A GIS Approach to Crime Mapping and Management in Nigeria: A Case Study of Victoria Island Lagos

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Key words: Geoinformation/GI, Spatial Planning, Crime Management and GIS.

SUMMARY

The level of development in any community depends to a large extent on its state of security. Over the years the rate of crime in Nigeria has been on the increase and these crimes are being carried out with more perfection and sophistication. Due to lack of adequate and modern technology and sufficient manpower, the Nigerian security agents have not been able to effectively tackle the issue of crime in the country. This has led to the formation of various vigilante groups, to combat crimes in some parts of the country. However, these groups have only succeeded in creating other problems instead of solving the existing ones. Geographic Information System (GIS) offers itself as a tool for effective crime mapping and management. It has many applications and promotes collaborations across a wide variety of disciplines. Therefore, crime analysis using GIS is today relevant in Nigeria, as the rate of crimes is very much on the rise. Since crimes have situational relevance, and hence have a positional element attached to them, GIS can be a very useful tool to display and apply spatial analysis to data, which reside in large databases, in order to obtain a strong visual appreciation of the patterns of crimes. This paper focuses on the utilization of GIS in the mapping and management of crimes in Nigeria using Victoria Island, an area in urban Lagos, as a case study.

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1. INTRODUCTION

Criminal activity continues to be a major concern in contemporary society. Most nations are faced with unacceptable levels of delinquency and crime. In many of the world's industrialized countries crime rates recorded by the police are many times those recorded 30 years ago. The International Crime Victim Survey (ICVS) has collected data on 55 countries, spread over six major world regions including Africa, Asia, Central and Eastern Europe, Latin America, and Western Europe. Findings showed that for the 1989–1996 period, more than half of the urban respondents reported being victimized at least once regardless of what part of the world they inhabit (Ackerman & Murray 2004). Also, it was stated that high crime rates are not unique features of a few nations, but a statistically normal feature of life all over the world. Research efforts seeking to explain the geographic variation in the rate of crime has been ongoing for more than 150 years (Eck and Weisburd, 1995). Quite a lot of researches have been carried out on integrating GIS application to crime.

The existence of crime is as old as the creation of man itself and man has always looked for ways to combat it and reduce it as much as possible. The occurrence of criminal activity in the form of thefts, assaults, homicide, etc is something that takes place every day in almost all reaches of our world. There is a great deal of debate on the causes of crime. In the 1980s, the rate of crime occurrence grew sharply to nearly epidemic proportions, particularly in Lagos and other urbanized areas due to population explosion by stark economic inequality and deprivation, social disorganization, inadequate government service and law enforcement incapability, unemployment, socio-political conditions etc. (Murray et al, 2001). A community with a high rate of criminal activities is unattractive or less attractive to both local and foreign investment and this is the present situation that prevails in parts of Nigeria. The Nigerian security agents, especially Nigerian Policemen, are not particularly effective in foreseeing where and when specific future crimes will take place.

The distribution of crime across the landscape is geographically random since crimes are human phenomena. For crimes to occur, offenders and their targets - the victims and/or property - must exist at the same location for a period of time. Several factors, including the lure of potential targets and simple geographic convenience for an offender, influence where people choose to break the law. Therefore, geography plays an important role in law enforcement and criminal justice. A popular slogan says criminals are not spirits. They move from one place to the other, and live in the society just like every one of us (GIS team, 2005).

The traditional and age-old system of intelligence and criminal record maintenance has failed to live up to the requirements of the existing crime scenario. Manual processes neither provide accurate, reliable and comprehensive data round the clock nor does it help in trend prediction and decision support. It also results in lower productivity and ineffective utilisation of manpower. The solution to this ever-increasing problem lies in the effective use of Information Technology.

A Geographic Information System (GIS) as a tool can be used by police personnel to plan effectively for emergency response, determine mitigation priorities, analyse historical events, and predict future events. GIS can also be used to get critical information to emergency responders upon dispatch or while en route to an incident to assist in tactical planning and response. GIS helps identify potential suspects to increase investigators suspect base when no leads are evident. Response capabilities often rely on a variety of data from multiple agencies and sources. The ability to access and process information quickly while displaying it in a spatial and visual medium allows agencies to allocate resources quickly and more effectively. In the 'mission-critical' nature of law enforcement, information about the location of a crime, incident, suspect, or victim is often crucial to determine the manner and size of the response. GIS software helps co-ordinate vast amounts of location-based data from multiple sources. It enables the user to create layers for the data and view the data most critical to the particular issue or mission (Johnson, 2000).

