Geographic Information Systems as a Tool for Effective Counter Terrorism across the United States

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ABSTRACT

The study is focused on the use of GIS technology systems for countering terrorism in the United States. Hence, the study is aimed at analyzing the application of GIS to counter terrorism. The study reviewed literature relating to the subject matter (GIS and terrorism). The components of GIS were reviewed in the study. Functionalist theory was adopted as the theoretical framework in the study. The study's findings revealed that technology such as GIS gives security agencies and the military an advantage in strategizing how to combat terrorism. It was also revealed that some of the applications include using drones to take aerial photographs and using GIS technology to simulate terrorism scenarios. Also, technology like light detection and ranging data in GIS are also used to analyze and understand areas where terrorists' habitats exist and develop accurate strategies. Geographic profiling features of GIS can also be applied when analyzing terrorists' areas and hot zones. The study recommended that research centers be financed to enhance innovation and conduct further research on the invention of new GIS technologies. Regular training and retraining of security agents or personnel should be done to educate them on how and when to use GIS technology to make decisions effectively. The government should also ensure the protection of data gathered by means of GIS on the profiles of suspected terrorists and terrorist buffer zones. GIS equipment should be installed in all areas of the country, and special attention should be placed on isolated areas and areas that have been marked as "hot zones" or "dark spots." This equipment should be checked and serviced regularly to ensure that it is up-to-date and still functioning properly.

KEYWORDS

Geographic Information System, geo-informatics, geography, cybersecurity, and counter terrorism.

1. Introduction

In this age of advanced technology, internet has become an effective tool of mass destruction and a reliable means of communication for terrorists. According to [1], "*depending on the specific problem to be solved or the investigations being made, matching sensors are selected to ensure that the results contain useful and easily quantifiable data*". This is so because internet can be accessed by anyone anywhere irrespective of their country and it aids terrorists in planning and strategizing on how to perpetrate their actions. The internet can be used as weapon by criminals and their organizations to cause body harm and cause damage to buildings, cause train crashes, plane crashes and explosions in public places (school, markets, fun parks, etc.) that may result to loss of many lives. Terrorist also use internet to cause damage to public and private IT infrastructures. Despite the disadvantages posed by use of internet by terrorists, GIS also uses internet to track activities of terrorists. The GIS technology makes it possible and easy to synthesize large volumes and varieties of data, while combining different layers of information to manage and retrieve data. GIS technology helps in solving problems and presents information in visually friendly manner that can help security agencies make decisions. The deployment of Geographic Information System through internet is creating new benchmarks as well as posing new problems for effective use of web-based geospatial applications [2].

In recent years, the rate of terrorists' attacks has been on the increase. The attack on the Twin Towers and other attacks are part of the reasons why it is necessary for government to develop and implement measures to prevent and mitigate terrorist activities [3]. Societies of the world have always found one way or the other to cope with terrorism. An example is the wake of the September 11 attack and subsequent attacks. The US government established the Department of Homeland Security to prevent and minimize the potential impacts of terrorism in the country. Prior to the attack on September 11, 2001, GIS technology was used during emergency response and used in recovery phases to rescue lives in event of major natural disasters in US. GIS technology was popular

for its usage after the Northridge Earthquake. The technology was used to gather and record information about damage, create maps showing the intensity of the earthquake and locate emergency shelters for victims of the event [4].

In fighting terrorism, geography is as important as it is to other facets of life. Security agencies use the 3D model of GIS for analysis of an area, digital photos of landscape in 3D view with features of rotating to different angles can be used to get details of a landscape [5]. To provide protection for such areas, such technology can be very useful. A viewshed is another GIS technology that can be used to trace terrorist as it can draw line or path through which a target can walk or drive. Another GIS technology that has proven useful for security agencies in tracking and fighting terrorism is the 3D spatial information which can recreate an area with real life photos and imagery, this helps to eliminate the stress of taking multiple trips to an area [6].

Terrorists are aware of the loopholes or vulnerability that may occur with the use of internet, so they use tools and software that can hide their identity or domain. They are also sensitive about their space and areas especially where they can strategize and do training. Geographic information tools will be very effective tools in tracking activities of terrorists, GIS has technology like 3D applications of hot spot identification that can be used to prevent terrorism. This study therefore examines the application of Geographic Information System in fighting terrorism.

