

# Geospatial Information System for Crime Analysis and Crime Zone Identification-Case Study of Katsina, Nigeria

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**Abstract**— Growing interest in the use of Geographical Information Systems (GIS) has led to its application as a tool in numerous research fields of interest one of which is crime analysis and management. But the situation in Nigeria is at its infancy as the Law Enforcement Agents saddled with the responsibility of combating crime in Nigeria have little or no education on the use of Geospatial Information System and the maintenance of Geo-database in analysing and predicting crime occurrences, patterns and routes to crime spots. Hence, bogus investments by the Federal Government in National Security have not yielded commensurate rewards. Attempt has been made by this research to use GIS as a spatial tool to classify crime zones in Katsina Metropolis, Katsina state of Nigeria, with a view to create crime database of the study area. An analogue map of the study area of scale 1:15,000 and crime records of six years (January, 2004 to December, 2009) were used in the geospatial classification of the types of crime with respect to the spots of occurrences. Areas of high and low frequency of crime occurrence were also highlighted. The study revealed that there is a marked variation in the distribution of crime between and within the zones. Theft and stealing cases accounted for about 45.17% of the total crime cases between 2004 and 2009. Assault accounted for 8.85%, while armed robbery accounted for 8.71% and rape for 6.57%. Murder had 6.57% while House Breaking and Criminal force had 5.90% and 5.09% respectively. Other crime categories contributed less than 5% each.

**Keywords**—*Geospatial Tool, Crime mapping, Crime management, Security, geographic profiling*

## I INTRODUCTION

Before the advent of the digital world, Hardcopy or analogue maps are the major tools depended on by law enforcement agencies and other allied organizations for monitoring and managing criminal activities. This is not only rigid and laborious; it is also highly time consuming as much as it consumes more resources with trivial results [6].

This classical method of identifying and mapping crime neither provide accurate, reliable and elaborate

data nor does it help in trend prediction and decision support [4]. The way forward is the adoption of sophisticated approaches (Information Technology).

One of such promising technologies employed in the management of crime in developed world is the use of Geospatial information System (GIS) [6]. With the help of GIS, since each crime spot has a geographic location, maps well digitized and geo-referenced showing crime spots are generated. These maps help police force and other law enforcement agencies to effectively plan for emergency service delivery, thereby providing mitigation for such issues like theft, and other related crimes. This in a way, aid in intelligence mapping [6].

Nigerian being a developing country is faced with security issues like BOKO HARAM (a popular nomenclature associated to an Islamic sect responsible for terrorism in the North-Eastern part of the country) is yet to fully embrace of GIS in crime mapping viz a viz terrorism.

This research attempts using such technology with a view to map crime zones and their spatial distribution and produce crime database of the study area, so as to get a clue on how such technology could be applied to crime mapping and analysis. Considering the associated benefits in crime analysis using GIS tool, this study has shown the benefit of GIS in crime analysis and management. This study has also produced a database for the study area, which is a positive step toward mitigating security challenges faced by the country as the agency concerned would see the study as a referrer for present and future study.

## II REVIEW OF LITERATURE

Crime mapping which allows for identification of hot spots, crime trend and pattern started in 1986 during which the US National Institute of Justice (NIJ) funded the a project aimed at experimenting crime mapping as a plus to community policing [11]. The history of crime mapping can be seen, see for example [10].

Historically, mapping out crime has been an important component of crime analysis. Surveying and Mapping plays a very significant role in crime location, detection, control and monitoring, prediction, and its

intelligent policing. To mitigate crimes and harness their impact, many law enforcement departments including researchers have embarked on the trend by conducting some form of crime analysis through mapping [8]. This is evident from the work of [8, 7, 3, 9]

### III STUDY AREA

Katsina Town located at 12°59'N and 7°36'E is the Headquarter of Katsina Emirate and administratively the capital of Katsina state located at 12°15'N and 7°30'E of Nigeria. It has a population of 318,132. The State was carved out of the old Kaduna State in September 1987. It is bounded in the north by Niger Republic, in the east by Kano and Jigawa States, in the south by Kaduna State and by Zamfara State in the west [5]. Figure A is a map showing the study area.