GIS helps crime officers determine potential crime sites by examining complex seemingly unrelated criteria and displaying them all in a graphical, layered, spatial interface or map. It also helps them map inmate populations, fixtures, and equipment to provide for the safety of inmates by separating gang members, identifying high-risk or potentially violent inmates, and identifying hazardous locations in an area. It reduces the potential for internal violence by providing better command and control (Johnson, 2000).

GIS can be used as an investigative methodology that uses the locations of a connected series of crimes to determine the most probable area of the residence of the offender. It can serve as the building block for several investigative strategies, including suspect and tip prioritization, address-based searches of police record systems, patrol saturation and surveillance, neighborhood canvasses and searches, and DNA screening prioritization. GIS technology, by high-end spatial analysis and querying, highlights the crime location, any physical boundaries that were present (that might not otherwise be noticed), and the types of roads and highways that come into both the abduction and body dump sites (Karthik, 2004).

Applications of GIS to crime mapping and management have been successful in many developed countries. Information associated with crime in Lima and Columbus (Ohio) was acquired and integrated in a GIS environment (Murray et al, 2005). Analysis in Lima has spanned crime from 1999 to the present. As a result, the work informed policy and decision making in Lima Police Department activities, particularly with respect to community policing (Murray et al, 2005).

The U.S. Department of Justice, Criminal Division, has developed an ESRI MapObjects based spatial crime analysis system. The application, known as RCAGIS (Regional Crime Analysis GIS), was specifically developed to assist police departments in analyzing crime on a regional basis (David & Alex, 1999).

In an effort to help prevent murders and aggravated battery with firearms, the Chicago Police Department's (CPD) Deployment Operations Center deployed GIS technologies to present crime information in geographic context. The point of using GIS technologies is to allow officers to make better-informed decisions about which areas of the city need additional police power. The first six months of GIS deployment, the CPD saw an 18 percent drop in murders compared with the same period the year before (Anne, 2004).

In Soneye (2002), it was established that a large proportion of the men of the Nigerian Police Force can hardly ascertain the areas under the jurisdiction of their stations or define the shortest route from their station) to specific crime areas. He concluded that the police stations in Ikeja LGA are far from being distributed according to geographical spread, population characteristics or crime incidence.

Currently, GIS is not being used for crime control and management in Nigeria. This is probably due to the lack awareness of the benefits offered by GIS in crime control and management in the country.

2. OBJECTIVES OF THIS STUDY

The objectives of this study are:

- To produce a map of Victoria Island showing plots and streets and create an attribute database containing the addresses, types and purpose of buildings e.t.c. as well as street names with a view of aiding the police to map out the scene of a crime and its environment to facilitate quick response to distress calls.

- To build a road network analysis to assist the police force get to a crime scene through the shortest possible route hereby facilitation quick intervention.

- To carry out a detailed analysis on the type of crime, location, time or period e.t.c. in Victoria Island with a view of making useful suggestions as to the reason for the prevalent of such crimes and proffer solutions for tackling such cases.

3. SCOPE OF THIS STUDY

The use of Geographical Information Systems (GIS) technology to map crime is a rapidly expanding field that is, as this paper will explain, still in a developmental stage, and a number of technical and ethical issues remain to be resolved. This paper will only give an overview of how GIS can be used as a potential analytical tool to reduce crime rate in Nigeria, using Victoria Island as a case study.

4. METHODOLOGY

4.1 Data Acquisition

Generally, data required for any GIS could be grouped into spatial and attribute (non spatial) data and there are various methods for obtaining these data.

4.1.1 Spatial Data Acquisition

The spatial data was obtained by taking GPS observations of the coordinate of the police stations, additional data were obtained from existing digital data files from past projects.

4.1.2 Attribute or Non Spatial Data Acquisition

The bulk of the attribute data were obtained directly from the field and police formations. The plot attributes such as address, purpose, height, name e.t.c were obtained directly from site. This was done by going to site with paper map(s) and identifying individual plots on the paper map and in the real world and entering in the attributes of each plot using already specified identity numbers. The data on crime record was obtained from the police station in Victoria Island. Some were also obtained from other police formation and the Federal Office of Statistics. Attributes of the police stations were also obtained while GPS readings of the stations were taken.

