

Review of the 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 the threshing floor for human blood is not an overstatement. Terrorists of diverse nomenclature are everywhere, and they seem to be operating with impunity under failed states. This study focuses on the potentials 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). The paper made use of secondary data to reveal the attribute of remote sensing as a real time data collection tool without physical contact with the object of phenomena of interest and the GIS that is used for environmental analysis and decision making in disaster management as a relevant tool for terrorist management. The paper revealed that Big-Data in GIS environment and sensors bearing Unscrewed Reconnaissance Vehicle (UAV) leveraged on natural abilities of birds and fix sensors in them during operations for the surveillance of enemies and the supply of logistics to troops. The paper therefore recommended that all the African countries should invest more in the security agencies human capacity development, remote sensing and GIS hardware and software for effective territorial security and defence.

Keywords: Big Data, Geographical Information Systems, Remote Sensing, Sub Sahara Africa, Terrorism

Introduction

One of the greatest challenges faced in the 21st century is the increasing trend of terrorism in the world in which cities in developed and developing countries have had their own fair share of terrorist attack in one form or the other. In fact, recently continuous terrorist attacks in Sub-Saharan Africa have bred extensive humanitarian crises ranging from loss of lives, forced eviction and loss of property worth billions of dollars. According to Chou

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(2017), 3.6 million people have lost their lives in Sub-Saharan Africa due to terrorism and that the highest manmade disasters in Sub Saharan Africa were recorded in Nigeria and Somalia. The global report on Internally Displaced Persons (IDP) in 2018 put the figure at 5.5 million for the Sub-Saharan Africa. The armed groups and organisations responsible for this terror were the Al-Shabab, Boko Haram, the lord's resistance army and the subsets of Al-Qaeda and ISIS operating in the region. Al-Shabab and Boko Haram were said to be responsible for the majority of the terrorist attacks experienced in the region (Feldstein, 2018).

The increasing number of terrorist attacks has prompted the need for the acquisition of real-time information in a dedicated format that can help in effectively countering terrorist threats. The information needed by security operatives exists in multiple forms and formats, cutting across different geographical locations, physical, socio-economic, institutions, and organizations. The sourcing and integration of data from these different sources by security operatives often require huge resources and time using the classical methods (Coskun *et al.*, 2008). Remote Sensing (RS) and GIS have proven to be very effective in filling the gap created by the classical methods in analysing big data. Remote Sensing and GIS applications in security operatives can be traced back to 1950s when it was solely used by the national military forces for enemy territory surveillance and warfare planning, (Deogawanka, 2015).

The advancement in Information Technology (IT) has resulted into the present global Big-Data model and all forms of algorithms that are used in conjunction with RS and GIS for combating terrorist attacks. It is against this background that this paper is examining the inter-operability of RS, GIS and Big-Data deployment in terrorist attack mitigation in Nigeria and Sub-Saharan Africa countries.

Conceptual Clarification

Remote Sensing (RS) Technology

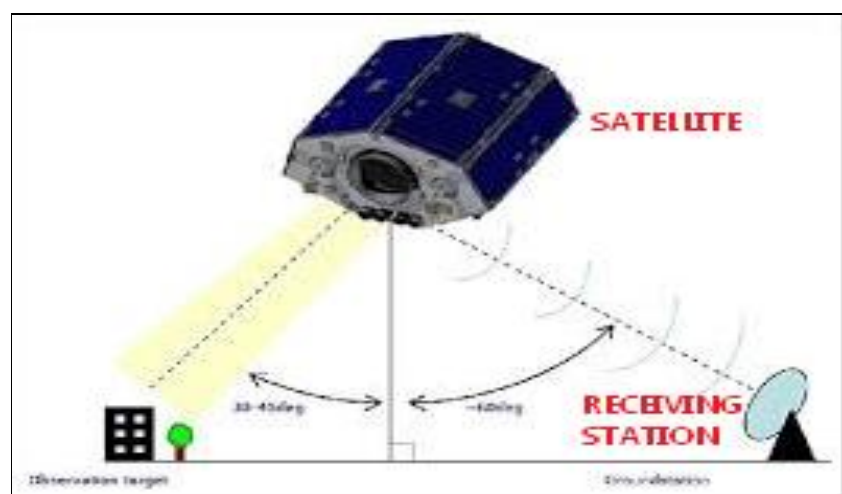
RS can be defined as the measurement or acquisition of information of a phenomenon or an object of interest by a recording device without