2. Literature Review

Geographic Information System is an existing computer system that is set up to capture, record, store and analyze information relating to features on earth's surface [7]. GIS is a computer-based tool used for mapping, identifying, and analyzing elements and events that occur on the earth's surface. The technology combines database operations and statistical analysis with the unique visualization capabilities and geographic analysis benefits provided by maps. The benefits from use of GIS makes it different from other information systems, this makes it more valuable in various fields of life in predicting

outcomes, analyzing events and planning strategies [8]. GIS is also called the Geospatial information system which of capable of integrating, storing, editing, analyzing, sharing, and visualizing geographically referenced information [9]. It combines various maps and remote sensing technology to generate various models which are used in real time environment. GIS is used to obtain information relating to earth features and their locations, monitor events as they happen, retrieval and display of special data and mapping. GIS uses remote sensing which has sensor technologies that that identifies and classes objects on the earth [10]. GIS is also used for geographic profiling as it makes it easy to enter an address digitally, analyze the address with patented algorithm that produces a probability surface showing likelihood address of targets. Over the years, the emergence of GIS has proved to be very effective as helps solve problems of mankind [11]. GIS consists of computer components (hardware and software) and procedural systems which are established for the purpose of capturing, administering, tweaking, analyzing, and graphing referenced geographic data to combat crime[2]. GIS is used to comprehensively analyze areas and can be used in all fields of life [12]. It is necessary to use GIS to make any decision that involves spatial information where simple maps are not sufficient. Security agencies also require GIS to effectively put in place, preventive measures against terrorism and to tighten security in threatened areas using spatially related decisions[2]. According to [1], "*depending on the problem to be solved, GIS could also be applied in other areas such as detection of groundwater aquifers and other geological areas.*

2.1. Components of GIS

There are five key components that are being integrated while using a GIS system: the hardware, software, data, people, and methods.

2.1.1. Hardware

This is the computer system which the GIS technology operates. The software technology works on different ranges of hardware, from centralized services to desktop to laptop used singly or as connected systems through networked configurations.

2.1.2. Software

This is a very key component that is regarded as GIS itself. The GIS software has features that provide the functions and tools needed to store, analyze, and display geographic information. The GIS software can be commercial software which is being paid for or developed on open-source domain where it can be gotten for free[9]. The key software components are:

     i.   Tools for input and manipulation of geographic information.
    ii.   Database management system.
   iii.   Tools that support geographic query, analysis, and visualization.
   iv.   Graphical user interface (GUI) for easy access to tools.

2.1.3. Data

This is another key component of GIS. Data can be sourced internally or purchased from commercial data providers. Geographic data and related tabular data are used in GIS, this data is integrated with spatial data while using database management system to manage, arrange and maintain spatial data. The spatial data can be in the form of a map or remotely sensed data such as satellite imagery and aerial photography. The data forms must be properly geo-referenced in latitude and longitude.

2.1.4. People

The GIS system becomes of limited value without personnel who manage the system and develop plans to apply the technology to real world problems. Users of GIS technology range from technical specialists who design and maintain the system to the users that use the technology to perform everyday tasks. Users of GIS are mainly interested in the results that are being generated from using the GIS. GIS has a user-

friendly interface that allows nontechnical users to have easy access to analytical features of the GIS without knowing detailed command [9].

2.1.5. Methods

Use of GIS technology yields result if used with appropriate processes and well-designed plans and rules which are particular or unique to each organization as the technology is used in various fields of life [8].

2.2. GIS Tasks

The tasks or processes of GIS can be broadly categorized in five, Input, Manipulation, Management, Query and Analysis and Visualization.

2.2.1. Input

Geographic data collected for use in GIS is first converted to suitable digital format as input. Digitized maps, spatial data, images, and tables are loaded in GIS as inputs. The process of converting data from paper maps to computer files is known as digitizing. Modern and advanced GIS technology has features that automate the process of digitizing for large projects using scanning technology. For smaller projects, this process is done manually using a digitizing table. There are also geographic data which are available in GIS compatible formats on data suppliers, this data can be loaded directly into GIS [8].