4.2 Spatial and Attribute Data Creation

This segment discusses methods used in converting analogue data to a digital format.

4.2.1 Creation of Spatial Data

The analogue map of Victoria Island obtained was scanned, then different features were digitized (on screen) on different layers in AutoCAD 2000 after georeferencing. The digitized map was then imported to ArcView GIS 3.1 where the coordinate of the police stations obtained using GPS which was saved in Microsoft Excel as a dBase IV file was added as an event theme.

4.2.2 Creation of Attribute Data

Some of the database of the attribute data acquired were created using Microsoft Excel and saved as dbase IV file and imported into ArcView 3.1 as an event theme while some were directly created in ArcView 3.1.

4.3 Data Processing

To carry out a proper analysis of the trend of crime occurrence in the area of study, there was a need to delineate the area into zones and study the characteristics of each of the zones as well as its level of crime occurrence using dot density maps with a view of trying to deduce the

relationship between the locations and purposes of plots/buildings to crime occurrences and various types of crime. The study area was divided into six parts. The zoning was done using the roads as guide and number/area of plots enclosed by each zone. Note that for the purpose of this project, these plots represent crime scenes or potential crime scenes.

Table 4.1: Number of plots/parcels in each zone according to their purpose

Purpose	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Shopping Comp.	5	0	5	1	0	0
Military Camp	13	0	0	0	0	0
Unknown	16	42	31	38	46	47
U/C	3	4	1	0	0	6
Restaurant / Bar	3	0	0	0	1	2
Residential	100	153	114	212	159	201
Multipurpose	6	15	27	19	0	3
Liaison Office	2	3	1	13	1	1
Hospital	1	2	1	2	0	2
Finance House	9	10	27	30	16	9
Educational	3	1	3	5	7	5
Embassy	15	8	5	1	1	1
Business / Offices	20	22	65	97	79	29
Government Offices	0	2	2	0	8	2
Hotel	0	3	0	1	0	5
Open Space	0	7	4	4	0	18
Religious	0	2	3	2	2	1
Unoccupied	0	1	3	7	0	7
Palace	0	1	0	0	0	0
Business / Residential	0	0	2	0	1	0
Car Park	0	0	2	0	1	0
Workshop	0	0	4	2	0	1
Leisure	0	0	0	1	0	0
Charity	0	0	0	0	0	1

Table 4.2: **The road partly or wholly contained in each zone**

ZONES	STREETS
Zone 1	Waziri Ibrahim, Adeleke Adedoyin, Arese, Elsie Femi, Pearce, Goriola, Anifowose, Abudu Smith, Musa Yaradua, Ozumba Mbadiwe, Amhadu Bello way, Eleke Cresent.

Zone 2	Louis Solomon close, Teslim Elias close, Danmole, Sakajoko, Akarigbere close, Idejo, Oju Olobun close, Ologun Agbaje, Adeola Odeku, Amhadu Bello way, Saka Tinubu, Bishop Oluwole.
Zone 3	Amodu Tijani, Adeyemo Alakija, Afribank, Adeola Hopewell, Akin Adesola, Akin Olugbade, Sapara Williams close, Ojora close, Idowu Martins, Kofo Abayomi, Idowu Taylor, Ahmed Onibadu, Engineering close, Ozumba Mbadiwe avenue, Maroko road.
Zone 4	Saka Tinubu, Bishop Oluwole, Oko Awo close, Imam Augusto close, Olosa, Tiamiyu Savage, Karimu Kotun, Sanusi Fafunwa, Akin Adesola road, Agoro Odiyan, Eletu Ogabo, Oyin Jolaosho, Olashore, Braimoh Kenku, Bakare close, Amhadu Bello way.
Zone 5	Bendel close, Festival road, Samuel Maruwa, Balarabe Musa crescent, Bishop Aboyade Cole, Adetokunbo Ademola, Maroko road, Muri Okunola, Etim Iyang crescent, Ligali Ayorinde.
Zone 6	Adetokunbo Ademola, Ajose Adeogun, Molade Okoya Thomas, Gafar Animashaun, Samuel Adedoyin, Adebisi Omotosho close, Yinus Bashorun, Sinari Daranijo, Akin Ogunleye, Jide Oki, Moshood Olugbami, Ade Odedina, Marinho drive, Daranijo Williams, Tony Anegbode, Dr Lawrence Omole close, Imam Abibu, Ligali Ayorinde.