### IV MATERIALS USED FOR THE STUDY

The materials used to carry out this research are;

- i. HP Pavilion dv5 Laptop
- ii. Garmin 76 CSXGPS
- iii. F2000 Series Printer
- iv. A1 Scanner
- v. Road map of Katsina Metropolis at 1: 15,000
- vi. ArcGIS 9.2
- vii. Microsoft Access and Excel

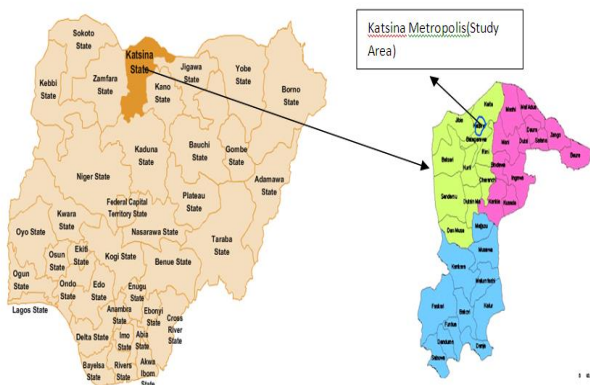


Fig. A: Map of Nigeria highlighting the study area

### V DATA ACQUISITION

Data used for any GIS work can be grouped into non spatial and spatial. And numerous methods exist for obtaining them [2]. The non-spatial data include the base map of the study area, crime records of six (6) years (January, 2004 to December, 2009) with their geographic locations, the names of the councillorship wards (which were later used in zoning the area) were also collected from Katsina Local Government Secretariat, the population figures of the study area were collected from the National Population Commission, Katsina branch. Handheld Global Positioning System receiver was used for the spatial data acquisition. Some of the data acquired include the X and Y coordinate of notable crime scenes and the coordinates used for the geo-referencing of the

base map. Table 1.0 Presents the Easting and Northings Coordinate acquired for the purpose of Geo-referencing the base map.

### VI CREATION OF ATTRIBUTE AND SPATIAL DATA

This is the step by step procedures used in converting analogue data into digital format. The base map of the study area was scanned using an A1 scanner. ArcGIS 9.2 was used for layer Creation, geo-referencing and other required analysis using coordinates presented in table 1.0.

### VII DEMARCATON OF THE CRIME ZONES

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. The study area was divided into thirteen (13) zones. The zoning was done based on the councillorship wards that the metropolis covers. This was done so as to help the police in the deployment of security personnel based on councillorship wards and to assist government to take consideration of councillorship wards that have the higher crime rate when carrying out budgets and also for easy planning by the government. See the Table 2.0 for the grouping of the entire study areas into zones.

All the polygons in the 13 zones were displayed in different colors. Fig. 1.0 is a map showing crime zones in Katsina metropolis. The ascending trend of the legend indicates the severity of crime in the zones.

### VIII CREATING DATABASE FOR THE CRIMES

Some parts of the database were created in Microsoft Excel and imported to ArcGIS as dBase III file format while some parts of the database were created directly in the ArcGIS environment. The fields consist of the following information:

- Types of crimes.
- Gender of suspect
- Crime zones.
- Total area of each zone.
- Total number of crimes for each zone

Table 1.0: Coordinates used for base map geo-referencing

ADDRESS (LOCATION)	EASTING(m)	NORTHING(m)
Kofar Kaura Roundabout	349372	1434924
Kofar Kwaya Roundabout	347954	1434761
KSTA Roundabout	346852	1435402
Kofar Guga Roundabout	346882	1437029
GRA Roundabout	351318	1436987
Kiddies International Sch. Roundabout	350101	1435835
State Secretariat Roundabout	352331	1431806
Steel Rolling Roundabout	351149	1433372
Ulul-albab T-junction	348420	1432183