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 and passive in operation. These sensors operate in the different regions of the Electromagnetic spectrum from the ultraviolet to microwave with the capacity to collect large amounts of information about the earth's surface daily (Malgorzata, 2010, Dukiya, 2014). The uniqueness of this technology includes the following:

- a. Real-time data-information collection;
- b. Potential for direct Electro-transmission to receiving stations and action areas;
- c. Comparatively low-cost of large area coverage;
- d. Ability to operate day and night via thermal infrared and microwave sensors.
- e. Synoptic coverage with repetitiveness of location.

A wide variety of imagery is made available from different countries' satellite platforms, which range from SPOT, Landsat series, Ikonos, Quick birds, SRTM: NigeriaSat-X and many others. The space satellites acquire images that are downloaded at the countries' ground receiving stations as illustrated in **Fig 1**.

Figure 1: Remote Sensing System



Source: Guo and Philippa (2009)

On a small-scale, as part of RS activities, Unscrewed Reconnaissance Vehicle (UAV) are used by researchers and security agents to fly over combat zones and staging areas, dropping supplies to troops, releasing bombs, and carrying out reconnaissance on enemy forces, (Microsoft Encarta, 2009). UAV are used to carry sensors for aerial surveillance of enemy locations and activities since they are unmanned, while modern research has leveraged on the naturalism of birds and used them to bear sensors that image enemy territory as illustrated in **Fig. 2a,b**

Figure 2: Sensor-bearing UAV and Birds for RS Operations



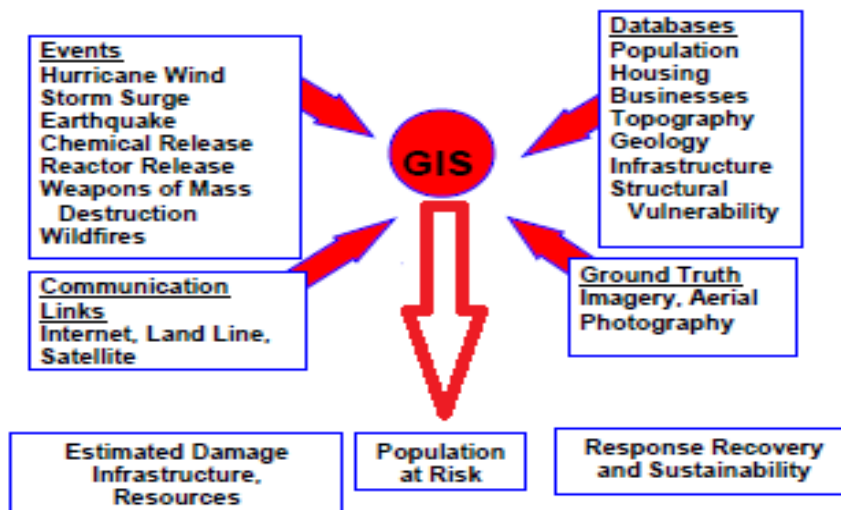
Source: Toro and Tsourdes (2018)

The advancement in RS technology has helped security operatives to achieve a highly favourable and decisive decision in all their operations. For example, in the first space war (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 weather satellite for planning purposes, ammunition selection, reorientation of troops, reconnaissance mission, movement of equipment and optimization for night vision. 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 organisations 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. 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). The GIS operations depend on referenced geographical and attribute data for spatial analysis queries and predictions as illustrated in Fig. 3. GIS applications are generally for environmental analysis and decision making in disaster management and sustainable development.