2.2.2. Manipulation

This involves transforming or adjusting data to a type required for a particular GIS project that will be compatible with the system. This manipulation could be temporary for display purposes or permanent one for analysis. GIS technology has tools for manipulating spatial data and deleting unnecessary data.

2.2.3. Management

For large volumes of data, in most cases the number of users becomes large, a database management system is required to help store, organize, and manage data. For small GIS projects, geographic data may be stored as simple files. There are different designs of Database Management System (DBMS), in GIS the relational design is the most useful as it stored data conceptually as collection of tables.

2.2.4. Query and Analysis

GIS technology is used to solve problems and provide answers to questions or queries. The technology with geographic information is used to answer simple questions like:

- o Who owns the portion of land on the corner?
- o How far is the distance between two places?
- o It is also used to answer analytical questions like.
- o What is the dominant soil type for oak forest?
- o If a new highway is built in the area, how will traffic be affected?

The technology provides both point and click query capabilities and has features that provide timely information to managers and analysts like. Analysis involves conducting spatial analysis or geographic analysis using geographic properties to look for patterns and trends to undertake "*what if*" scenarios[9].

2.2.5. Visualization

For many types of geographic operation, the result or output is best visualized as a map or graph. Maps are more efficient and advisable to use for storing and communicating geographic information. GIS provides new and exciting tools to extend the art and science of cartography. Map displays can be integrated with reports, three-dimensional views, photographic images, and other outputs such as multimedia[8].

2.3. Terrorism

This can be regarded as action that causes terror, violence, killing, intimidation, bombing, etc. [13]. In a United Nations Report, terrorism was described as any act intended to cause body harm or death to non-military personnel usually civilians with the purpose of compelling government to a agree to some demands or intimidate the population [11]. It is the perpetration of indiscriminate and planned acts of terror or violent acts done to create fear and intimidation for the purpose of forcefully achieving an economic, political, or social goal. Among the examples of actions that are regarded as acts of terrorism include kidnapping, bombing of public infrastructures, mass killing of defenseless citizens, rape, armed robbery, etc.[13]. In 18 US Code 2331, terrorism is defined as "violent acts or acts dangerous to human life that occur primarily within the US territory". The act categories terrorism into 3 components; that is, act that is intended to intimidate the civilian population, act that is aim towards influencing the policy of government by force and involves mass destruction of properties and lives, kidnapping and assassination [14].

In 1994, the United Nations General Assembly's Declaration on Measures to Eliminate International Terrorism, set out in its resolution 49/60, defined terrorism as "criminal acts intended or calculated to provoke a state of terror in the general public, a group of persons or particular persons for political purposes" and that such acts "are in any circumstances unjustifiable, whatever the considerations of a political, philosophical, ideological, racial, ethnic, religious or other nature that may be invoked to justify them" [15]. In 2004, the security council of UN in its resolution 1566 defined terrorism as "criminal acts, including against civilians, committed with the intent to cause death or serious bodily injury, or taking of hostages, with the purpose to provoke a state of terror in the general public or in a group of persons or particular persons, intimidate a population or compel a Government or an international organization to do or to abstain from doing any act" [15]

2.4. Theoretical Framework

2.4.1. Functionalist Theory

The theory sees society as an integrated social system which consists of many parts that come together with the aim of achieving a goal that makes the system work. The theory postulated that as the system continues to evolve and exist, faults and challenges are developed along the line. It is necessary to adopt inherent internal mechanism to adjust or resolve the problems to meet up with needs of growth and development [13]. Functionalists believed that human society exists because of human existence. As the society experience development, problems like crime, poverty, unemployment continue to emerge thereby leading to serious insecurity problems. As the insecurity problem occurs, society initiates and implements measures to resolve the problems through internal mechanisms. The theory postulated that terrorism is inevitable as it is associated with growth and development but can be resolved through process of social adjustment [16].

2.4.2. Empirical Review

The role of GIS in effective control of terrorism in Nigeria was evaluated by Umar [13]. The study adopted secondary data and concluded that GIS can be useful in monitoring terrorists' hot spots, possible targets, movement of arms and suspects, as well as, intelligent gathering and accurate profiling of suspected persons, with the view of interrupting, intercepting and possibly smashing intended terrorists' attacks in the country.