Table 4.3: **Showing the area and perimeter of each zone.**

ZONES	AREA (sqr m)	PERIMETER (m)
1	1503010.66	5248.67
2	1312638.13	4730.37
3	1203403.27	4737.12
4	978373.25	4604.24
5	1105276.88	4117.10
6	1146873.77	4522.00

5. RESULT AND ANALYSIS

Some sample queries were also carried out to demonstrate the usability of this project for mapping purposes and for fast and efficient response by the various police stations/formations to distress calls from members of the public. Also, some deductions were made concerning areas where cases of some particular types of reported crime incidence are more.

5.1 Queries

Queries were built to define the crime location or zones and to determine the particular streets or the crime scene.

Query 1: A robbery is going on at Mega Plaza, No 13b, Idowu Martins Street and the occupants need to communicate with the police station. In this query, the occupants want to obtain information about the police stations around the area, i.e. phone no., address/location e.t.c. This query displays the attribute table of the police stations around. (See Fig. 1 below).

Fig 1: Shows query being performed to obtain information about Victoria Island police station

- **Query 2**: The police have been notified about the crime taking place at Mega Plaza presently and needs to know the location and the route leading to the crime scene. The police queries for the name of the Street to display the exact location as well as possible routes to the location. (See Fig 2 – 3 below).

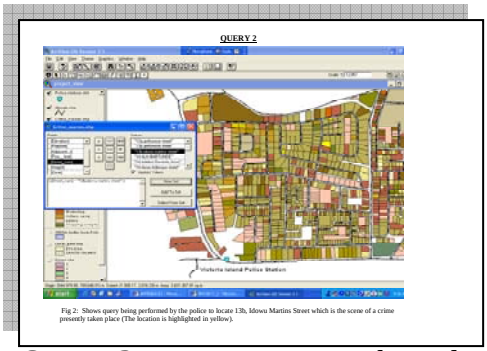

Fig 2: Shows query being performed by the police to locate 13b, Idowu Martins Street which is the scene of a crime presently taken place (The location is highlighted in yellow).

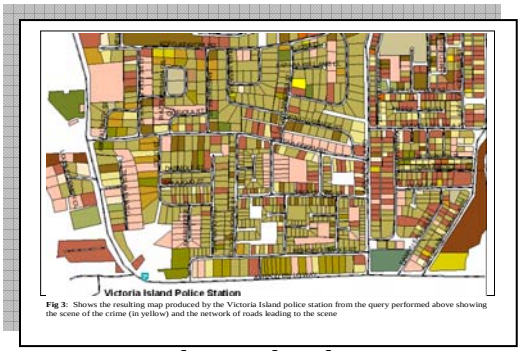

Fig 3: Shows the resulting map produced by the Victoria Island police station from the query performed above showing the scene of the crime (in yellow) and the network of roads leading to the scene

- **Query 3**: In some cases, the police may require to know the shortest route to the crime scene. This query in AutoCAD Map first locates the crime scene (see Fig. 4) and then determines the shortest route from the police station (Victoria Island police station) to the scene. (See Fig 5).

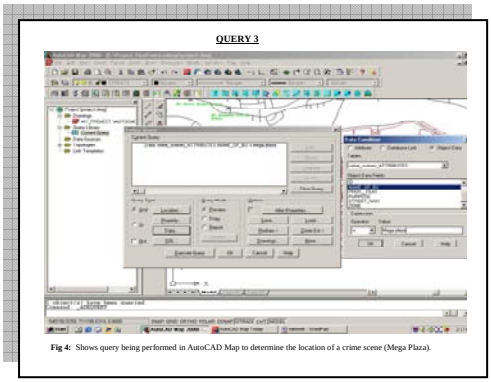

Fig 4: Shows query being performed in AutoCAD Map to determine the location of a crime scene (Mega Plaza).