Figure 3: GIS Model

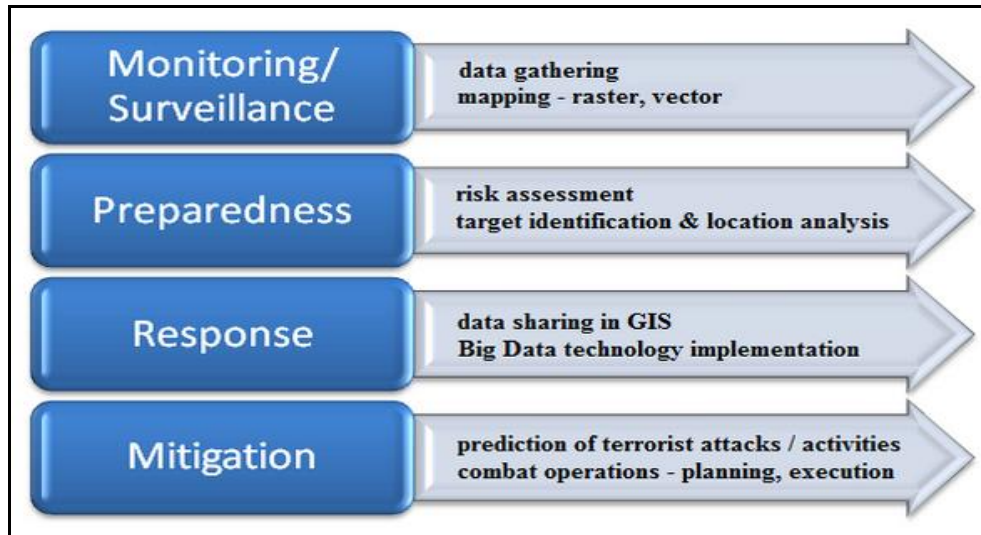


Source: Longley, Goodchild, Majuire and Rhind (2011)

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. Data are shared in a simpler format for easy comprehension,

that is at the third stage (Responses), while prediction of activities combat operation and execution are examined at the fourth stage (Mitigation). The stages in GIS implementation for counterterrorism is as indicated in Fig. 4.

Figure 4: Stages in GIS Implementation for Counterterrorism



Source: Deogawanka (2015)

The Concept of Big Data and National Security

Big Data is a phrase used to mean a massive volume of both structured and unstructured data that is so large and difficult to process using traditional database and software techniques. In another way, Big Data is a collection of large datasets that cannot be adequately processed using traditional processing techniques. It does not refer to a specific amount of data, but rather describes a dataset that cannot be stored or processed using traditional database software which has become a complete subject involving various tools, techniques and frameworks. Examples of big data include the Google search index, the database of Facebook user profiles, and Amazon.com’s product list.

Government agencies harnessing and applying analytics to their big data they have improvise a lot in terms of managing utilities, running agencies, dealing with traffic congestion or preventing the effects of crime, and also

in addressing issues of transparency and privacy. Combination of big data with high-powered analytics can have great impact on strategy such as:

- a. Finding the root cause of failures, issues and defects in real time operations.
- b. Recalculating entire risk portfolios in just minutes.
- c. Detecting fraudulent behaviour before it affects and risks a community, region, or nation.

Big Data sources

Remote Sensing data: the pilot uses data from the Sentinel satellites operated by ESA in the framework of the Copernicus programme funded and managed by the European Commission. The free, full and open data policy adopted for the Copernicus programme foresees access available to all users for the Sentinel data products. The initial satellite data ingested in the pilot comes from Sentinel-1 that has a revisiting time of 6 days above the same areas at mid-latitudes.

Social Sensing data comes from two complementary sources of information: *social media, represented by Twitter*, and *news agencies, represented by Reuters*. Recently, Twitter has emerged as a major platform for on-time detection of events, both in research and in industry. The pilot uses the free Twitter Public Streams API that provides a random sample of its content. The content provided by news agencies through public RSS feeds is also free of charge. Within the pilot, the content from Twitter is used for the extraction of metadata, while the user is pointed to the original source for more information to abide by the principles of intellectual analysis.

Figure 5: Big Data Integration into GIS and Neural Network for National Security



Source: The Big Data Europe Secure Societies pilot (2019)

Methodological Approaches in Rs, Gis and Big Data Analysis

RS Data

High resolution multi-temporal satellite imageries of area of interest (AoI) are 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 a given area (criminal hideouts), which is similar to the pilot work conceived by the European Union Satellite Centre, together with the University of Athens and the NCSR “Demokritos”, (Fig. 5).

