Abstract:
The applications of GIS in law enforcement in Nigeria is relatively narrow, because: Although police forces are using GIS technology, the penetration of GIS into every application is still relatively limited. In Yewa South LGA, GIS has not yet been viewed as an obligatory technology within the security force, this is due to high cost of GIS tools and lack of GIS experts in the police force. Law enforcement needs information management, especially location information. Traditional law enforcement for different types of police applications really deals with data collection. Hence, this study applied GIS in crime mapping and analysis of Yewa South LGA in Ogun State with the view of providing a decision support system for crime analysis. This was achieved by acquiring and digitizing the base map of Yewa South LGA and coordinate plotting of the crime locations, developing functional spatial database on crime activities in Yewa South LGA and performing query analysis to show the potentials of GIS in modeling crime pattern within the study area. The methodology used involved the acquisition, data conversion and coordinate plotting of the crime locations on the base map of Yewa South LGA, GIS database design and GIS query and Analysis. From the results, it was observed that the top two crime activities in Yewa South LGA covering about 24% of the total crimes were rice smuggling and armed robbery. This was following by car snatching with about 19.23% of the crimes committed in Yewa South LGA.Cultism and ritual killings were tied with 11.53% of the total crimes committed in Yewa South LGA while contra banned goods were the least type of crime committed in Yewa South LGA with 8.97%. The study successfully applied GIS in crime mapping and analysis of Yewa South LGA in Ogun State Nigeria. The study also showed crimes committed in Yewa South such as rice smuggling, armed robbery, car snatching and cultism. The benefits derived from the application of GIS in crime analysis are considered enormous hence it is recommended to the security force for adoption. Furthermore, the application of GIS in crime study will enable the creation of a geo-database to reduce redundancy, automate police field operation and increase the effectiveness of crime fighting in all ramifications.

Keywords: Crime, Mapping, GIS, Database, Spatial Query

1. Introduction

Since 1960's, Geographic Information Systems (GIS) have been applied to a vast number of studies and criminality is not an exception (Brown and Dalton, 1998). However, it was only in the beginning of the 1980's with the reducing prices of technology that GIS saw a significant development on new research fields, such as crime analysis, relocation of police precincts and crime reduction strategies (Herbert, 1982). From the first stage of data collection to monitoring and modeling future scenarios to evaluate how, when and where to react, GIS plays a role in vast number of applications.

Crime analysis involves the manipulation and processing of spatially referenced crime data in order to display visually in an output that is informative to the particular user (Alex and Kate 2001). Crime mapping can provide information concerning the location of hotspots or high level of reported crime. Crime analysis is a set of processes applied on relevant information about crime patterns. Administrative and operational personnel can use the result of analysis to prevent and suppress criminal activities and also for investigation aims. Crime prevention seeks to reduce the risks of criminal events and related anti-social behavior by intervening in their causes.

Crime can be modeled in a variety of different ways. A particular crime incident can be modeled as point and assigned a real-world location such as an address or absolute location (Latitude and Longitude). Information about this point can have a variety of attributes (day/time the crime was committed, address of crime). Quantitative indicators of social constructs such as the measure of civilization, the distribution of various cultural groups (Howard et. al. 2000), and the measure of strain via economic disparity (Neapolitan 1996), help to explain how and why crime occurs, where and when it occurs. The computerization of police records has come with a realization that this research can be used for crime and intelligence analysis (Ratcliffe, 2004).

Researchers have used crime mapping technologies to go beyond exploratory draws of crime and have been engaged in trying to discover the roots and structural causes of crimes. Those drivers are often used to observe long-term strains related to social behaviors. Crime mapping and spatial analysis of crime are recognized as powerful tools for the study and control of crime, because crime maps help police identify problems at the block. The most powerful weapon in law enforcement is information technology (Neapolitan, 1996).

Francis et al (2006) stated that 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. They also stated that 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 will be 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.