According to [2], examined the application of Geographical Information Systems (GIS) in the Kingdom of Saudi Arabia to combat terrorist activities. The study revealed that different tools and methods related to GIS technology are discussed and their applications in ensuring effective security measures are focused upon. It was concluded in the study that GIS provides the technology that enables geographical data collection from LIDAR, aerial photography and satellite imagery, data that is captured, stored,

analyzed, and displayed in maps. The maps can reflect hot-spot gas field and oil field where terrorist activities are carried out. This also makes geography a key subject in understanding such activities. Apart from terrorism, the public health sector also has a huge application for GIS. Such technological methods require effective mapping and when combined with geospatial technologies, terrorism can be countered with appropriate action.

In [17], the analysis focused on how integration of GIS and spatial mining techniques is used in fighting Boko Haram Terrorists in Nigeria. The study concluded the integration helps to accurately predict the targets of Boko Haram Terrorists in Nigeria. GIS and spatial Data mining technique have been applied in a wide interdisciplinary research area spanning several disciplines such as expert system, database system, statistic, security modeling, environmental studies and intelligent information systems.

In [6], the exploration delves on how terrorism can be prevented through using three-dimensional (3D) analysis for the protection of populations in urban environments. The study adopted primary methodology using the concept of a viewshed and line of sight (LOS). To test the model, the Gerald R. Ford Funeral in Grand Rapids, Michigan, is used to examine the protection of individuals from sniper fire. It is found in the study that using viewsheds has good potential to aid protection agents responsible for protecting individuals and populations.

In [18], the analysis focused on the geographical perspectives and the various approach in terrorism research. The article suggested three particular contributions from geographical perspectives; local level governance failures result to grievances and create opportunities for terrorists to establish black spots which geographical location later becomes territory for terrorism; the terrorist attack cycle occurs along specific spatial trajectories that can be identified and possibly policed; the study also suggested that terrorist attacks have significant negative impacts but are spatially limited and not as serious as presumed by much of the conventional literature.

3. Application of GIS on Counter Terrorism

The use of GIS helps crime analysts in identifying crime hot spots and the crime patterns used by criminals. The feature of geographic profiling possessed by GIS enables analyst to nearest principle as key to tracking criminals within a limited range that is comfortable to be arrested by law enforcement officers. It is very important to note that the occurrence and distribution of terrorism like other crimes in all its ramifications is of geographical relevance because it has to do with the human environment [19]. Hence, the GIS is functionally necessary and inevitable in effective combating terrorism. According to [20], GIS can also be used to predict activities of terrorists group. GIS is used to do intelligence analysis. Light Detection and Ranging data in GIS are a sensing technology which allows for collection of dense samples in 3D, it can be used to analyze and understand areas where terrorists' habitats to develop accurate strategies [21]. Also, the UAV (Unmanned Area vehicles) technology of GIS can be used to identify positions and take photographs of areas which are perceived inaccessible [2]. GIS produced maps are used to monitor terrorists' activities and movements. GIS is also used for simulation of scenarios involving terrorists' attacks and targets who are difficult to track. In response to terrorists' attacks, GIS can be used to strategize by using knowledge of attack sites provided by GIS technology to access the site. Also, to assess the aftermath effect of terrorist attack, GIS with airborne technologies like aerial videography and infrared detection can be used to examine the short- and long-term effect of the attack and identify area that can be used as evacuation zones [22].

Unmanned Aerial Vehicles (UAR) also known as drones, are powered by an engine which has features that enable it to independently maintain, control and sustain flight. Drones are usually in different, shapes and configurations and can either be controlled remotely or configured to fly towards certain direction autonomously [23]. Drones can be used by security agencies and military to combat terrorism by using it carry out intelligence tasks such as revealing the enemy's hiding places, scan enemy or terrorist territory, to take aerial photographs etc. Such drones are usually very small such that

they are difficult to notice Drones are also used for combat purpose of discharging bombs on terrorist territory. The use of drones is cost effective and helps eradicate risk associated with using human to carry out those tasks. Remote sensing technology is used to gather data for GIS. Among the common types of remote sensing technology or method is the Light Detection and Ranging (LIDAR). LIDAR is a surveying method that measures distance from its laser emitter to an object or surface using a pulsed laser beam. The distance is determined by measuring the time delay between the pulse emission and detection of the reflected signal. Information obtained using the LIDAR is a very important component of any GIS set up. Data from LIDAR enables production of longitudinal profiles with high precision. Remote sensing technology like LIDAR have features that allow for detection of installations or structures that are not noticeable if any type of aerial photography is used. It provides additional information that are not easily noticeable to security forces to carry out preventive operations in the area [24]. The technology can be used at any time and any day as the laser is an active sensor which is not affected by atmospheric conditions and solar light.

