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Crime Mapping in Enugu Urban Area of Enugu State, Nigeria using GIS Approach

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Abstract
The aim of this research was to use a GIS approach in mapping crime activities in Enugu urban area of Enugu State. This was achieved through the following objectives: acquiring comprehensive base map of the study area, developing a robust database on crime and performing various GIS analysis to show the crime patterns within the study area. The methodology adopted involved creating a geocoded database and digital maps of crime cases recorded in twelve (12) police stations situated in Enugu urban for the year 2015, using ARCGIS 10.2 software to carryout various spatial analytical procedures such as spatial query, spatial location query, multiple buffer analysis and kernel density hotspot mapping. The results of the research showed nineteen (19) different types of crimes mapped from geocoded crime data of reported crime cases/activities in various parts of the study area. The summary of findings were as follows: crime distribution was dependent on various factors which were spatial in nature and related to various points of interests; Hotspot analysis of crimes recorded revealed five (5) hotspots where crime activities were concentrated in Enugu urban namely- New haven, Ogui, Coal camp, Uwani and Achalla layout; areas further away from police stations were prone to more crime activities. It was recommended that an increase in policing/ ground patrol around tertiary institutions, schools, banks and recreational areas in Enugu urban; creation police outposts and implementing neighborhood watch in hotspots where crimes are concentrated.
Keywords: Crime, Geocoding, Geodatabase, GIS, Mapping, Spatial Analysis, Spatial Query

1.0 Introduction

Crime is a human phenomenon; therefore, its distribution in space is not random. Crime analysis is important because it helps to identify the different geographic patterns in criminal behaviour (Sahu, 2004).

The scenario of crime in Nigeria disregards class distinction in the society, as both high (haves), and low (have nots), experienced similar and equal visitation of the hoodlums from time to time. The resultant tragedy, suffering, colossal loss and distress, occasioned by those inimical visits, have been pervasive and had left an indelible mark on our national psyche and societal tranquility. Worse still is the fact that the law enforcement agencies are yet to be computerized for effective record keeping, analysis of cases, easy reference cum retrieval and storage of information to help strategize and adequately plan the combating and eradication of crimes in general (Bala et al, 2015). As an entity, crime has spatial attributes, i.e. location, time and process. Mapping is the key to understanding the spatial and temporal occurrence of crime, but it is only the beginning. The fact that criminal activity is non-random in time and space raises questions about its location and the reasons for its location.

GIS allows integration and analysis of data to identify, apprehend and prosecute suspects; it aids more proactive behaviour through effective allocation of resources and better policy setting (Lew, 1999). For example, thematic maps could be used to predict likely sensitive points/areas in hotspot area. Data on surface communication, telephone communication and demographic pattern can all be used to predict sensitivity of a locality in relation to a given time (Mishra, 2003)

GIS is pervasive in its use, ranging from identification of illicit cultivation of poppy seeds in Afghanistan with satellite imageries (Andreas, 1997) to measuring the geographic displacement of 9 drug offenders (Green, 1993) and monitoring the effects of law enforcement strategies on nuisance bar activity (Cohen, 1993). 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 (Mostapha, 2003).

In a recent survey of criminal investigations in Enugu State police command (Chinwokwu, 2013), it was revealed that the investigative strategies and techniques adopted by the police were not effective enough in addressing the challenges facing the police criminal investigation department. The steady increase of crimes and undetected criminal activities continues to raise a general feeling of insecurity of lives and property among Nigerians.

The apparent inefficiency of the Nigeria Police to combat crime in the society through effective/ efficient

management of criminal cases is a serious setback in the criminal justice system. This is partly because the Nigerian Police is not well equipped in modern trends of criminal investigation, mapping and spatial analysis to effectively discharge her responsibilities. Unfortunately, many law enforcement agencies especially the Nigerian police in Enugu State have yet to take advantage of GIS in crime mapping and criminal investigation / analysis. In essence, availability and quick access to timely and up-to-date spatial information about crime-prone areas, to the law enforcement agencies, will in no small way contribute to effective policing of the entire state.

Policing methods in Nigeria are still manual and un-automated. The old filing system of record-keeping is still in use. This limits the force from having the technological edge over the ever increasing technology sophistication of the criminals. The challenge herein is to create a geocoded database and digital map of crime cases recorded in various police stations situated in Enugu urban as well as carryout spatial analysis to find spatial relationships and underlying factors that perpetrate such crime relative to other points of interest within the study area such as hotels, schools, markets, banks, religious centre and sit outs.

2.0 Study Area

Enugu urban is the administrative capital of Enugu State, South East Nigeria located within coordinates 6˚22'N to 6˚38'N and 7˚28'E to 7˚37'E. It is made up of Enugu North, Enugu South and Enugu East local government areas.

The study area has districts/ settlements situated in parts of Enugu North, South and East Urban which is within the heart of Enugu metropolis. The districts include: Trans Ekulu, Abakpa Nike, Ugwu Odogwu, Iva valley, G.R.A., Emene, Asata, New Haven, Independence Layout, Coal camp, Idaw River, Mary Land, Achara Layout and Awkunanuw. They lie within longitudes 7 29’ 13.5”E and 7 30’ 30.1”E, and latitudes 6 24’ 07.5”N and 6 25’ 29”N, and encompasses major high density residential and commercial areas in the urban part of Enugu State with an area of about 10km2 and a population of up to 80,000 residents. The map(s) of sudy area is shown in figures 1,1.1 and 1.2 below.

Figure 1: Map of Nigeria Showing Enugu State

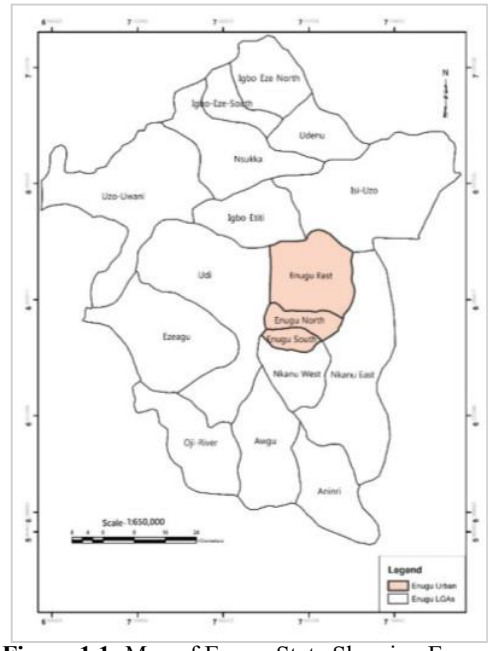


Figure 1.1: Map of Enugu State Showing Enugu Urban

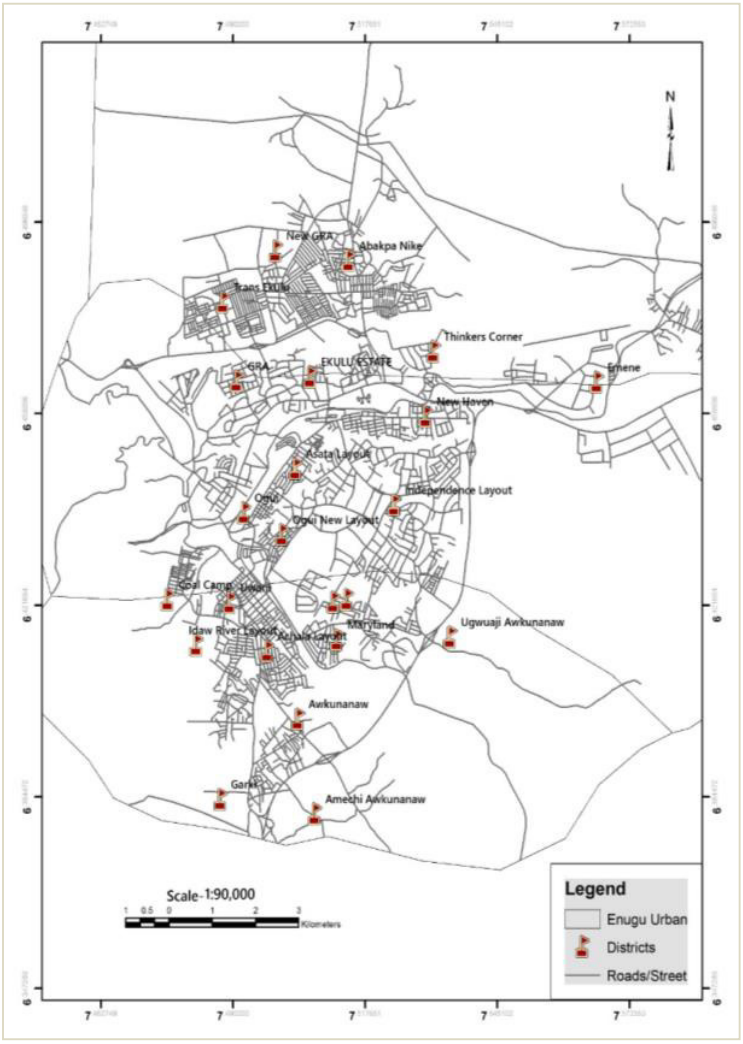


Figure 1.2: Map of the Study Area (Enugu Urban)

3.0 Methodology

This section details the methodology adopted in the execution of this research. It is subdivided into various steps such as: Planning, Data acquisition, GIS database design and creation and GIS analysis. The flow chart below (figure 2) shows a summary of the methodology adopted.

