating blast radius.

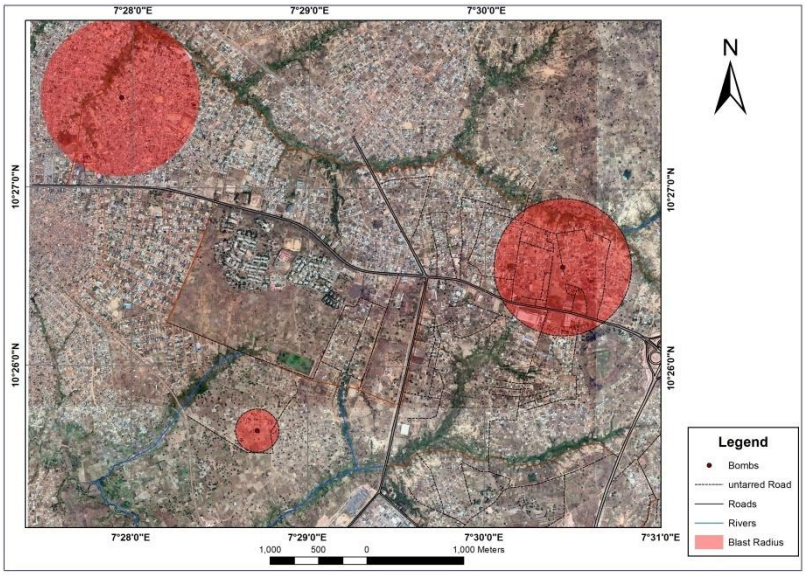

Figure 8: Multiple Bomb Locations with their Respective Blast Radius
Source: After. Mustafa (2020)

Anderson and Lochery. (2008) earlier reported that he UN Institute for Training and Research (UNITAR) also used Moderate Resolution Imaging Spectroradiometer (MODIS) images to identify the areas showing signs of violence occurrences following Kenyan National Election violence.s. While Madden et al (2009) used a combined data from personal narrates with GIS data to assess mass atrocities in the northern part of Uganda. In fact, night time RS imageries are equally very effective in the Study of conflict regions as demonstrated by Jiang et al. (2017) and Levin et al. (2018). They both reported the use of night-time light data to study the rate of armed conflicts growth over the last decade; where Suomi National Polar-Orbiting Partnership Visible Infrared Imaging Radiometer Suite sensor (NPP-VIIRS) has been used to evaluate the crisis in Sana, A study of the extent of conflict area in which settlements were burnt up using RS and GIS was also carried out by Marx et al. (2013; 2019). in which they used change detection in the near-nifrared reflectance] of multi-tempora images to determine levels of fire conflict damage in the Rakhine state of Myanmar. Apart from the G5 nations like USA, Japan, France, UK, and Russia, Iraq is another country that has demonstrated the effectiveness of GIS in analysing the spread and spatial pattern of insurgency overa period of time (Brown et al., 2004). Generally, according to Wolfendale (2021), the deployment of technology in the fight against terrorism simply means any human made artifact, including everything from basic tools, specific invented devices, to complex socio-technological systems that involve a range of concepts and associations that may not be explicit, but shape our moral thinking, mediate moral decisions that instil norms. Therefore, although, the enormous benefits of RS and GIS are yet to be fully explored by security operatives in the Sub-Saharan Africa in the face of increasing domineering activities of terrorism in the region, the process of geometry (polygons/polylines) created on satellite imagery was however used to evaluate the damages done by Boko Haram

in Bama, Borno State by the Nigerian Military in 2015. This availed them the opportunity to carry-cot reconnaissance survey of large expanse of land in short time. Features that appear vague during the reconnaissance survey are detected using near-infrared (Amnesty International, 2015).

Pre-attack activities of terrorist can be monitored by military personnel in space over a period of time with the use of remote sensing platforms. Victims and terrorist can be tracked in real time, this information can be retrieved and catalogued using ArcGIS full motion video add-in or the hexagon geospatial Geo-media motion Geo Video analyst (Gisgeography, 2018). Monitoring of terrorist activities by military personals can also be done through the use of the unmanned aerial vehicle (Drones) which is also a remote sensing platform. Ultraviolet to microwave visual data are other methods of investigating terrorist activities.

Geospatial techniques can help the Military analyst in Sub Saharan Africa to build a robust digital database which can be accessed by just a "click". Responding to terrorism activities with a data driven approach, the pattern of terrorist attacks can be mapped within a region by the military personnel using GIS. Data acquired from the field can be categorized according to their prevalent level of occurrences (Madden, and Ross, 2009; Awatef. and Yasser, 2018). This map will help Military officers to familiarize their selves with peculiarities of terror activities (arson, abduction, suicide attacks and bombing) attributed to different locations, streets and districts within a region. Earlier usage of remote sensing and GIS in insecurity management in Africa is as shown in table 1.

Table 1: Case studies of remote sensing and GIS application in insecurity management in African countries.