Toju et al (2014) first examines crime situation in Benin in large databases, in order to obtain a strong visual tool to display and apply spatial analysis to data, which reside query and buffering using ILWIS and ArcGIS software and crime geo-spatial database, and 3) spatial analysis such as creating 1) digital landuse map showing the crime locations, 2) crime geo-spatial database, and 3) spatial analysis such as query and buffering using ILWIS and ArcGIS software and GPS. The result of buffering analysis shows crime hotspots, areas deficient in security outfit, areas of overlap and areas requiring constant police patrol. Their study proved that GIS can give a better synoptic perspective to crime study, analysis, mapping, proactive decision making and prevention of crime. It however suggests that migrating from traditional method of crime management to GIS demands capacity building in the area of personnel, laboratory and facilities backed up with policy statement.

Yelwa (2012) stated that one of the fundamental techniques to combat criminal activities is the better understanding of the dynamics of crime. Techniques are needed to categorize geographical areas according to their similarities in criminal activities that would facilitate the understanding of why and where crimes take place. The detection of crime hot-spot areas would enhance the policing agencies and policy makers to develop appropriate techniques for controlling and prevention of crime. Nigeria is experiencing a dull moment due to high level of insecurity that ravage the country. Criminal activities are believed to constitute a significant proportion to this increased insecurity situation. While, advanced strategies in GIS such as crime analyses are available and can have great potential for impacting a department’s efficiency in crime reduction and professionalism, today relevant officials in most crime departments in Nigeria may or may not have the necessary skills to engage in computerized crime mapping. Saad and Kuta (2015), aimed at exploring how the technology of GIS is being used in crime control research, identify the challenges of this technology in relation to crime control in Nigeria and finally design strategic measures to overcome obstacles.

After careful review of all the various related literatures, it was decided that combining GIS with GPS will suit this study as it enables ground factors to come into play, since there is little or no maps detailing crimes, crime locations or patterns in the study area. Coordinate locations of the various crime spots and police stations acquired with GPS.

In Yewa South L.G.A, GIS has not yet been viewed as an obligatory technology within the security force, this is due to high cost of GIS tools and lack of GIS experts in the police force. Law enforcement needs information management, especially location information. Traditional law enforcement for different types of police applications really deals with data collection. However, data collection without data analysis is useless. Not only does GIS allow integration and spatial analysis of data to identify, apprehend, and prosecute suspects, it also aids more proactive measures through effective allocation of resources and better policy setting.

It is known that crime monitoring and prevention agencies keep manual recordings of crimes activities in their respective areas, the manual method of recording crime activities is ineffective, old and outdated. This makes it hard for decision making relating to crime management. There is no system for evaluating the effectiveness of crime management and assistance in the prevention and rapid response to crime. Hence, there is no decision support system for crime management within the Local Government Area.

2. Material and Method

2.1 Study area

Yewa South, is a Local Government Area in the west of Ogun State, Nigeria (figure 1.0), bordering the Republic of Benin. Its headquarters are in the town of Ilaro at 6°53′00″N 3°01′00″E in the north of the Area. It has an area of 629 km² and a population of 168,850 at the 2006 census.

The area has 10 wards, Ilaro I, Ilaro II, Ilaro III, Iwoye, Idogo, Owode I, Owode II, Ilobi/Erinja, Oke-Odan and Ajilete. The people speak the Yewa and Egun dialects of the Yoruba language.
2.2 Materials and Method

2.2.1 Materials

The data used for the research is grouped into two main classes; primary and secondary data sets.

The primary data source that was used for this research included the following:
1. GPS co-ordinates: The entire crime locations were coordinated using the GPS. The GPS has accuracy of 5 meters which makes it appropriate enough for the purpose of co-coordinating the crime locations since only their locations is required.
2. Attribute data: this includes non-spatial descriptive information of sites of interest that were obtained.

The secondary data source that was required for this research included the following:
3. Yewa South L.G.A map showing road network, towns and locations of sites of interest.
4. General information about crimes in Yewa South L.G.A was also obtained from journals, networks, newspapers.