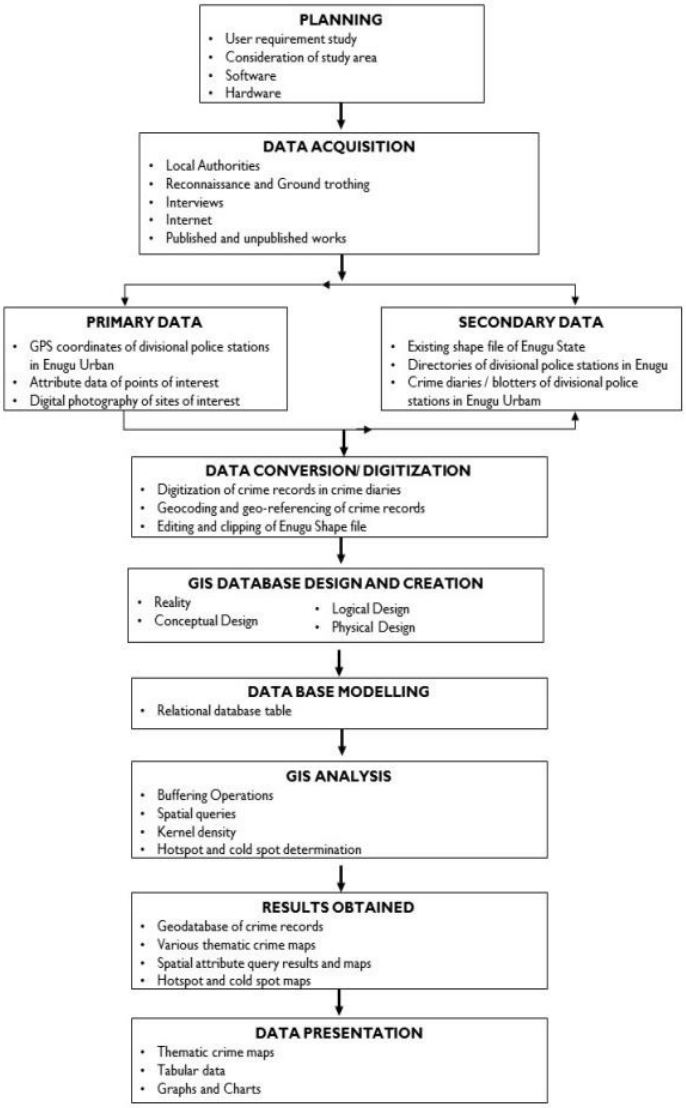


Figure 2: Flow Chart of Methodology

3.1 Planning

This stage of the research involved proper planning to ensure effective execution and optimization. In this phase, a needs assessment and user requirement analysis was carried out. This included carrying out a preliminary check on existing methodologies for crime data collation, analysis and reporting procedures in the Nigerian police force with emphasis on the study area. Key police officers were evaluated on their knowledge and need for crime mapping using GIS. This information was obtained through review of related literatures, documentations / press releases of the Nigeria police force and interviews with relevant personnel in various divisional police stations in Enugu urban. This stage also involved planning for choice of hardware and software to be used in the research.

3.2 Data Requirements and Acquisition

To accomplish the set objectives of the research, primary and secondary data which contain both spatial and non-spatial data were used. They are highlighted in the sub sections (Primary and secondary data) below:

3.2.1 Source of Primary Data

The sources of primary data for the research include:

i. GPS coordinates recording: the location / coordinate of divisional police stations in Enugu urban and other points of interests were obtained using Garmin GPSMAP 76s Hand held GPS with an accuracy of at least 5 metres.

ii. Attribute data: These were non-spatial descriptive information of points of interests.
iii. Digital photographs of points of interests were obtained where necessary.
iv. Satellite imagery obtained from google earth was used to validate the location, coordinates, features and attributes of various streets, districts and points of interests such as banks, schools, markets, universities among others.

3.2.2 Source of Secondary Data

The sources of secondary data for the research include:

i. Administrative map of Enugu State showing Local Government boundaries was obtained from the urban planning section in the Ministry of Lands and Survey, Enugu State.
ii. Street guide map and ArcGIS shape file of Enugu urban showing road network, constituent districts and some points of interest was obtained from the Department of Surveying and Geoinformatics in Enugu State University of Science and Technology (ESUT).
iii. Crime data and related information were obtained from crime diaries and blotters in divisional police stations in Enugu Urban.
iv. Additional data and general information related to crime was obtained from the Police Area Command (headquarters) in Enugu state.
v. Other relevant information was obtained from published journals and articles as well as available materials from the department of surveying and Geoinformatics, Nnamdi Azikiwe University, Awka.

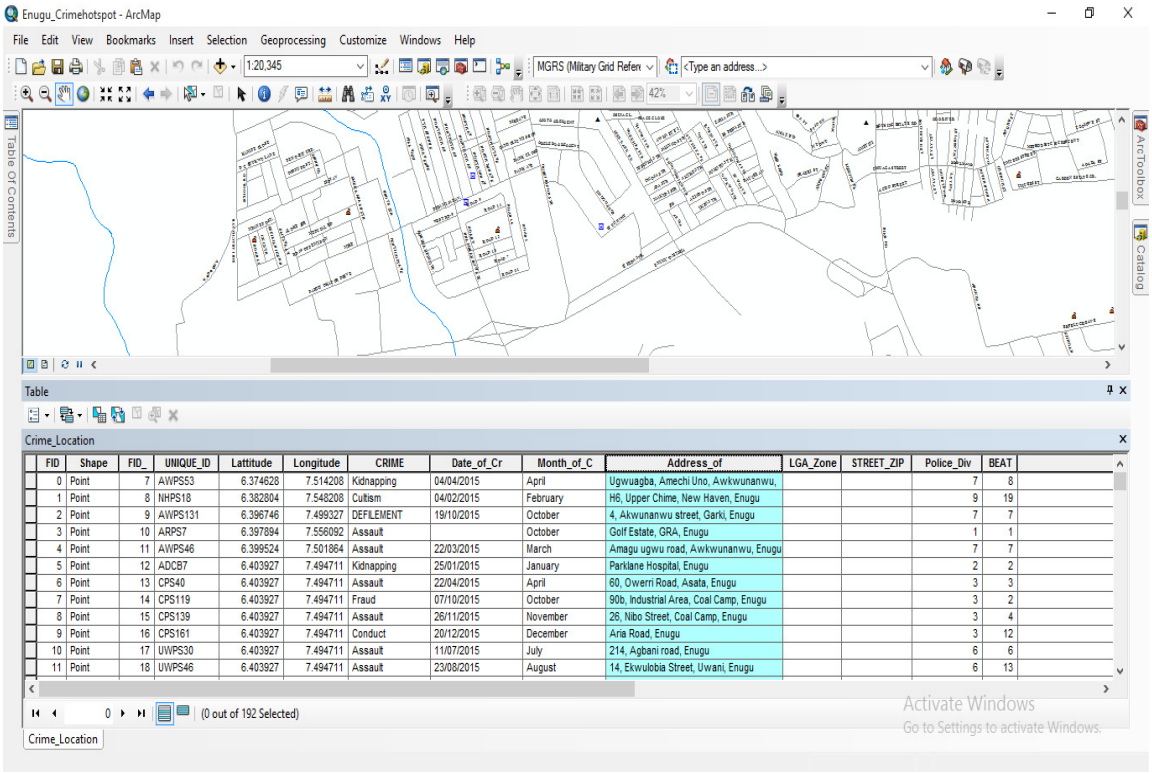
The projection datum used for the implementation of the research was WGS 84 which was the standard used to overlay various datasets as generated during the mapping process.

3.3 GIS Database Design and Creation

A database is a repository, capable of storing large amounts of data. Geospatial data handling process entails a demand supply processing of a phenomenon (crime) in the world, applying (GPS) technology to acquire survey data, creating a (relational) database by choice of a model at the conceptual level, and applying technology, (software & hardware) and methodology on processing (analysis). A GIS database is made up of two parts: (a) The components of the database, and (b) the design phases of the database (Kufoniyi, 1998). The two are composed of five basic components, made up of geographic or location entities, non-geographic or attribute entities, topological relationship, enterprise rules and procedure to be followed.

Prior to designing the geodatabase for this research, a search in blotters (crime diaries) of the police stations in Enugu urban for one year (2015) was done to extract relevant and related data on crime cases reported at various police stations. Interviews were done with relevant authorities of the police stations using semi structured questionnaire to determine and validate the major crimes committed and other attributes related to the offences committed.