Telecom Network Data

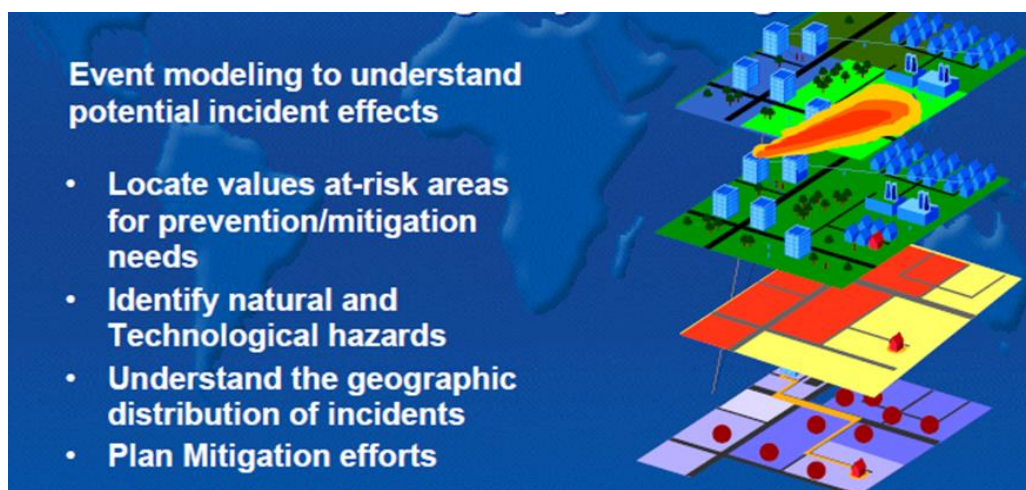
Special Memorandum of Understanding (MoU) between the government and the network providers will be required to access the database of all communication flow within the country. The origin and destination of all

telecom calls have geographical coordinates that are stored in the data base of network providers which form the big data together with social medias like WhatsApp, Twitter, and Facebook. The Change Detection workflow ingests satellite images to detect areas with changes on land-cover or land-use by using change detection techniques; the identified Area of Interest (AoI) is then associated with social media and news agencies' items and presented to the user for cross-validation.

Data Analysis

The social media and news agencies' information that serves as attribute data to the geo-referenced imageries are to be 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 could activate the change detection, where corresponding satellite images are acquired and processed. All the calls made by terrorists 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 law enforcement agents.

Figure 6: GIS Overlay Analysis for Hazard Management



Source: Elham and Masoudi (2012)

Results and Discussion

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 following are the success stories of RS, GIS and big data in combating terrorism.

In assessing the damage and loss incurred during and after the terrorist mayhem in a region, RS and GIS is carried out by geometry (polygons/polylines) created on the satellite imagery. This procedure was used by the Nigerian Military in 2015 to evaluate the damage done by Boko Haram in Bama, Borno State. Military personnel are availed with the opportunity to carry out reconnaissance survey of large expanse of land in short time with the aid of remote sensing and GIS. Features that appear vague during the reconnaissance survey can be detected using near “infrared”. After a critical evaluation of the surrounding /environment through the use of the “near infrared”, paratroopers and other logistics can be deployed.