2.2.2 Method

This stage involved the conversion of the map of Yewa South L.G.A which was originally in analogue format into a computer-based format using the AO Scanner. Subsequently, the scanned map was exported to the Arc Map environment for geo-referencing using the Arc GIS 10.7 software. This was then be followed by the creation and on-screen digitizing of shapefile layers for each of the geographic features and classes on the map this was done in order to get a vectorized map of the L.G.A. Each of the layers became themes. The following themes were available amongst others: major roads, crime locations, towns and local government boundary.

A. Database design and creation

This is one of the fundamental process in every GIS work executed. It is the process by which real world entities and their relationships are analyzed and modeled in order to solve specific problems and find solution to questions of interest. A database is designed to service the need of a group of users. Such needs are called the information needs of the users or the user requirements. The heart of a geographic information system is a well-structured database i.e. spatial database. The process of designing a database is called data modeling. The database design phase comprises of three basic processes; namely conceptual, logical and physical design as illustrated in the figure below. Database design in GIS is basically in two phases namely (Kufoniyi, 1998):

i. The Design Phase
ii. The Construction Phase

The design phase consists of three levels (Kufoniyi, 1998):

a. Conceptual Design
b. Logical Design and
c. Physical design

Figure 2.1 shows the two phases in database design. It gives a breakdown of the design phase to include conceptual, logical and the physical designs, while the construction phase is as a collector of the logical and physical designs data stored in the spatial database.
B. View of Reality
These are the view of object as they naturally exist. The view of reality is the initial abstraction of reality for a particular application or group of application (Hernandez, 2012). The application may refer to land management in this case, which consists of elements such as boundaries, blocks, parcels, roads etc.

C. Conceptual Design
This is the presentation of human conceptualization of reality in a simplified manner to meet the information requirement of the application (Kufoniyi, 1998). The objective is to determine the basic entities, the spatial relationships among the entities and the attribute of each entity that support the process and application for which the database is designed. Conceptual design is a modeling of the projected system that is independent of implementation of the data method that is to be used for the conceptual modeling and it must enable analyst to express the structure of information in the system (data type and relationship). It is an arrangement of human conception of reality and is decided by the human on how to present it in a simpler manner but still will satisfy information required of the GIS concerned. One of the following three types of representation scheme is adopted, these are;
   i. Tessellation
   ii. Vector
   iii. Object-oriented

For this work, the vector conceptual scheme or model whereby Yewa South L.G.A.boundary, roads, crime locations, police stations were represented as point object, roads as linear (line) features while boundary were represented as polygon was adopted.

D. Identification of Entity Types in the Study Area
Entity type is a basic component of the entity relationship model. It can be defined as an abstraction of a collection of similar objects, about which the system holds information (Kufoniyi, 1998). The entity relationship diagram is shown in Fig. 2.2.
E. Logical Design

This is the design aspect of the database which deals with the transition of the conceptual data model into data structure of particular database management software (DBMS). In this phase, the entities, their attributes and their relationships are represented in a single uniform manner in form of relation in such a way that would be no information loss and at the same time no unnecessary duplication of data. In this study, the logical database design is employed to generate a geo-relation database structure.

Table 2.1: Logical Design Phase

<table>
<thead>
<tr>
<th>Entity types</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yewa South</td>
<td>Yewa South_id, Yewa South_name, Yewa South_Population</td>
</tr>
<tr>
<td>Road</td>
<td>Road_id, Rd_name, Rd_class, Rd_length.</td>
</tr>
<tr>
<td>Town</td>
<td>Town_id, Town_name, Location, Easting, Northings</td>
</tr>
<tr>
<td>Crime Location</td>
<td>Crime_location_id, Crime_location_name, Location, Easting, Northings, Crime_Type, Crime_Occurrence, Crime_Perpetrators</td>
</tr>
<tr>
<td>Stream</td>
<td>Stream_id, Stream_name, Stream_class, Stream_length.</td>
</tr>
</tbody>
</table>