Crime records were obtained from crime diaries in twelve (12) police stations situated in Enugu metropolis. The data were collated and coded using Microsoft excel 2013 software package and imported to a GIS environment as a shape file layer. The two main parameters used for filtering the crime data were crime type and availability of accurate crime location; since there were so many offences recorded in crime diaries, records extracted were offences related to assaults, rape, defilement, conduct, wounding, kidnapping, burglary, theft, robbery, armed robbery, murder, fraud and car snatch. However, only records with correct geocodable address were included in the final geodatabase used for crime mapping and multi-criteria analysis. ESRI ArcGIS 10.2 software was used to map the crime cases and other associated attributes. Vector representation was used for hotspots generation. A screenshot of geo database created in ArcGIS environment is shown in figure 3 below:



FID	Shape	FID_	UNIQUE_ID	Lattitude	Longitude	CRIME	Date_of_Cr	Month_of_C	Address_of	LGA_Zone	STREET_ZIP	Police_Div	BEAT
0	Point	7	AWPS53	6.374628	7.514208	Kidnapping	04/04/2015	April	Ugwuagba, Amechi Uno, Awkwunanwu,			7	8
1	Point	8	NHPS18	6.382804	7.548208	Cultism	04/02/2015	February	H6, Upper Chime, New Haven, Enugu			9	19
2	Point	9	AWPS131	6.396746	7.499327	DEFLEMENT	19/10/2015	October	4, Akwunanwu street, Garki, Enugu			7	7
3	Point	10	ARPS7	6.397894	7.556092	Assault		October	Golf Estate, GRA, Enugu			1	1
4	Point	11	AWPS46	6.399524	7.501864	Assault	22/03/2015	March	Amagu ugwu road, Awkwunanwu, Enugu			7	7
5	Point	12	ADCB7	6.403927	7.494711	Kidnapping	25/01/2015	January	Parklane Hospital, Enugu			2	2
6	Point	13	CPS40	6.403927	7.494711	Assault	22/04/2015	April	60, Owerri Road, Asata, Enugu			3	3
7	Point	14	CPS119	6.403927	7.494711	Fraud	07/10/2015	October	90b, Industrial Area, Coal Camp, Enugu			3	2
8	Point	15	CPS139	6.403927	7.494711	Assault	26/11/2015	November	26, Nibo Street, Coal Camp, Enugu			3	4
9	Point	16	CPS161	6.403927	7.494711	Conduct	20/12/2015	December	Aria Road, Enugu			3	12
10	Point	17	UWPS30	6.403927	7.494711	Assault	11/07/2015	July	214, Agbani road, Enugu			6	6
11	Point	18	UWPS46	6.403927	7.494711	Assault	23/08/2015	August	14, Ekwulobia Street, Uwani, Enugu			6	13

Figure 3: Geo-database of crime records and attribute data in ArcGIS 10.2 environment

4.0 Results

4.1 Crime Pattern Analyses

The crime dataset obtained from the field was subjected to various crime pattern analyses in the context of spatial query and multiple ring buffer analysis which was aimed at showing the relative occurrence and distribution of various crimes in Enugu urban within the year under study. Spatial location query was also carried out to reveal the pattern of various crimes within a specified distance around particular points of interest such as banks, schools, universities and markets. The essence was to highlight the efficiency of geo spatial analysis of crime occurrence using various tools such as the spatial query tool and spatial location query tool in ARCGIS to identify emerging patterns, series and trends as quickly as possible. Also, the analysis of various phenomena (crimes) based on relevant factors can sometimes predict or forecast future occurrences thus issuing alerts to relevant security agencies and authorities to carryout evidence based decision making and intervention. The key crime pattern analysis executed in the research include Multiple ring buffer analysis around twenty (20) districts and fourteen (14) police stations located within the study area. Spatial query of crimes using SQL in the select by attribute tool in ArcGIS 10.2 was also performed.

4.1.1 Multiple Ring Buffer (Analysis) Of Crime around Districts in Enugu Urban.

This type of analysis creates multiple buffers at specified distances around the input features. These buffers can optionally be merged and dissolved using the buffer distance values to create non-overlapping buffers.

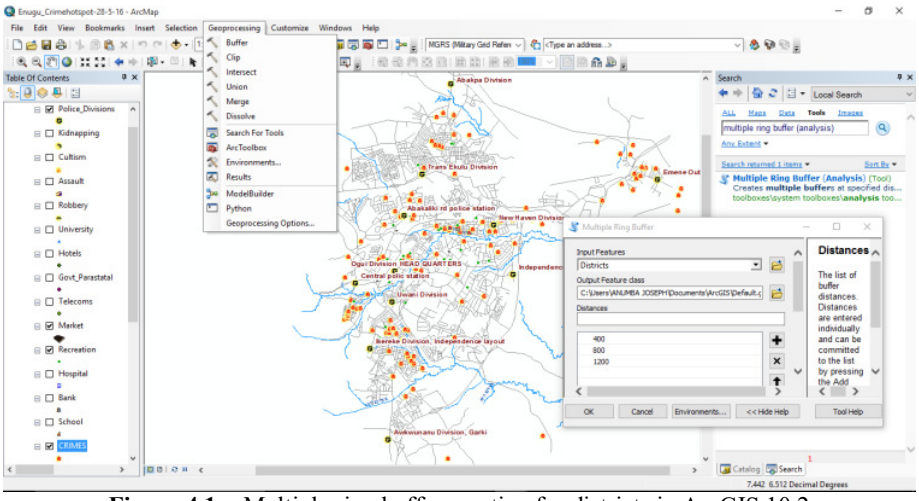


Figure 4.1a: Multiple ring buffer creation for districts in ArcGIS 10.2

In context of this research, one of the input feature used was the district around which crime incidences occurred. The buffer distances were 400meters, 800meters and 1200meters with a dissolve all option for the buffers. The result of the buffer creation is shown in Figure 4.1 b.

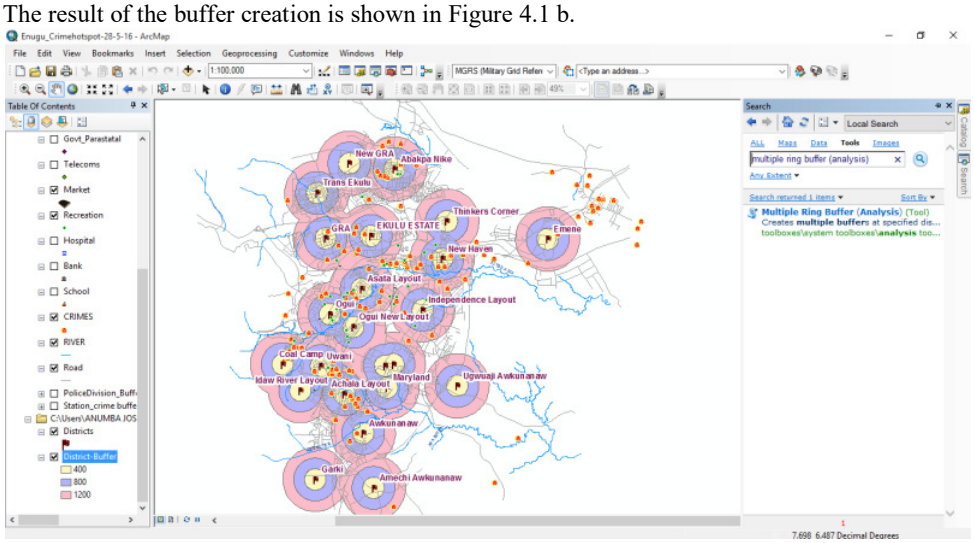


Figure 4.1b: Result of Multiple Ring Buffer (analysis) around Districts in Enugu Urban

Figure 4.1b above shows that 143 (74.5%) of 192 crimes occurred at varying distance around 20 districts multi-buffered at 400metres, 800metres and 1200metres respectively. Spatial analytical breakdown showed that 20 (10.4%) of crimes occurred 400m around the districts, 78 (40.6%) occurred around 800m while 143 (74.5%) occurred 1200m around various districts in Enugu Urban.

By inference, in the study area, there was relative increment of 58 (30.2%) in crime incidence between 400m and 800m around the districts. Also, a relative increment of 65 (33.9%) was recorded in crime incidence between 800m and 1200m around the districts. This further reveals that the pattern of crime occurrence changes with varying distances around the districts.

4.1.2 Multiple ring buffer (analysis) of crime around police stations in Enugu urban.

In line with the objectives of the research, spatial analysis of crime around police stations in the study area was carried out to determine occurrence and pattern of crime within the police divisions. Using the multiple ring buffer analysis tool in ArcGIS 10.2, another input feature used was the location of police stations (divisions) around which crime also occurred.

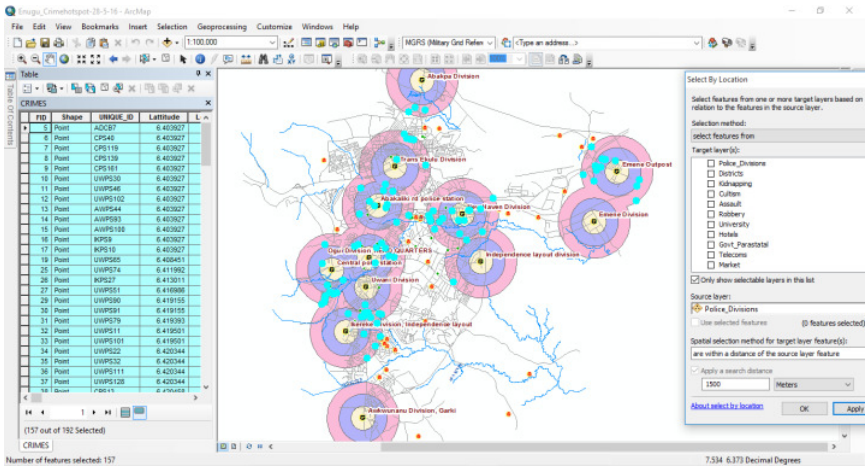


Figure 4.2: Location Query result showing crime occurrence around multi-buffered police stations (divisions) in the study area.