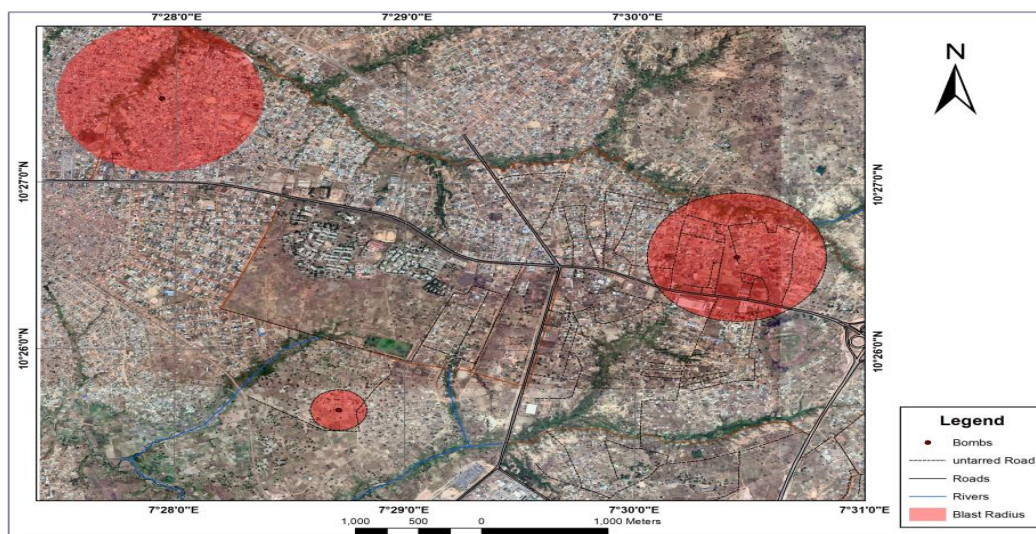
Pre-attack activities of terrorists can be monitored by military personnel in space over a period of time with the use of remote sensing platforms. Victims and terrorists can be tracked in real time, and this information can be retrieved and catalogued using ArcGIS full motion video add-in or the hexagon geospatial Geo-media motion Geo Video analyst (Gisgeography, 2018). Monitoring of terrorist activities by military personnel 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 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. This map will help Military officers to familiarize themselves with peculiarities of terror activities (arson,

abduction, suicide attacks and bombing) attributed to different locations, streets and districts within a region.

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. 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 be use as a vulnerability map to caution the populace on where to develop their properties, location they should not visit and a blast radius. The Buffer map generated through the “*analysis tool*” on ArcGIS can serve as a guide in evacuating residents within the trouble zones. **Fig. 7** shows a vulnerability map indicating a blast radius.

Figure 7: Multiple Bomb Locations with their Respective Blast Radius



Source: Author's Field Data (2018)

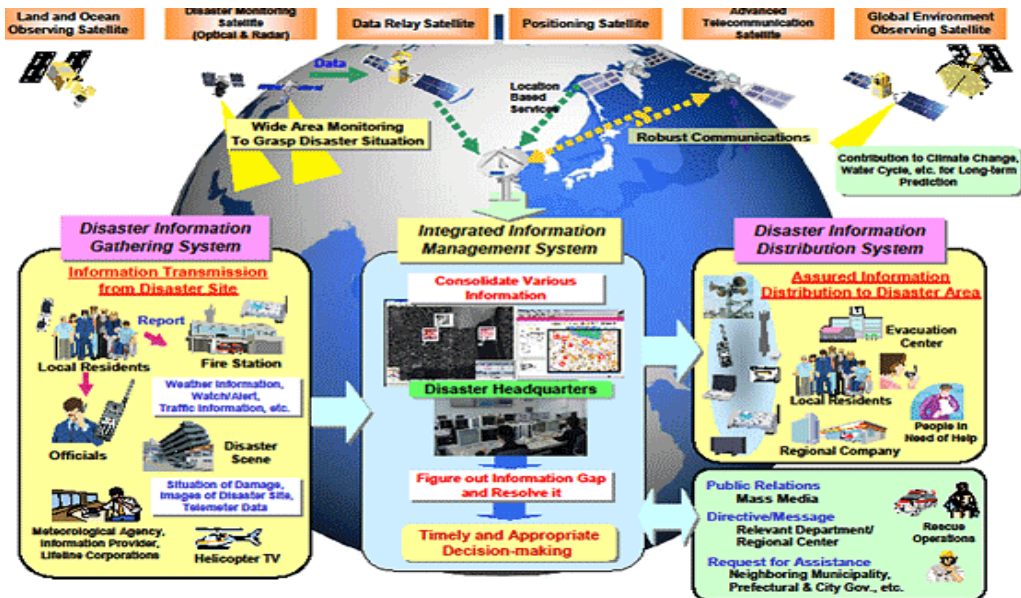
Terrorists are sensitive about spaces and places for their planning and training (Alharith and Samak, 2018). Therefore, it is pertinent for military personnel to understand the terrain of the location where terrorist operate before any rescue mission is carried out. RS and GIS provides military personnels the opportunity to analyse the terrain of the area they intend 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 just like the plans of terrorists. 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 referenced base map with clear features that would aid effective counter attack. 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 most essential component for monitoring terrorist movements, communicating with ground operations and actual police/military trail or combat as illustrated in **Fig 8**.