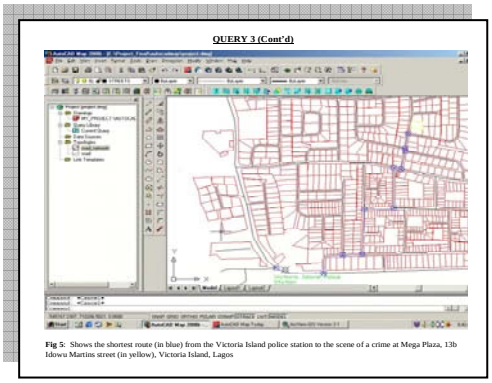

Fig 5: Shows the shortest route (in blue) from the Victoria Island police station to the scene of a crime at Mega Plaza, 13b Idowu Martins street (in yellow), Victoria Island, Lagos

Query 4: In this case, we wish to determine the zone with the highest total no. of reported crime incidences (2001). (See Fig 6).

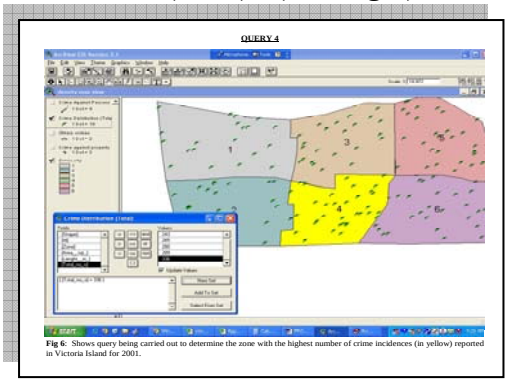

Fig 6: Shows query being carried out to determine the zone with the highest number of crime incidences (in yellow) reported in Victoria Island for 2001.

Query 5: In this case, we wish to determine the zone with the lowest total no. of reported crime incidences (2001). (See Fig 7).

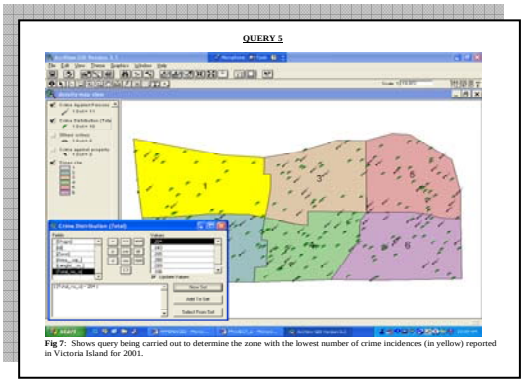

Fig 7: Shows query being carried out to determine the zone with the lowest number of crime incidences (in yellow) reported in Victoria Island for 2001.

Query 6: This query is performed to locate a particular street (Maroko rd.) on the map. (See Fig 8).

Fig 8: Shows query being carried out to locate a particular street (in yellow and black stripes).

Query 7: This query is performed using the "identifier", to identify a particular police station. (See Fig 9).

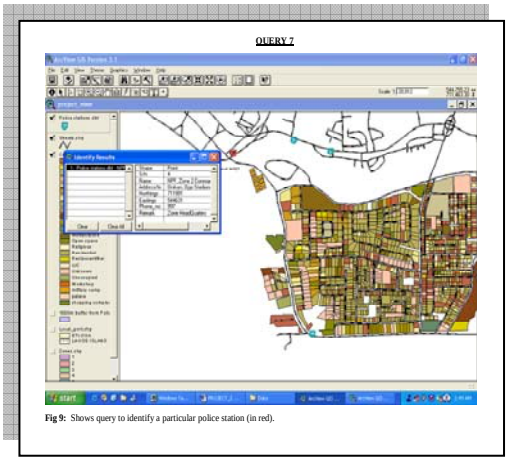

Fig 9: Shows query to identify a particular police station (in red).

Query 8: This identified the attributes of all embassies in the crime scene attribute table. (See Fig. 10)**.**

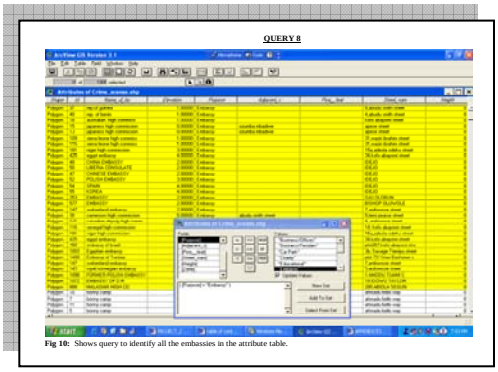

Fig 10: Shows query to identify all the embassies in the attribute table.