Figure 4.2 shows that 157 (81.8%) of 192 crimes occurred at varying distance around 14 police stations (divisions) mapped in the study area. The police stations were multi-buffered at 500metres, 1000metres and 1500metres respectively. Spatial analytical breakdown showed that 19 (9.9%) of crimes occurred 500m around the police stations, 67 (34.9%) occurred around 1000m while 157 (81.8%) occurred 1500m around various police stations in Enugu Urban.

By inference, in the study area, there was relative increment of 48 (25.0%) in the occurrence of crime between 500m and 1000m around police stations. Also, a relative increment of 90 (45.7%) was recorded in the occurrence of crime between 1000m and 1500m around police stations. This affirms that the presence of police stations in an area reduces the occurrence of crime within the area as more crime was seen to occur in areas further away from the police stations. Although this varies in relation to the location of the police station as well as the distance.

4.2 Spatial Query of Crime Incidence in Enugu Urban

The select layer by attribute table tool in ArcGIS 10.2 was used to perform a spatial query of the geodatabase to show the incidence of various crimes committed within a year in the study area. This tool applies an SQL query to a database and the results are represented in a map layer or table view. The various crimes queried in the geodatabase include: assaults, burglary, car snatch, suicide, murder, fraud, felony, defilement, rape, robbery, kidnapping and cultism. The various spatial queries executed are shown and discussed below:

a) Spatial query to show assault crimes committed in the area within the year

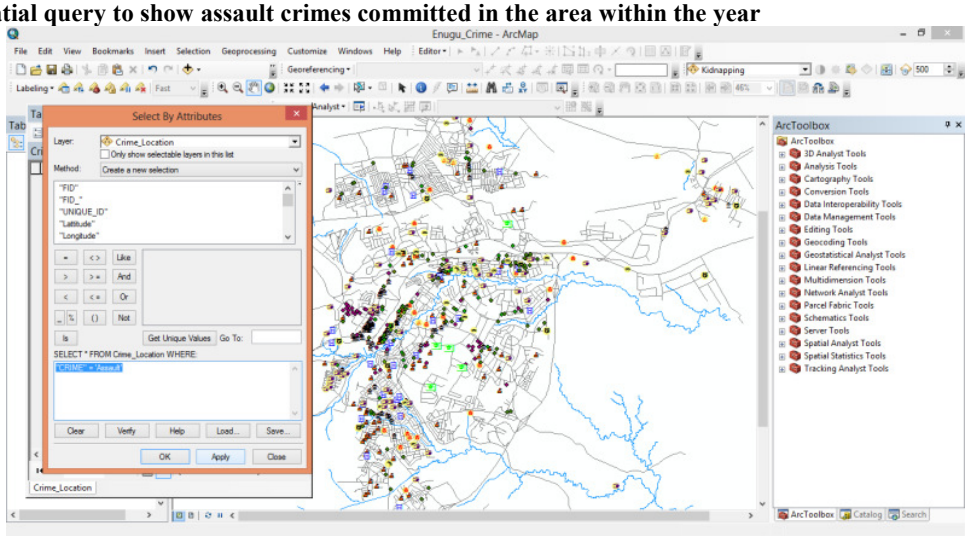


Figure 4.3a: SQL to show Assault crime committed in the study area within a year

Figure 4.3a shows a screenshot of the ArcGIS environment while performing SQL query in the geodatabase. The layer used for the attribute selection was the crime committed. Using the SQL Statement ("CRIME" = 'Assault') a query was formulated to show assault crimes committed within the year. The query results is

shown in Figure 4.3b below.

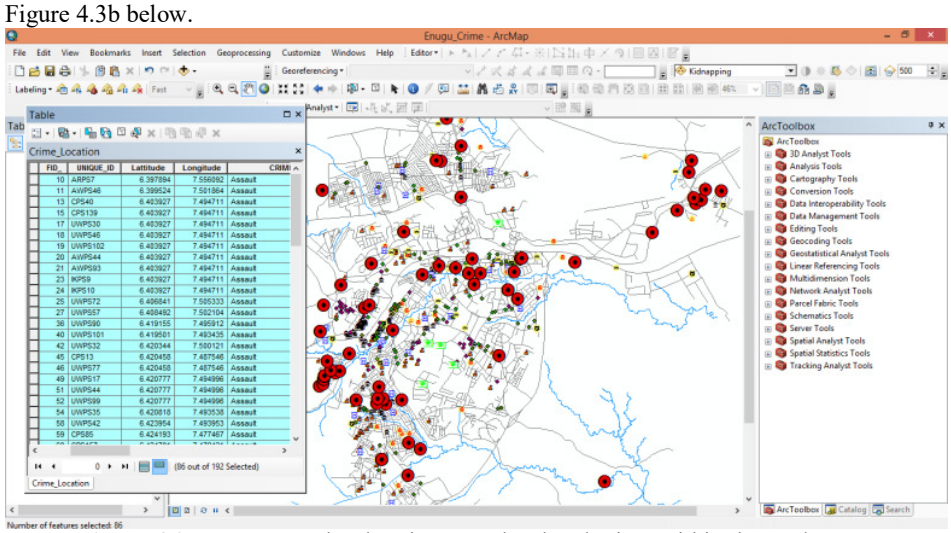


Figure 4.3b: Query results showing assault related crime within the study area.

The query results in Figure 4.3b showed that 86 out of 192 (44.7%) offences committed within the year were assault related crime.

b) Spatial query to show Burglary and Car Snatch crimes committed in the area

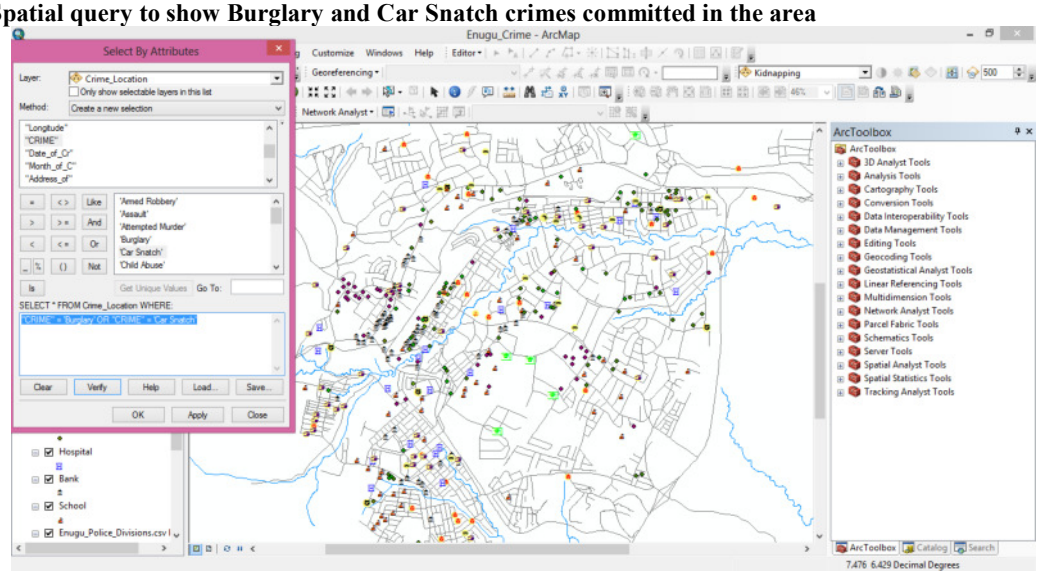


Figure 4.4a: SQL to show burglary and car snatch committed in the study area within a year

Using the SQL Statement ("CRIME" = 'Burglary' OR "CRIME" = 'Car Snatch') a query was formulated to show Burglary and car snatch crimes committed within the year. The results are shown in Figure 4.4b

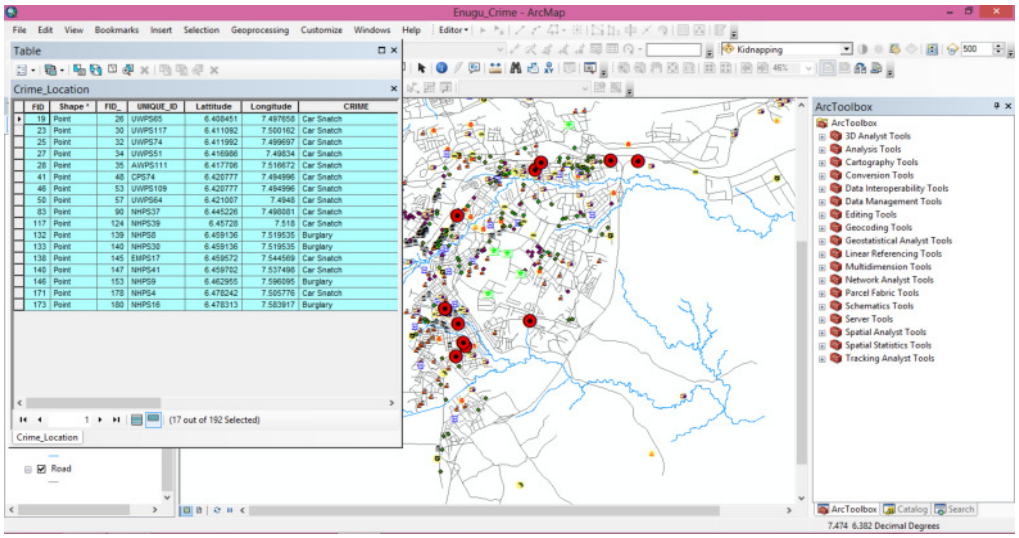


Figure 4.4b: Query results showing burglary and car snatch crimes within the study area.