Synthetic Aperture Radar (SAR) observation provides more accurate elevation data than optical observation and can be used for mapping. Additionally, it is suitable for resource management purposes such as monitoring for illegal settlements through periodic observation. Today, we can proactively detect and prevent disasters by observing the earth from space.

Figure 8: Disaster Monitoring Solution Architecture



Source: Elham and Masoudi (2012)

The Challenge for Adoption in Sub-Saharan Africa

Though the roles of RS, GIS, and Big data in combating terrorism cannot be overstressed, the issues that are acting as impediment to their usage in Sub-Saharan Africa including Nigeria are as follows:

- i. **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 equipment. The issue of unavailability of data and poor data management has been hindering the effective utilization of RS and GIS. In fact, one can easily download archive satellite images of western countries than get access to imageries from Nigeria satellite. Data acquisition in Sub Saharan Africa is always marred by long bureaucratic processes.
- ii. **Inadequate Skilled Personnel:** for effective utilization of RS and GIS tools, it is important to have adequate skilled personnel who are versatile in manipulating of software and equipment that will aid data collection in countering terrorism. Personnel with these capacities

tend to be inadequate amidst security operatives in Sub-Saharan Africa.

- iii. **Poor funding:** little or no funds are often allocated to relevant research institutes and this affects 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 is the bane of military ineffectiveness in the Sub-Saharan Africa.
- iv. **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 nation's, universities of technology as a feeder to national security.
- v. **Over politicking of issue:** In the words of Professor Emeritus Eskotoyo, 'there is no democracy in Africa but plutocracy'. The aforementioned argument is based on the observation that all issues accorded attention in Africa's democratic practice are marred by politicking to the detriment of the commoners. This phenomenon results in state and non-state actors paying lip service to issues that threaten their very survival. For instance, Boko haram started as one state's affair and was handled as such, without the seriousness required, and has now become a threat of national concern.
- vi. **Cancer worm of misappropriation of fund:** this is not unconnected to the value system in the continent and is seen as a "monsters" that has eaten deep into the fabrics of sub-Saharan States. 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.

Recommendations

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

- i. There should be training and re-training of military officers in latest software to man the GIS workstation within their jurisdiction in order to enhance their technical knowhow. The national search and rescue units should be devoid of nepotism as obtainable in the western world. and techniques in order to abreast them of knowledge on how to tackle current and trending issues as regarding terrorism and other form of insecurity ravaging sub-Saharan Africa.
- ii. 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 of the impending activities of terrorist in the Sub Saharan region.
- iii. The government should as a matter of urgency establish the National Search and Rescue Operation Agency with modern day equipment. While the national satellite should be upgraded to carry on board **RADAR sensor** that can operate day and night and as well penetrate the sub-surface to detect bombs buried in targeted areas.
- iv. The government should also as a matter of urgency pass into law the Big-data technology for national security in which the SAR of the country can access the telecommunication data base of all service providers for the tracking of terrorist and kidnapers geolocation and networking. This will end the problem of anonymous calls by evil perpetrators.
- v. The law enforcement agents of the Sub Saharan countries should invest more in local Research and Development (RD) and sponsor specific research in universities of technology in the country as feeders to their operational prowess. This will help the military carry out researches that are worthwhile in countering the four components (where, when how and who) of terrorism.

- vi. A vulnerability map should be produced by the military stating “*soft spot*” and “*hot spot*” areas. The vulnerability map will also guide NGOs and health workers in the region with their logistics.

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 African 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 has become obligatory for the government to invest in space research as it will avail the security operatives the opportunities to trail and predict the activities of terrorists. Tracking and predicting the activities of terrorists will help the Military and other security operative in Sub-Saharan Africa to be well informed ahead of any impending attack.

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