Table 2.2: Logical Design Phase 2

<table>
<thead>
<tr>
<th>TABLE NAME</th>
<th>ENTITY TYPE</th>
<th>ATTRIBUTES</th>
<th>FIELD DESCRIPTION</th>
<th>DATA TYPE</th>
<th>DATA WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yewa South</td>
<td>Polygon</td>
<td>Yewa South_id</td>
<td>Locality identifier</td>
<td>Object id</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population</td>
<td>No of Population</td>
<td>Text</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No_of_Towns</td>
<td>Estimated population</td>
<td>Number</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Northing</td>
<td>Northing</td>
<td>Number</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Easting</td>
<td>Eastings</td>
<td>Number</td>
<td>20</td>
</tr>
<tr>
<td>Road</td>
<td>Polyline</td>
<td>Road_id</td>
<td>Road identifier</td>
<td>Object id</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rd_name</td>
<td>Name of road</td>
<td>Text</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rd_class</td>
<td>Road class</td>
<td>Text</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rd_length</td>
<td>Road length in meters</td>
<td>Number</td>
<td>10</td>
</tr>
<tr>
<td>Crime Location</td>
<td>Point</td>
<td>Crime_location_id</td>
<td>Crime Identifier</td>
<td>Object id</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crime_location_name</td>
<td>Crime Location Name</td>
<td>Text</td>
<td>20</td>
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<td></td>
<td></td>
<td>Location</td>
<td>X,Y Coordinates</td>
<td>Number</td>
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<td></td>
<td></td>
<td>Easting</td>
<td>Type</td>
<td>Number</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Northings</td>
<td>No of Times</td>
<td>Text</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crime_Type</td>
<td>Perpetrators</td>
<td>Text</td>
<td>20</td>
</tr>
</tbody>
</table>
Physical Design
This involves the translation of the real-world entities into the computer compactable forms of the chosen structuring model such as relational, geo-relational, network, and hierarchical. For this project, relational (table) structuring method was used due to its easy implementation and management.
All geospatial and non-spatial (attribute) data were structured and actualized to form a database in a format acceptable by the implementing software and hardware. Thus, point, line and polygon layers were created for spatial objects on the digital map. Attribute data needs of the database were also structured as shown in the following tables.
This was done such that:
(i) Stored information can be accessed and retrieved at a later date
(ii) Update can be done from time to time.
(iii) Analytical functions can be performed to answer some generic question for the study
ArcGIS 10.1 was used for the database creation for the study area.

Linking of Data
Spatial and attribute data such as points, lines and area features and their attributes were linked together using the attribute table feature in ArcGIS i.e. for every feature created, its attributes are entered into the attribute table.

Spatial Queries
This is also known as spatial search. The analysis provides solutions/answers for questions about some specific entity in the study area extracted from the database created, based on particular criteria. In this study, both single query and display (where one field result will be address) and multiple queries (where multiple criteria are involved) will be used to answer specific questions using the ArcGIS query builder module.

Overlay Operation
This is another important operation of GIS package. Map can be combined and new information derived. The principle of spatial overlay is to compare/superimpose the characteristics of the same location in both data layers and produce new characteristics for each location in the output data theme.

Results and Discussion
Results of database queries were presented in form of digital maps and tables. These maps could be thematic in nature. The results include the following:

3.1. Rice Smuggling committed in Yewa South Local Government area by Males
A query to determine the rice smuggling crimes in Yewa South LGA was formulated using the Query module: (“Crime” = “Rice Smuggling”) as shown in Fig 3.1

From the query result shown in Fig 3.1, it shows that about 19 out of 78 crimes in the area were rice smuggling. This query result is also presented in a digital map (see fig 3.2)
3.2. Armed Robbery in Yewa South Local Government area

A query to determine the armed robbery crimes in the area was formulated using the command ("Crime" = "Armed Robbery") as shown in Fig 3.3.