The query results in Figure 4.4b showed that 17 out of the 192 (8.5%) offences committed within the year were burglary and car snatch related.

c) Spatial query to show Suicide and Murder committed within the year

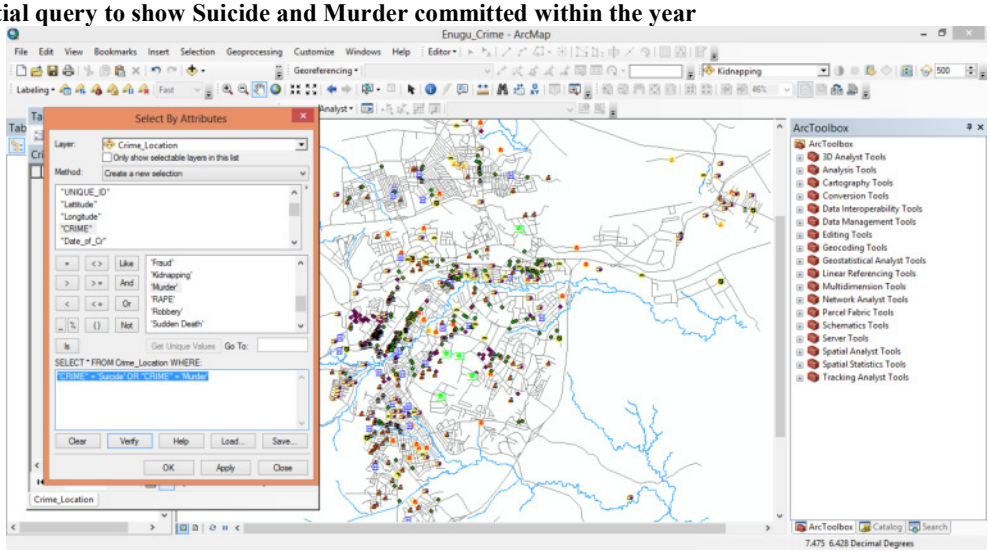


Figure 4.5a: SQL to show suicide and murder committed in the study area within a year

Using the SQL Statement ("CRIME" = 'Suicide' OR "CRIME" = 'Murder') a query was formulated to show Suicide and Murder committed within the year. The results are shown in Figure 4.5b

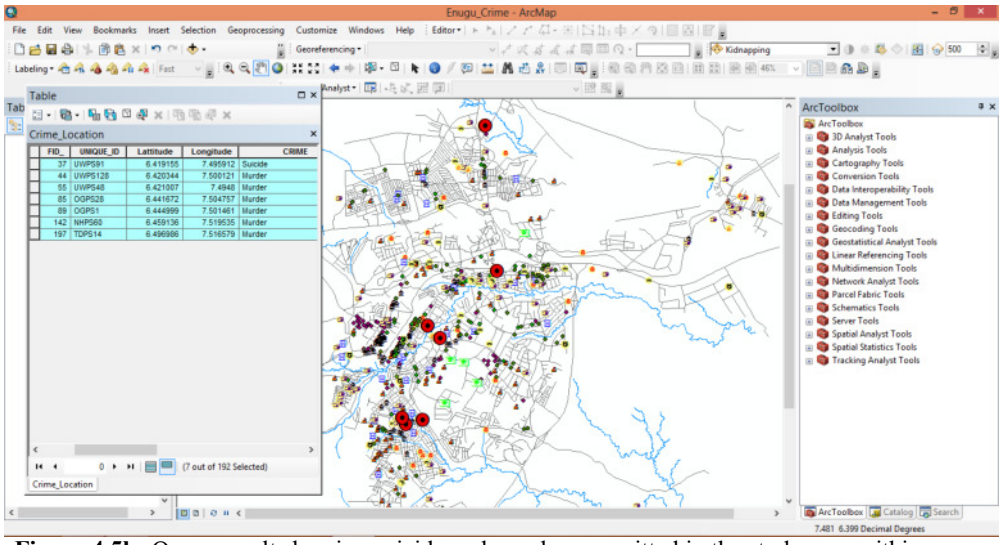


Figure 4.5b: Query result showing suicide and murder committed in the study area within a year

The results in figure 4.5b showed that 7 out of the 192 crimes (3.6%) committed within the year were Suicide and Murder.

d) Spatial query to show Fraud and Felony committed within the year

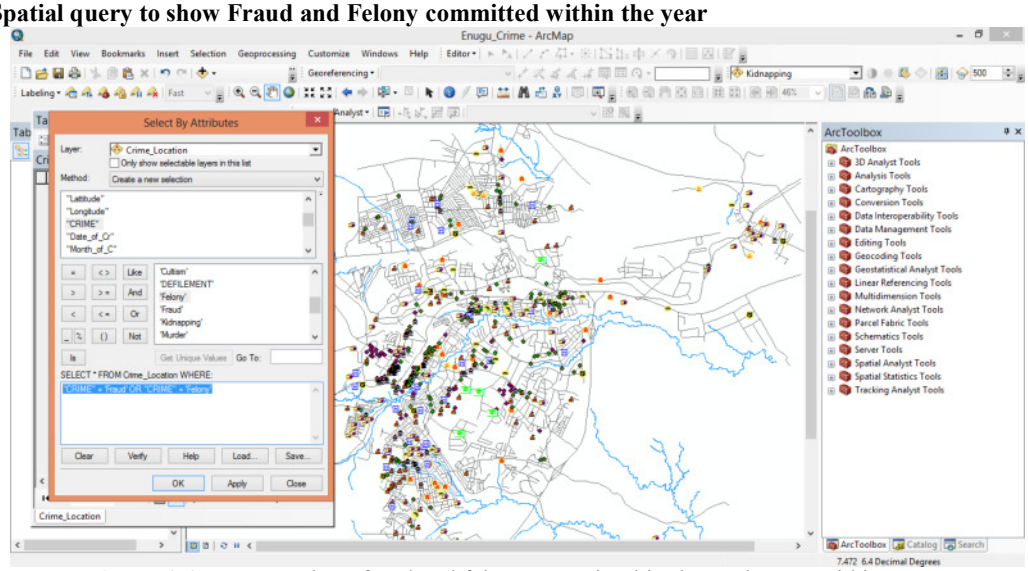


Figure 4.6a: SQL to show fraud and felony committed in the study area within a year

Using the SQL Statement ("CRIME" = 'Fraud' OR "CRIME" = 'Felony') a query was formulated to show Fraud and Felony crimes committed within the year. The results are shown in Figure 4.6b

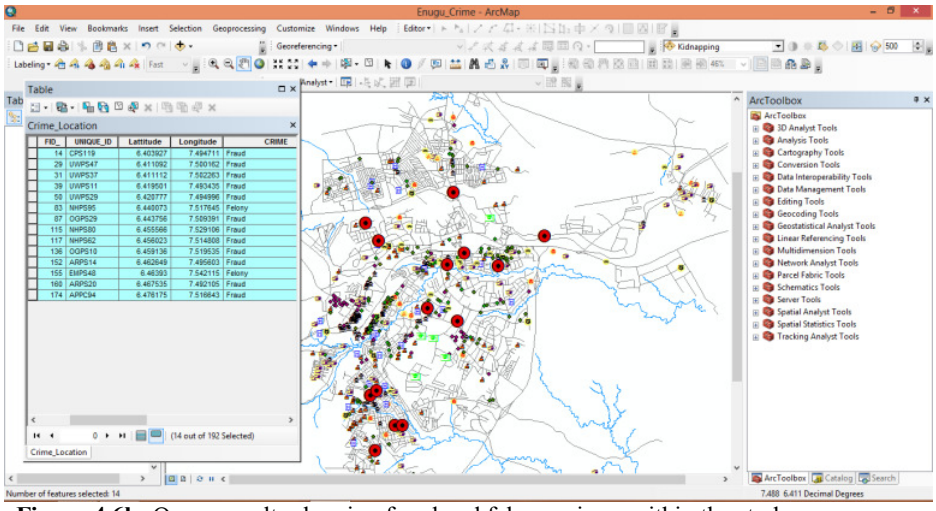


Figure 4.6b: Query results showing fraud and felony crimes within the study area.