S/S	Authors	Study Area	RS Sensors	Methodologies
1	Anderson et al. (2008)	Rift Valley province, Kenya	MODIS	Active fire detection
2	Madden et al. (2009)	Uganda	Landsat, Google Earth	Visual interpretation
3	Schoepfer et al. (2010)	The Democratic Republic of the Congo	Rapideye, Geoeye-1	Object-based image classification
4	Gorsevski et al. (2012)	South Sudan and Uganda border	Landsat, MODIS, Aerial photographs	Image classification, TCA disturbance index (DI),, NDVI
5	Pech et al. (2017)	Goma city, the Democratic Republic of the Congo	Landsat, Worldview-2, topographic maps	Image processing and visual interpretation

Source: After Avtar, et al, (2021)

Application of the grid referencing system in GIS can be used to locate the precise location of points on the earth's surface. This technique can be employed by the military to strike the terrorist camp with precision by just acquiring the coordinates of the enemy's camp. This technique can also be used to dispatch personnel to trouble zones/locations in response to distress calls when under attack (Ansary, 2017; NATO, 2024). The use of geospatial techniques by the military can help delineate or buffer a high risk area or hot spot zone (Minefield). This

map can use as a vulnerability map to caution the populace on where to develop their properties, location they should not visit and a blast radius (Asmat, 2010).

Terrorist are sensitive about spaces and places for their planning and training (Alharith and Samak, 2018). It is pertinent for military personnel to understand the terrain of the location where terrorist operate before any rescue mission is carried out. RS and GIS provide military personals the opportunity to analyse the terrain of the area they wish to raid in 3-dimensional views. Digital photos of a landscape can be displayed and viewed at different angles in 3D models. To protect an area from harmful activities 3D models can help the military visualize and estimate the region where a target could be more vulnerable (Alharith and Samak, 2018). 3D models (Digital Elevation Models) can also help the military to determine the natural flow of drainages.

Strategic military plans hinge on an accurate base map so as well that of the terrorist. To generate a base map that will surpass that of the terrorist organizations. The use of RS and GIS will help the military generate a well reference base map with clear features that would aid effective counter attack (Haney, 2017). The base map can also be used by the military to monitor the depletion of some mineral resources (Uranium) in order to prevent these resources from falling into the wrong hands. The simulation methods in GIS can help the military understand the dynamics of the urban areas. According to Deoganwaka (2015) Maps are the key components in the surveillance of terrorist migratory activities and communicating geocoded data to ground troop stations to trail and combat the enemies (Ram et al, 2021).

Synthetic Aperture Radar (SAR) is most suitable for night operations, mountain ranges and clouded areas as it has the ability to propagate its own radiant energy as an active sensor see the illustration in Fig 9.

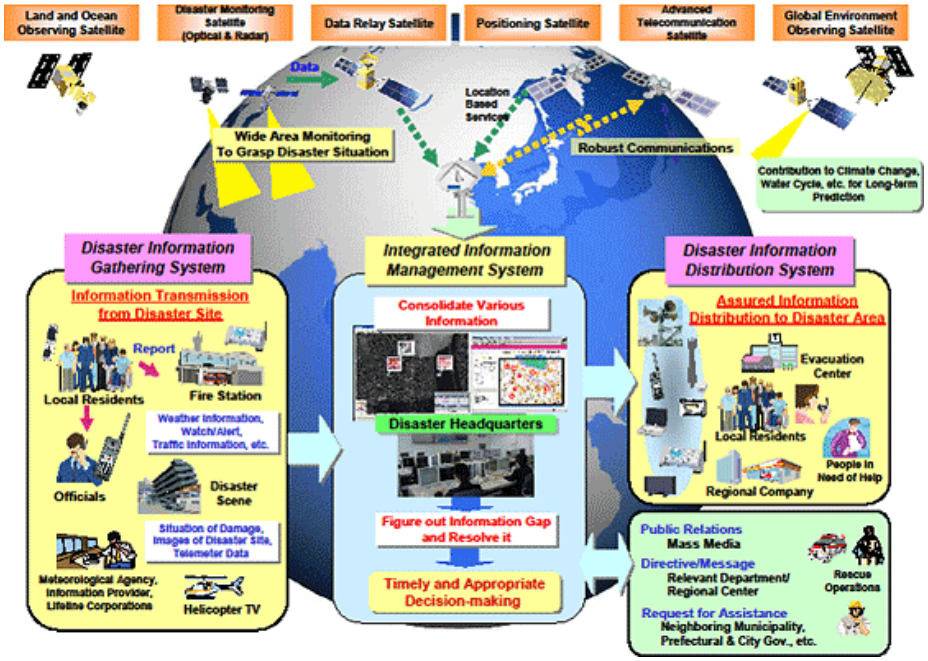

Figure 9: Disaster Monitoring Solution architecture.
Source; Yu (2018)