Query 9: Here, a flood trace analysis was carried out to display all routes (in blue) within the extent of 2000m from the V/I Police station. (See Fig. 11)

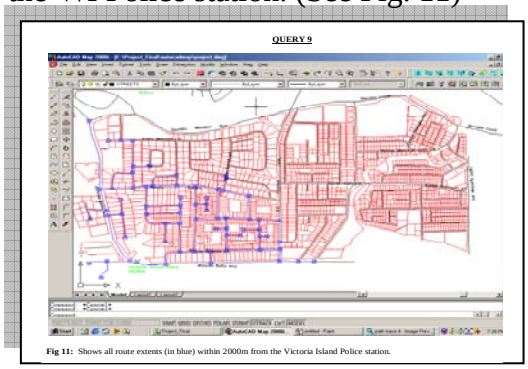

Fig 11: Shows all route extents (in blue) within 2000m from the Victoria Island Police station.

Query 10: Flood trace analysis displaying all routes within the extent of 2000m from the Maroko Police station. (See Fig. 12)

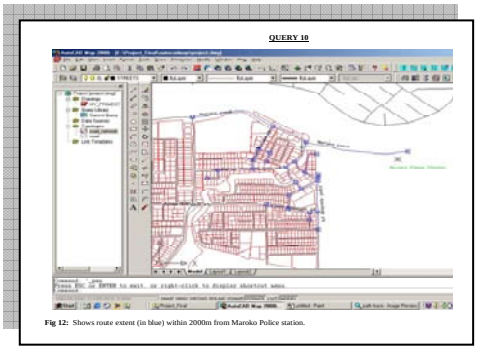

Fig 12: Shows route extent (in blue) within 2000m from Maroko Police station.

Query 11: Flood trace analysis displaying all routes (in blue) within 2000m extent from a centrally located part of V/I (See Fig. 13 below)

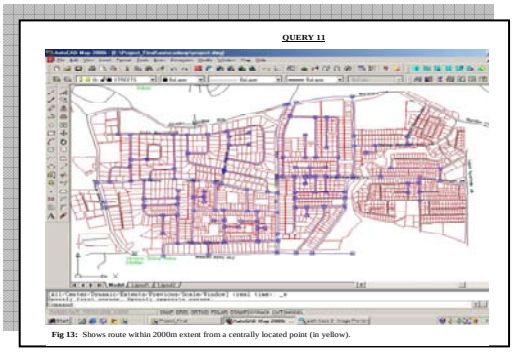

Fig 13: Shows route within 2000m extent from a centrally located point (in yellow).

5.2 Analysis and Findings

From the crime statistics obtained form the Victoria Island police station, the bar charts below (see Fig 14 -16) were plotted using Microsoft Excel to show the relationship between the number of crime occurrences and the period of occurrence (i.e. month and years) for the years 2000 and 2001.

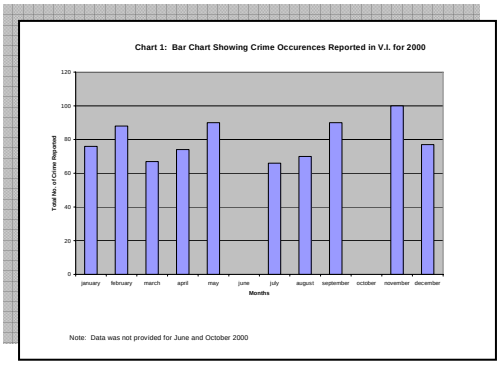

Fig 14: Bar Chart Showing Crime Occurrences reported in Victoria Island Police station for 2000