The results in figure 4.6b showed that 14 out of the 192 (7.2%) offences committed within the year were fraud and felony crimes

e) Spatial query to show DEFILEMENT and RAPE committed within the year

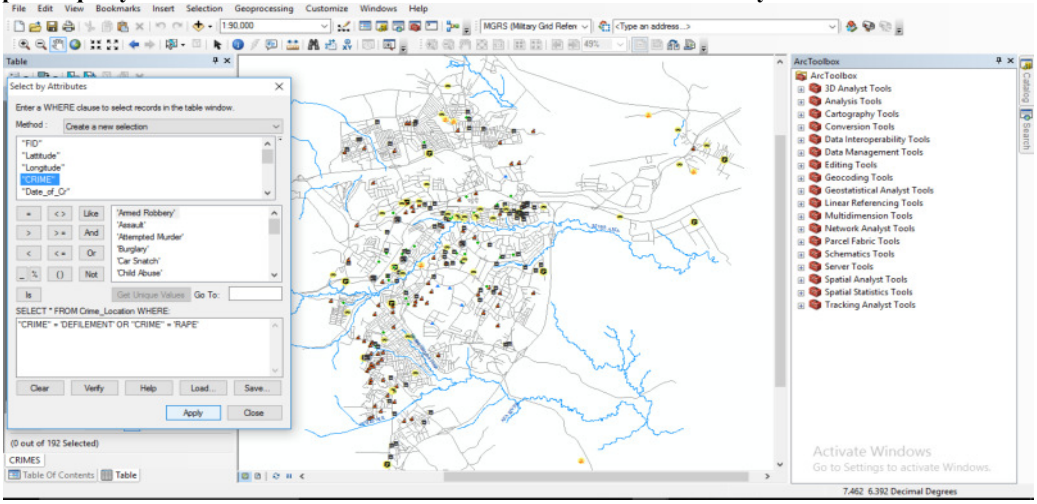


Figure 4.7a: SQL to show defilement and rape committed in the study area within a year

Using the SQL Statement ("CRIME" = 'DEFILEMENT' OR "CRIME" = 'RAPE') a query was formulated to show Defilement and Rape crimes committed within the year. The results are shown in Figure 4.7b

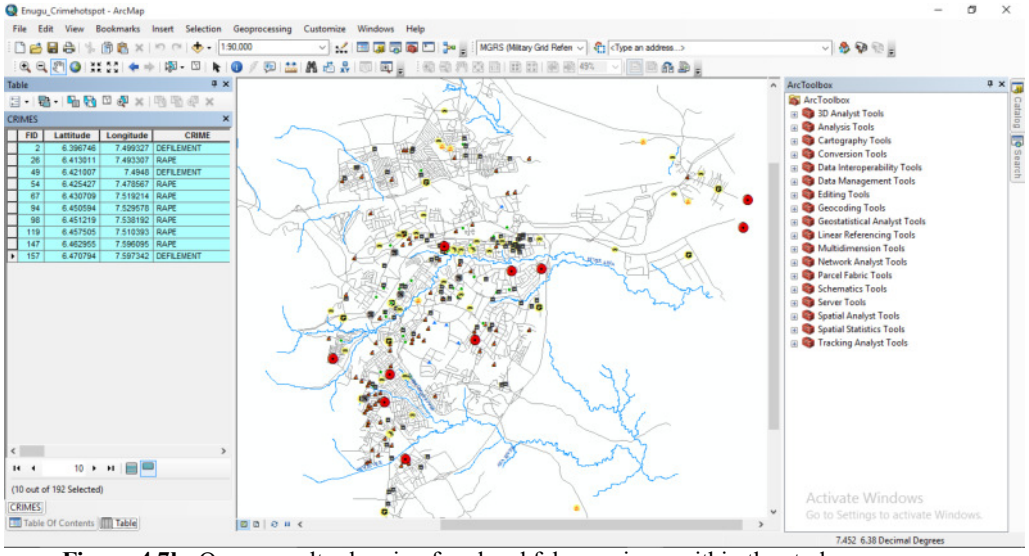


Figure 4.7b: Query results showing fraud and felony crimes within the study area.

The results in figure 4.7b showed that 10 out of the 192 (5.2%) crimes committed within the year were Defilements and Rape crimes

f) Spatial query to show Kidnaps committed within the year

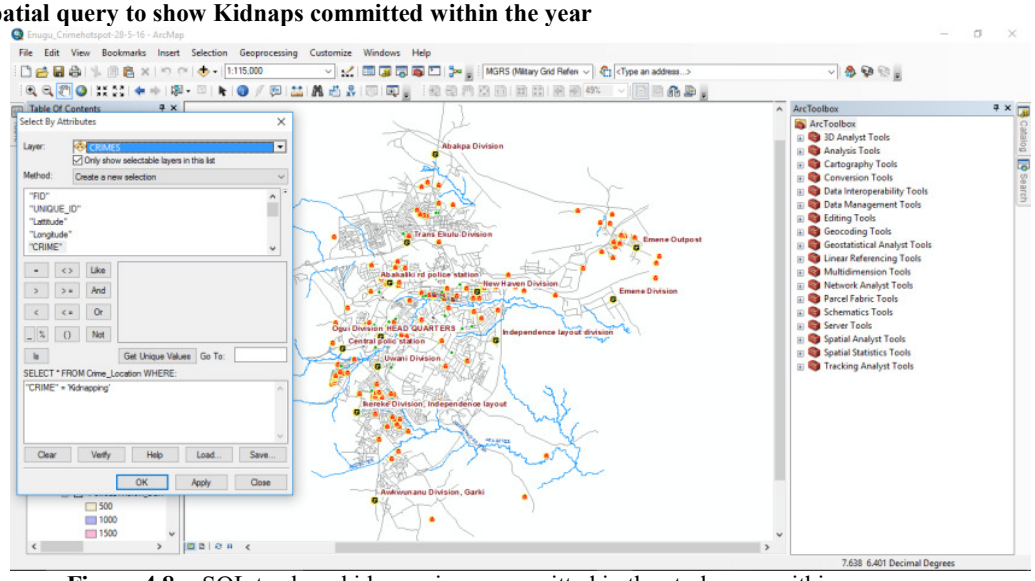


Figure 4.8a: SQL to show kidnap crimes committed in the study area within a year

Using the SQL Statement ("CRIME" = 'KIDNAPPIING) a query was formulated to show Defilement and Rape crimes committed within the year. The results are shown in Figure 4.8b

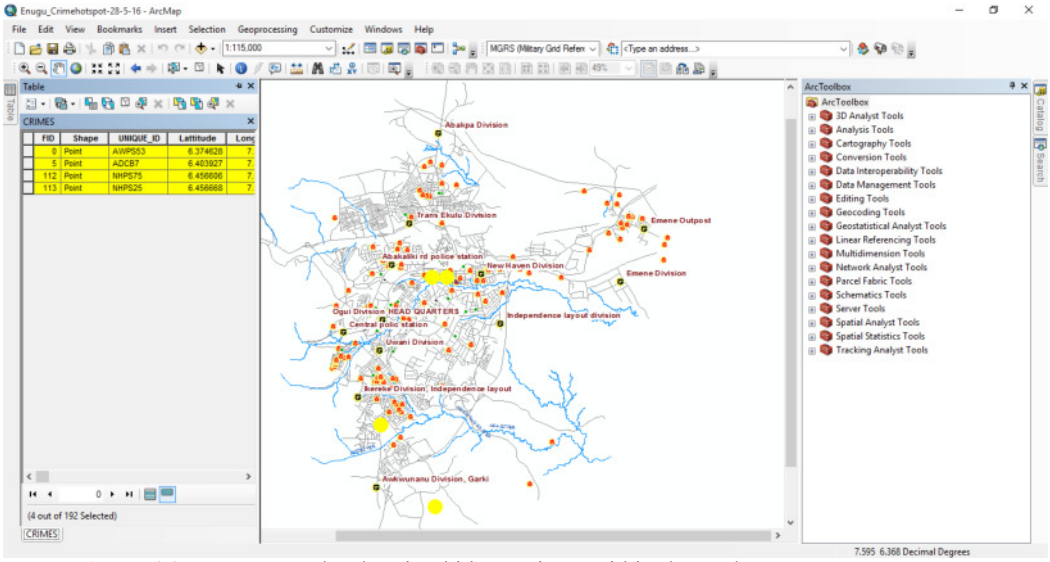


Figure 4.8b: Query results showing kidnap crimes within the study area.

The results in figure 4.8b showed that 4 out of the 192 (2.1%) crimes committed within the year were kidnapping.

g) Spatial Location query to show robberies committed within 0.5km of banks within the year

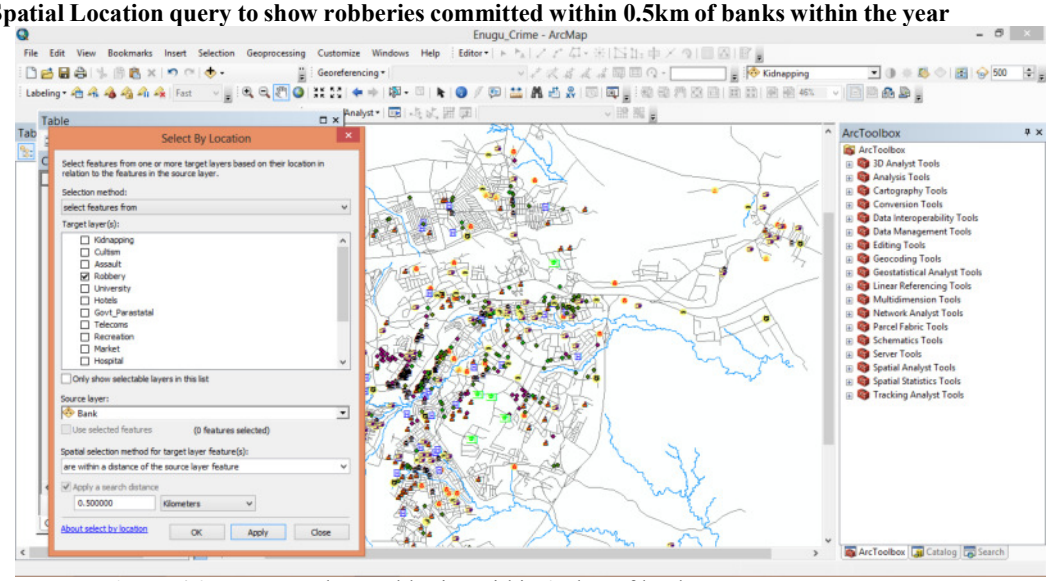


Figure 4.9a: SQL to show robberies within 0.5km of banks

Using the select by location query tool, robberies occurring within a distance of 0.5km of banks was selected from the geodatabase. The results are shown in figure 4.9b