From the query result shown in Fig 3.3, 19 out of 78 crimes in the area were armed robberies. The result is also presented in a map form below in fig 3.4.
3.3 Ritual Crimes in Yewa South Local Government area

A query to show ritual killings crimes in the area was formulated using the command ("Crime " = "Ritual killings") as shown in Fig 3.5.

From the query result shown in Fig 3.5 it shows that about 9 out of 78 crimes in the area ritual killings. This query result is also presented in a map form below in fig 3.6.
3.4 Contra banned goods in Yewa South Local Government area

A query to determine the locations of Contra banned goods in the area was formulated using the command ("Crime " = “Contra banned”) as shown in Fig 3.7.

From the query result shown in Fig 3.7 it shows that about 7 out of 78 crimes in the area are Contra banned goods crime. This query result is also presented in a map form below in fig 3.8.
3.5 Cultism in Yewa South Local Government area

A query to determine the locations of cultism activities in the area was formulated using the command ("Crime" = "cultism") as shown in Fig 3.8.

From the query result shown in Fig 3.8 it shows that about 9 out of 78 crimes in the area are cult activities. This query result is also presented in a map form below in fig 3.9.
3.6 Car Snatching in Yewa South Local Government area

A query to determine the locations of car snatching in the area was formulated using the command ("Crime" = "car snatching") as shown in Fig 3.10.

From the query result shown in Fig 3.10 it shows that about 15 out of 78 crimes in the area are car snatching activities. This query result is also presented in a map form below in fig 3.11.
3.7: Finding and Discussion

It was observed that the top two crime activities in Yewa South L.G.A covering about 24% of the total crimes were rice smuggling and armed robbery. This was followed by car snatching with about 19.23% of the crimes committed in Yewa South L.G.A.

Cultism and ritual killings were tied with 11.53% of the total crimes committed in Yewa South L.G.A while contra banned goods were the least type of crime committed in Yewa South L.G.A with 8.97%, see table 3.1 and figure 3.12.

<table>
<thead>
<tr>
<th>Crime Activity</th>
<th>Occurrence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice Smuggling</td>
<td>19</td>
<td>24.35</td>
</tr>
<tr>
<td>Armed Robbery</td>
<td>19</td>
<td>24.35</td>
</tr>
<tr>
<td>Contra Banned Goods</td>
<td>7</td>
<td>8.97</td>
</tr>
<tr>
<td>Cultism</td>
<td>9</td>
<td>11.53</td>
</tr>
<tr>
<td>Car Snatching</td>
<td>15</td>
<td>19.23</td>
</tr>
<tr>
<td>Ritual Killings</td>
<td>9</td>
<td>11.53</td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>100</td>
</tr>
</tbody>
</table>

Fig 3.11: location of car snatchings in the study area.

Fig 3.12: Distribution of crime activities in Yewa South L.G.A.
4. Summary and Conclusion

The study applied GIS in crime mapping and analysis of Yewa South L.G.A in Ogun State Nigeria. The study also shows crimes committed in Yewa South rice smuggling, armed robbery, car snatching, cultism etc. The benefits derived from the application of GIS in crime analysis are considered enormous hence it is recommended to the security Force for adoption. Furthermore, the application of GIS in crime study will enable the creation of a “geo-database” to reduce redundancy, automate police field operation and increase the effectiveness of crime fighting in all ramifications. GIS uses automated means of detecting, analyzing and combating crime through the production and use of hardcopy and soft-copy guidable maps to analyze crime trends based on their location, types, or time of occurrence.

It is concluded that for effective crime control and management in Nigeria, the security operatives should engage in the modern standard of policing by adopting and integrating GIS methodology as this will help the force to be proactive in their operations.

References


Francis, F., Adewale, T. I, Abimbola O. and BabajideM. (2006), A GIS Approach to Crime Mapping and Management in Nigeria: A Case Study of Victoria Island Lagos Xxiii Fig CongressMunich, Germany