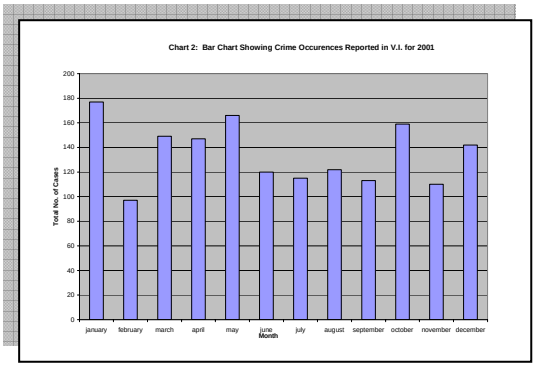

Fig 15: Bar Chart Showing Crime Occurrences reported in Victoria Island Police station for 2001

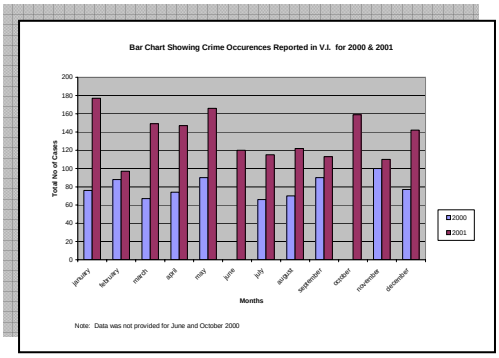

Fig 16: Bar Chart Showing Crime Occurrences reported in Victoria Island Police station for 2000 & 2001

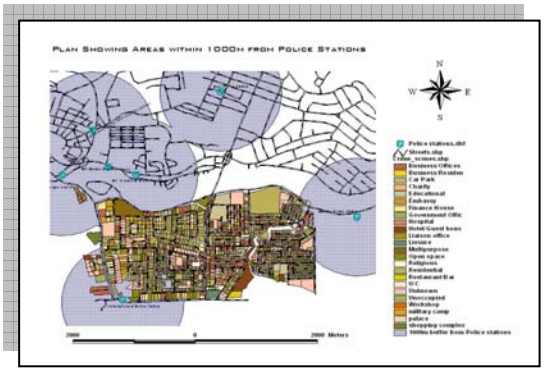

Fig. 17: map showing 1000m buffer from the police stations

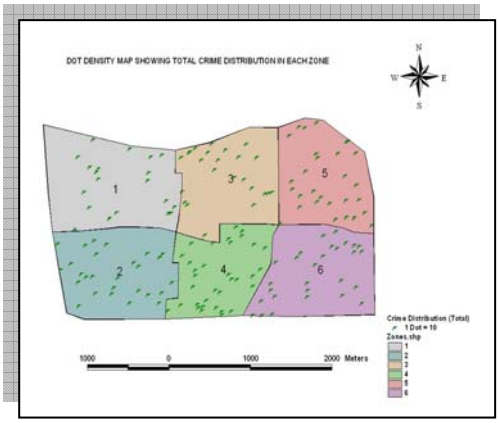

Fig. 18: dot density map showing total crime distribution

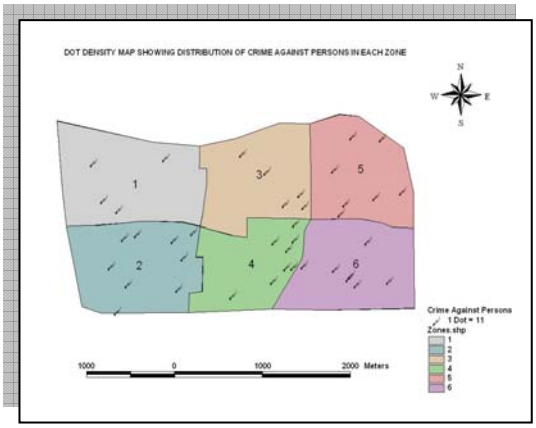

Fig. 19: the largest number of crime incidences against persons

From the map showing 1000m buffer from the police stations (see fig. 17) it could be observed that police station in Victoria Island is not in the best location because it is not centrally located, a great part of the 1000m radius falls into the bar beach. This fact is also demonstrated in the flood analysis trace query showing routes which are within 2000m from the police station (see fig 11). In this query, it can be seen that the routes covered (in blue) falls mostly in zone 2 and a bit in zone 1. As a result of this, it might be necessary for another police post to be located somewhere in zone 4 or 5 for the entire Victoria Island to be adequately covered. There is suppose to be a police post at 1004 (zone 5) but it does not seem to be functional. The Maroko police station is nearer to zone 5 and could be the fastest point of call in case of emergency. This is shown in the query to determine routes within the extent of 2000m from the police station (see Fig. 12,). Fig 13 shows routes that are within the extent of 2000m from a centrally located point around the junction of interception between Adeola Odeku and Akin Adesola streets and it can be seen clearly that almost all the areas and zones are covered. This implies that for equal coverage of all the areas in Victoria Island, the best location for a police station should be somewhere along the junction where Adeola Odeku and Akin Adesola streets meet.