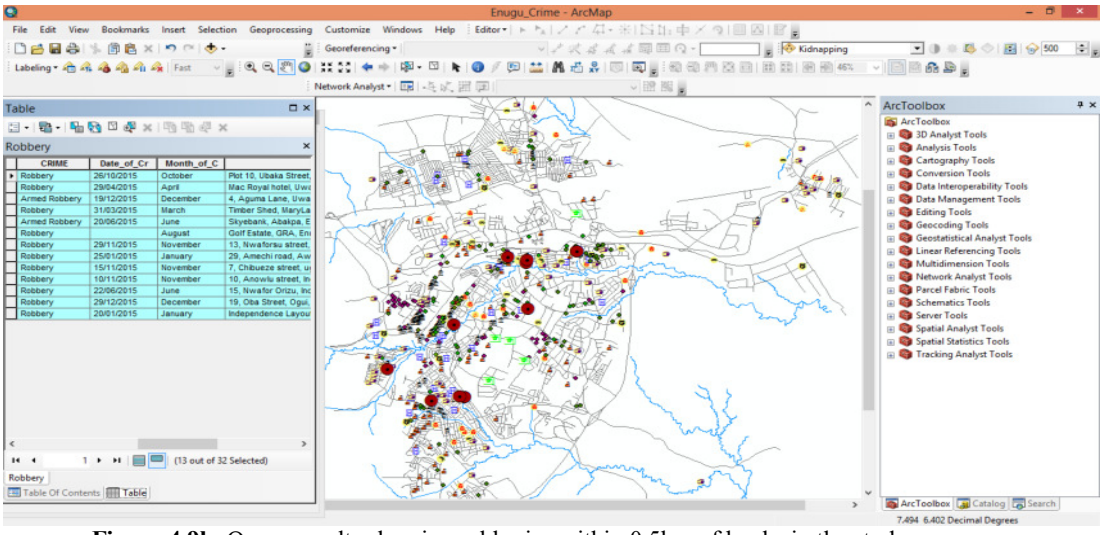


Figure 4.9b: Query results showing robberies within 0.5km of banks in the study area.

The results showed that 13 out of the 32 (40.6%) robberies committed with the year were within 0.5km of banks. Most of the banks were situated more around the centre of the study area.

h) Spatial Location query to show Cultism cases within 1km of Universities or Schools within the year

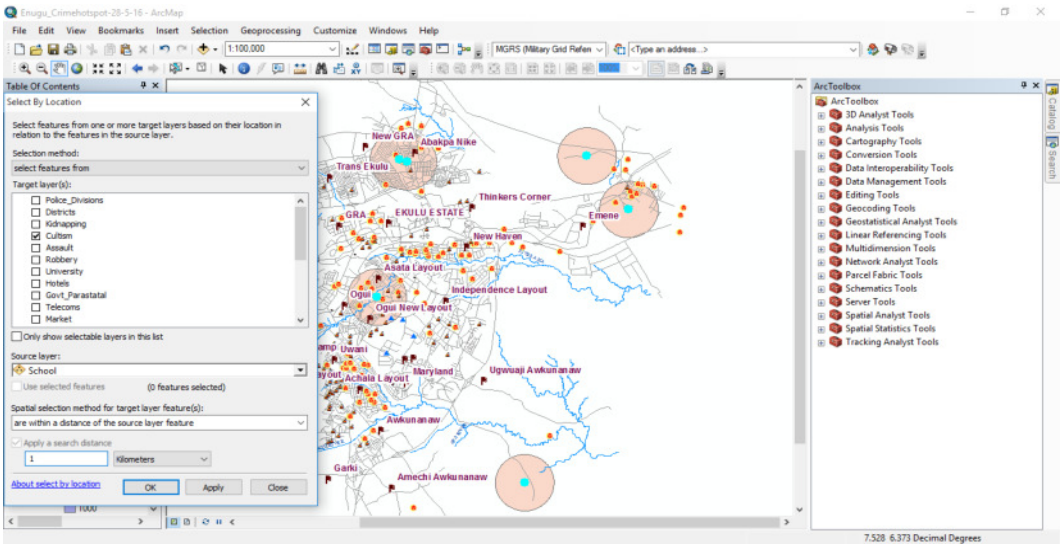


Figure 4.10a: Buffer and SQL to show Cultism within 1km of Universities or Schools

Using a combination of the select by location query tool and buffer tool, cult cases occurring within a distance of 1km around universities or schools was determined. The results are shown in figure 4.10b below.

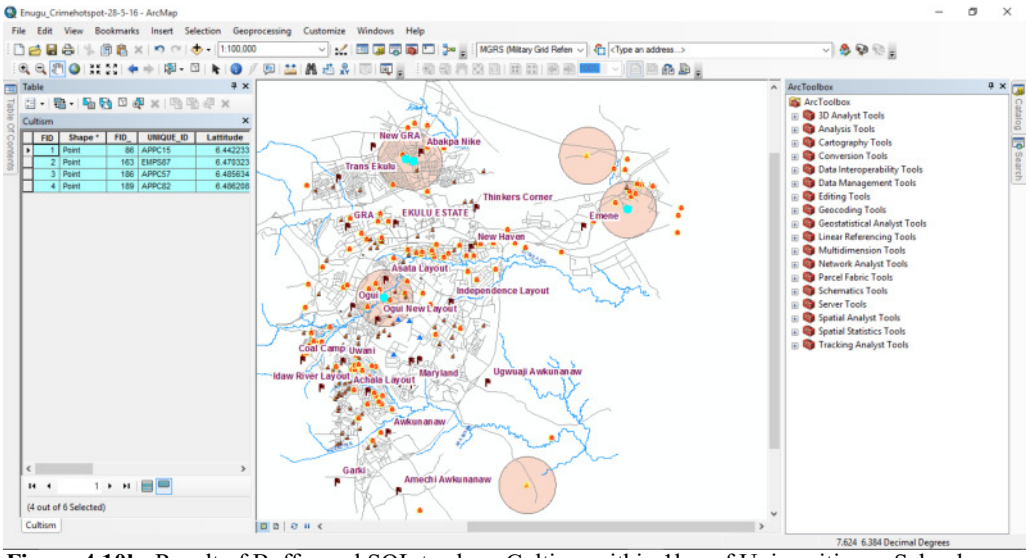


Figure 4.10b: Result of Buffer and SQL to show Cultism within 1km of Universities or Schools

The results in figure 4.10b showed that 4 out of the 6 (66.7%) of cultism cases were recorded within 1km of universities in Enugu urban within the year. The universities include situated inside the 1km buffer of cult cases were: ESUT Msp campus and IMT campus situated around Uwani and New layout respectively. The schools inside the 1km buffer of cult cases were: Treasure Int. School, Kingdom Heritage model school and spring field primary/nursery school.

i) Spatial Location query to show general crimes committed within 0.5km of Markets within the year

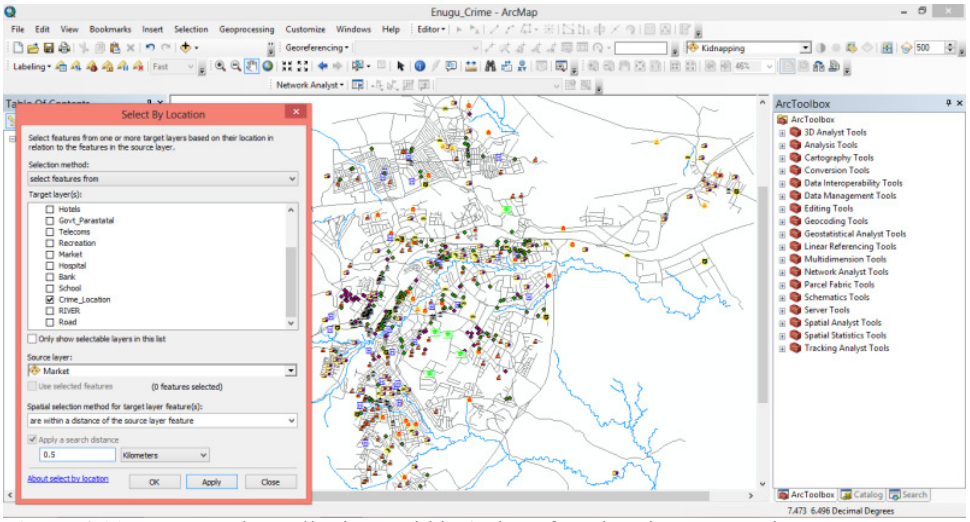


Figure 4.11a: SQL to show all crimes within 0.5km of markets in Enugu Urban.