4. Conclusion and Recommendations

The use of internet and advanced technology have made terrorism easy for perpetrators as it helps them navigate, strategize, and carry out their crimes. On the other hand, technology like GIS gives security agencies and military advantage to strategize on how to tackle terrorism while doing it lower risk, the technology also helps in putting measures in place to prevent terrorism. It is concluded that GIS have various application in terms of combating terrorism, some of the application include using drones to take aerial photography, use of GIS technology to simulate terrorism scenarios, this prepares security agencies when putting up strategies to prevent or combat terrorism. Also, technology like Light Detection and Ranging data in GIS allows for collection of dense samples in 3D which can be used to analyze and understand areas where terrorists' habitats to develop accurate strategies. Geographic profiling features of GIS can also be

applied when analyzing terrorists' area and hot zone. From the conclusion of this study, it is recommended that research centers are financed improve innovation and conduct further research on invention of new GIS technologies and how to better ones. It is also recommended that regular training and retraining of security agents or personnel should be done to educate them on how and when to use GIS technology to make decisions effectively. Government should ensure protection of data gathered by means of GIS on the profile of suspected terrorists and terrorists buffer zones. This data should also be handled by highly trained professionals for effective analysis and control. GIS equipment should be installed in all areas of the country, special attention should be placed on isolated areas and areas that have been marked as hot zone or dark spot. This equipment should be checked and serviced regularly to ensure that it is up to date and still functioning properly.

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Short Biography

Callistus Obunadike holds three Master of Science degrees in geology, mining engineering, and computer science. Callistus combines his extensive knowledge of geosciences with data science. Callistus has a passion for applying machine learning algorithms to improve geological processes and predicting of future events.

Kunle Oloyede has a B.Sc. in Geography and M.Sc. in Geographic Information System and is currently pursuing his second M.Sc. degree in Computer Science & Quantitative Methods. With 7 years of experience in the IT space. Kunle is passionate about using data to forecast and improve organizational metrics.

Adeniyi Phillips is a highly skilled professional with a passion for leveraging data to drive innovation and improve business outcomes. Holding a master's degree in computer science, he has established himself as a proficient data engineer with a keen understanding of cutting-edge technologies and their applications.

Somtobe Olisah is a geoscientist and data analyst with a bachelor's degree in Geological Sciences and double master's degrees in GeoMining, and Predictive Analytics. He has gained experience in geological modeling, and machine learning. He is interested in the application of data analytics across geosciences and believes it has the potential to revolutionize risk assessment and environmental remediation.

Echezona Stanley Obunadike is a dynamic and dedicated individual in the realm of technology and data, stands as a proficient graduate armed with a Master of Science (MSc.) degree in Computer Science & Quantitative Methods, specializing in Predictive Analytics. He also holds a Bachelor of Science (BSc.) degree in Biochemistry. His diverse and impactful professional experiences, and his zeal for leveraging data to create positive change define his narrative

Esther Taiwo, a dedicated professional in the IT and data field holds a Bachelor of Science (BSc.) degree in Mathematics and Statistics. Currently, she is pursuing a Master of Science (MSc.) degree in Computer Science and Quantitative Methods. Esther's passion lies in utilizing data to foster innovation and enhance solutions that positively impact our world.

Babatunde Yusuf, driven by an enduring passion for data analysis, graduated with a bachelor's degree in computer science from the University of Ibadan. Presently pursuing a master's at Austin Peay State University, whose focus lies in Predictive Analytics, covering skills like Python and Machine Learning. Outside of this realm, he's a loving husband since 2019 and takes pride in parenthood with his son, illustrating his commitment to both data and family.