It can also be seen from the dot density map showing total crime distribution (see fig. 18) that zone 4 which has the largest concentration of residential and business/office areas has the greatest proportion of the total crime incidences especially crimes that relate to properties (see Fig. 6). Zones 2 and 4 also have the largest number of crime incidences against persons (see fig. 19). This could be attributed largely to the fact that this areas covers the bar beach area which serves as a leisure resort and tourist attraction; as a result a lot of miscreants and prostitutes have turned the area to their base, making it exposed to crime incidences like rape, assault, molestation, fighting e.t.c. On the whole, zone 1 has the lowest incidences of reported crime. This may be attributed to the fact that it has the least structures in terms of business and residential purposes; it could also be due the military presence in that area. In summary, it was

discovered that cases of crime incidences is to a great extent a factor of the population and structures/facilities in a community and not necessary the area extent of such a community.

7. PROBLEMS ENCOUNTERED

It was not an easy task to obtain data from the relevant authority (police in this case) because there is no efficient and consistent method of keeping and retrieving data; old methods are employed in keeping records which makes it difficult to retrieve these information when needed and some of these records cannot be said to be reliable. There are instances where some police officers find it difficult to release the phone numbers of their stations.

7.1 How Problems Were Solved

Due to our inability to obtain data of the daily crime inventory which contains all the description, suspects, location, dates, victims e.t.c. because of the volume and sensitive nature of the data, what was done was to use the crime data obtained to allocate assumed numbers of crime incidences for the various categories of crime using a general knowledge of the trend of crime in the area i.e allocate more number of crime incidences to areas which are more likely to have more of crime occurrences according to the different crime types. This was done in order to create a dot density map to view areas were crime is more prominent and relate these crimes with the characteristics of the locations where they fall according to the zones and to demonstrate the analytical powers of GIS for crime management. If actual locational data had been used, then a more accurate representation of these crime occurrences with respect to the location where it happened would have given a better picture of the actual crime trend in Victoria Island and could be used for proper analysis.

8. CONCLUSIONS

The use of GIS in crime mapping and management has been discussed. Given the right atmosphere and cooperation from all relevant authorities, GIS can be used to map and analyze crime occurrences with a view to determining factors leading to such crimes and how they can be effectively managed. With GIS, the police and other law enforcement agents could produce maps showing the scene of crimes and the route(s) leading to scene areas by performing simple queries. The queries can also be performed to display the shortest route to the scene of the crime from the police station in the event of an emergency. The analysis carried out using dot density map could be used to forecast and map out strategies for combating crime.

9. RECOMMENDATIONS

- The Federal Government should set up GIS departments in all police stations to provide spatial analysis of resource allocation for administrative planning.
- Another police station should be created in a more central part of Victoria Island and the police post at 1004 should be made functional.

- The patrol units should be equipped with GPS so that their locations could be known as often as each unit is "polled," or automatically asked to respond.
- The crime data should be made available on the Web to facilitate data sharing but these will be offset to some extent by security and privacy concerns.
- The buffer zones generated shows that the location of the police station at Victoria Island is not located were it can serve the entire area optimally; therefore, the police post at 1004 (zone 5) should be made functional to ensure that the area is well served. The police could also use the maps showing crime incidences to map out areas for special attention (zones 2 and 4 in this case).

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Prof. Francis Fajemirokun obtained the B.Sc (Surveying) degree in 1966 at the University of Nigeria, Nsukka. He had his postgraduate training at the Ohio State University, Columbus, Ohio where he obtained the M.Sc and Ph.D degrees in Geodetic Science in 1968 and 1971 respectively.

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Prof. Fajemirokun's areas of expertise include geodesy mathematical modeling, geodetic network observations and adjustment, structural and crustal deformation survey and analysis, gravity surveys, tidal analysis and datum determination, and datum transformation.

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