Using the select by location query tool, all crimes that occurred within a distance of 0.5km of markets in Enugu urban was selected from the geodatabase. The results are shown in figure 4.11b

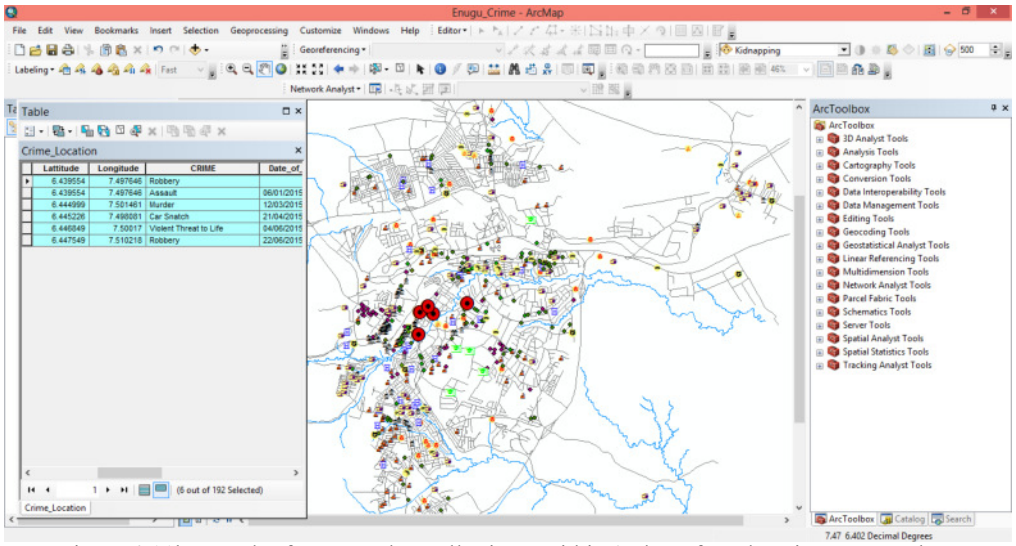


Figure 4.11b: Result of SQL to show all crimes within 0.5km of markets in Enugu Urban

The result in figure 4.11b showed that 6 out of the 192 (3.1%) crimes were recorded within 0.5km of markets. They include robbery, assault, Treat to life, car snatching.

j) Spatial Location query to show general crimes committed further 1km of Markets within the year

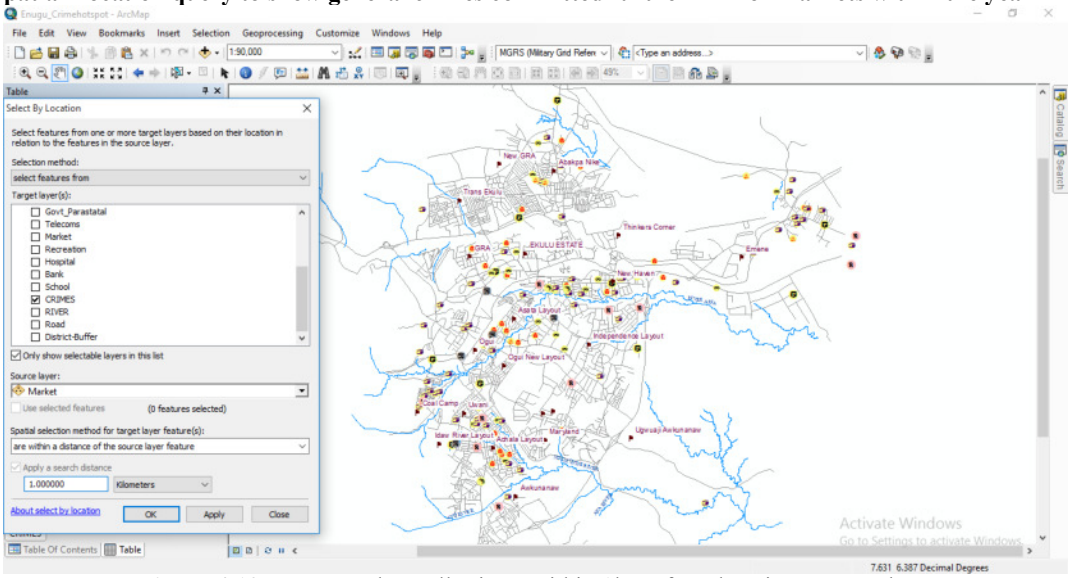


Figure 4.12a: SQL to show all crimes within 1km of markets in Enugu Urban.

Using the select by location query tool, all crimes that further occurred within a distance of 1km around markets in Enugu urban was selected from the geodatabase. The results are shown in figure 4.12b

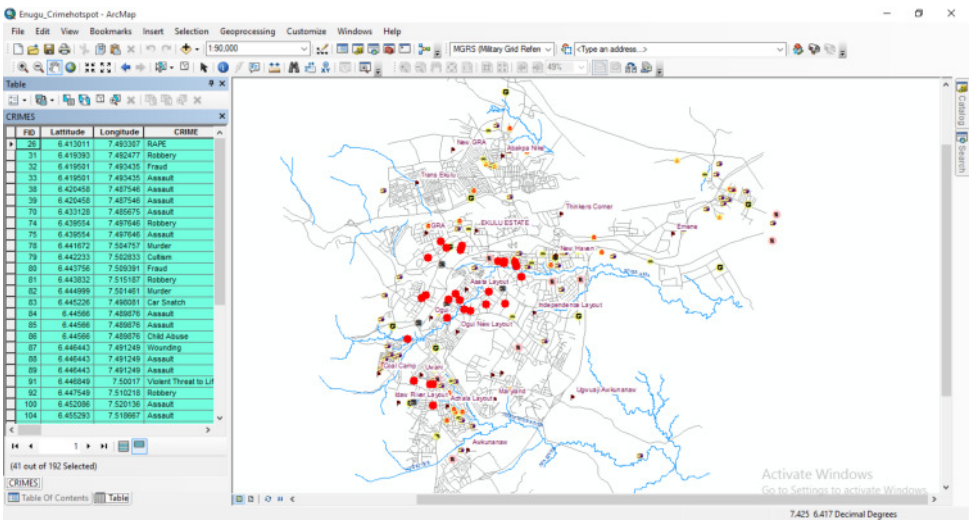


Figure 4.12b: Result of SQL to show all crimes within 1km of markets in Enugu Urban

The result in figure 4.12b showed that 41 out of the 192 crimes (21.4%) were recorded within 1km of markets within the year. These include rape, robbery, fraud, assault, murder, cultism, treat to life, car snatching, kidnapping and child abuse.

4.3 Enugu Urban Hotspot Mapping

Crime hotspot is widely referred to as areas of cluster concentration of criminal activities usually ascertained from the analysis of crime data in a GIS. A Crime hotspots map represents the high- crime density area and the result of a typical Hot spot analysis helps the law enforcement authorities, the police and other relevant professionals such as town planners and city management officials to identify high-crime areas, types of crime being committed and the best way to respond. The kernel density itself calculates a magnitude per unit area from crime point features using a kernel function to fit a smoothly tapered surface.

A crime hotspot was produced using kernel density to show the area with high to low susceptibility to crime within the year 2015 in Enugu urban was performed in ArcGIS10.2. The result is shown in Figure 4.13 below

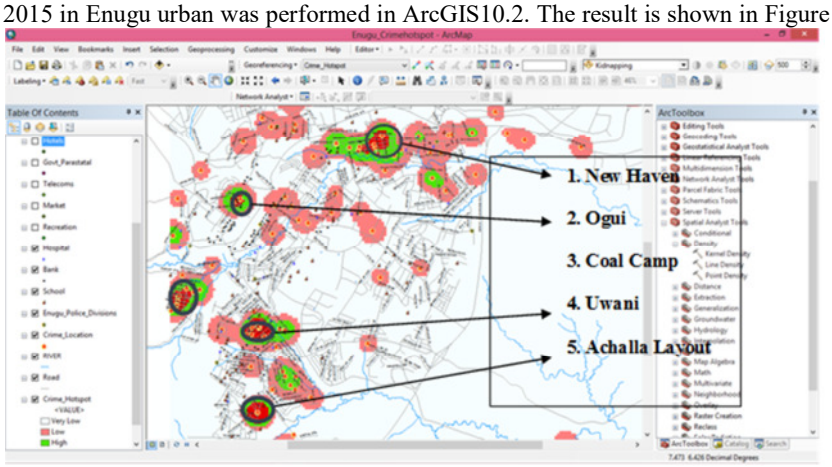


Figure 4.13: Kernel Density Hotspot Mapping of Crimes in Enugu Urban

The kernel density hotspot was calculated using crime incidences or occurrence per month within the year 2015. The result in figure 4.13 showed that *New Haven, Abakpa, Coal camp, Uwani and Awkwunanwu* showed high density crime areas with crimes such as Rape, Fraud, Murder, assault and car snatching having the highest occurrence per month in these areas. While Transekwulu, Maryland and New GRA are very low density crime areas with little crimes recorded.

5.0 Conclusion

This research implemented / used a GIS approach to study and map crime activities in Enugu urban area of Enugu State, Nigeria. It was able to develop a geodatabase of crime records using collated crime data from 12 divisional police stations located in the study area for the year 2015.

Various GIS analysis such as buffering, multiple rings buffer (analysis), spatial location query, SQL spatial

select query, kernel density and hotspot analysis was performed on the dataset using tools and features in ArcGIS 10.2 software. This showed the occurrence, spatial distribution and pattern of crime in the study area relative to thematic points of interest. This research has affirmed the efficiency of using a GIS approach to map crime activities in Enugu Urban.

The results and outcome in the execution of this research is a clear indication that Geographic Information System (GIS) can be used as a viable tool and approach in tracking, monitoring and evaluating the occurrence and pattern of crime in various districts and streets in an urban setting such as in Enugu Metropolis. This will inform decision making process in policing and control of crime in urban areas.

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