The Challenge of adopting SR GIS and Big Data in Sub-Saharan Africa

Though the roles of RS, GIS, and Big Data in combating terrorism cannot be over emphasized (Yu, 2018) the issues that are acting as impediment to their usage in the Sub-Saharan Africa and Nigeria in particular are as follows:

1. **Paucity of data in relevant format and Poor database Management**: data management has always been an issue in developing countries because of the use of obsolete equipments. The issue of unavailability of data and poor data management has being hindering the effective utilization of RS and GIS. In fact one can easily download archive satellite images of western countries than accessing imageries from Nigeria satellite. Data acquisition in Sub Saharan Africa is always marred by long bureaucratic process (Oarhe, 2013).
2. **Inadequate Skilled Personnel**: for effective utilization of RS, GIS and Big Data tools, it is important to have adequate skilled personnel who are versatile in manipulating of software and equipments that will aid data collection in countering terrorism. Personnel with these capacities tend to be inadequate amidst security operatives in the Sub Saharan Africa (Onapajo, 2013).
3. **Poor funding**: little or no funds are often allocated to relevant research institutes and this affect the quality of research carried out in these institutes. The use of unlicensed cracked software is prevalent in Nigeria for instance; obsolete equipment in combating terrorism is consequential to the funds made available by the government. Inadequate funding has the bane of military ineffectiveness in the Sub Saharan Africa.
4. **Poor coordination of allied agencies**: As at now, no Sub Saharan African country has a well defined formidable national Search and Rescue operation (SAR) with modern equipment. The research technology institutes are not well integrated with the national defence institute; neither do they sponsor research in the nations, universities of technology as a feeder to national security (Onapajo, 2013).
5. **Over politicking of issue:** In the words of professor Eskotoyo emeritus, 'there is no democracy in Africa but plutocracy'. All issues are marred by politicking to the detriment of the commonersas also observed by (Onuoha, 2012). This then causes lip service to threatening issues, for instance, Boko haram in Nigeria started as one state affair and was handled as such (Onapajo, 2013).
6. **Cancer worm of misappropriation of fund:** this is not unconnected to the value system in continent and is seen as a "monsters" that has eaten deep into the fabrics of the sub-Saharan States (U.S. State Department.,2014). For instance, as reported in some of the national dailies, millions of dollars were misappropriated by the then National Security Adviser (Sambo Dasuki) of Nigeria. The act of fund mismanagement in Sub Saharan Africa countries is an impediment in building a robust digital database from RS and GIS technology (Siegle, 2013).

RECOMMENDATIONS

To ameliorate the problems of RS, GIS, and Big Data utilization in combating terrorism in Sub-Saharan Africa, the following recommendations are made:

1. There should be adequate coordination and harnessing of the nucleated research outputs in each country and the region in general to effectively manage and curtail terrorism in Sub Sahara Africa. There are lots of cut-edge researches across the research

institutes and universities of technologies in the region that are covered with dust in various hard disk sheaves.

2. The paucity of relevant satellite data and accessibility should be addressed by the association of RS and GIS stakeholders through memorandum of understanding (MoU). There should be website like GLCF where raw satellite data can be downloaded for research purposes from the few receiving stations like NASRDA in Nigeria.
3. Research institutes, universities and military training centres should as a matter of necessity invest licensed current software acquisition and development to meet global trends in RS and geospatial data storage. This becomes necessary in the face of proliferations of cracked software across Africa.
4. A vulnerability map should be produced by the military in conjunction with relevant agencies indicating "soft and hot spots" areas. The vulnerability map will also guide NGOs and health workers in the region with their logistics.
5. The military should collaborate with space research institute in their countries in order to acquire recent high resolution imageries as revealed in the work of Dukiya (2013). This will help in keeping up to date data bank, which can be used for monitoring and predicting impending activities of terrorist in the Sub Saharan region.
6. The controversial Big-Data technology law for national security in which the SAR of each country can access should be define and upheld across the region. The establishment of Big-Data work-station that utilizes the telecomm data base of all service providers for the tracking of terrorist and kidnapers geolocation should be a matter of priority in the region (United Nations, 2015). This will put to rest the problem of anonymous calls by evil perpetrators.

CONCLUSION

The role of RS and GIS in military operation is indispensable, while mechatronics and robotic applications is on the increase in territorial defence and war against terror globally, Sub Saharan Africa countries cannot but join in the crusade if peace will not be a mirage in the sub-continent as advocated in the work of Dukiya and Zagi (2016). Amidst the increasing number of terrorist attacks in sub Saharan Africa (especially in Nigeria and Somalia), it become obligatory for the government to invest in space research as it avail the security operatives the opportunities to trail and predict the activities of terrorism. Big-Data technology is a requirement in an effective tracking and predicting terrorist activities as it will help the Military and other security operative in the Sub Saharan Africa to be well informed ahead of any impeding attack.

Although some researchers are of the opinion that in some cases big-Data may not be necessary where basic social amenities and right data are lacking. Poverty is hazards that incubate terrorism and disaster. Thus, big data may not be the solution for all society problems like deprivation and injustice.

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