**Table 2.0:** Crime zones with their sub-divisions

S/N	ZONES	LOCATIONS
1.	BATAGARAWA I	BABBAR RUGA, INWALAVILLAGE, HUK POLY, SABONGARIN YAHUZA, PROPOSED CIVIL DEFENCE SCHOOL, NEAR COMPANION F.M., ULUL-ALBAB SCH., KATSINAUNIVERSITY
2.	BATAGARAWAII	DANDAGWAURO, KABAKAWA FOREST RESERVE, EEC/KTSG, BARHIN, TAFAWA BALEWA WAY, F.C.E., FEDERAL SECRETARIATE, KTARDA STAFF QTRS.,
3.	KANGIWA	KOFARSORO, SAULAWA, YAR'ADUA, YARANCHI, KAYALWA, YAR' KUTUNGU, GWAN-GWAN, GENERAL HOSP., KORAU CINEMA,
4.	SHINKAF III	KAMBARAWA, KWADO, G.R.A., NEW STADIUM, MOBILE POLICE BARRACK, KANGIWA ROAD, G.D.S.S. K/ SAURI, AIRPORT COMPLEX, BAGARUWA, YAN DADI, KUKAR GYESA,
5.	WAKILIN AREWA I	OPEN THEATRE, BALA DANSANI, SABONGIDA, ARMY BARRACK, DUTSEN SAFE, GIDANSARKIN NASARAWA,
6.	WAKILIN AREWA II	TSOHUWARKASUWA, YAMMAWA, FARIN YARO, GALADANCHI, SABUWARKOFA,
7.	WAKILIN GABAS I	RAFUKKA, ZANGUNA, K/SAURI, FILIN SAMJI, MODOJI, GORUBA ROAD, O. OBASANJO DRIVE, TUDUNWADA, K/BAI,
8.	WAKILIN GABAS II	KOFAR MARUSA, KERAU, DUTSEN AMARE, S/UNGUWAR K/MARUSA, K/DURBI, SHA'ISKAWA, TUDUN KATSIRA, OLD C.B.N., MAIKUDI HOTEL, KATSINA GUESS INN,
9.	WAKILIN KUDU I	AMBUTTAI, RAFINDADI, DANMARN, UNGUWARMADAWAKI, POST OFFICE,
10.	WAKILIN KUDU II	SABONLAYI, KWALAN-KWALAN, TEXACO FILLING STATION, DAKI TARA, GARAMA, KOFARKAURA
11.	WAKILIN KUDU III	INWALA, K/KWAYA, ABERTOURE, LUNAR CASTLE HOTEL, KOFAR KAURA LAYOUT, CENTRAL MARKET, LIYafa PALACE HOTEL, KWABRON DOROWA, KORAMAR NAYALLI, S/
12.	WAKILINYAMMA I	MAKUDAWA, UNGUWARYARI, FILIN BUGU, K/ GUGA, SOKOTORIMA, TUDUNYAR' LIHIDDA
13.	WAKILIN YAMMA II	KOFARYANDAKA, FILIN POLO, K.T.S.A., SHAGARILOWCOST

### IX HOT SPOTS OF CRIME IN KATSINA METROPOLIS

Areas prone or susceptible to crime or criminal activities are known as hot spots. Cool spots are places or areas with less than the average amount of crime or disorder. Some hot spots may be hotter than others [1].

Therefore, if that is the case, we can then calculate the hot spots of crimes of the metropolis using Equation (1):

$$\text{Average Crime Incidence} = \frac{\text{Total Number of CrimeCases}}{\text{Total Number of Zones}} \quad (1)$$

Where total number of crime cases reported between the study period = 746 and

Total Number of zones = 13

Therefore, Average Crime Incidence = 57

The average crime incidence was used in the creation of crimes zone map and querying used for the analysis as shown pictorially in the analysis.

### X RESULTS

Some sample queries were carried out to demonstrate the usability of this project. The results obtained from the queries and analysis are shown in the Fig. 2.0 to 11.0.

Table 3.0 shows the zones, their number of recorded crime cases and their hot spot status or designation while Table 4.0 shows the rate of crimes committed by type. This was also presented diagrammatically as Fig. 7.0.



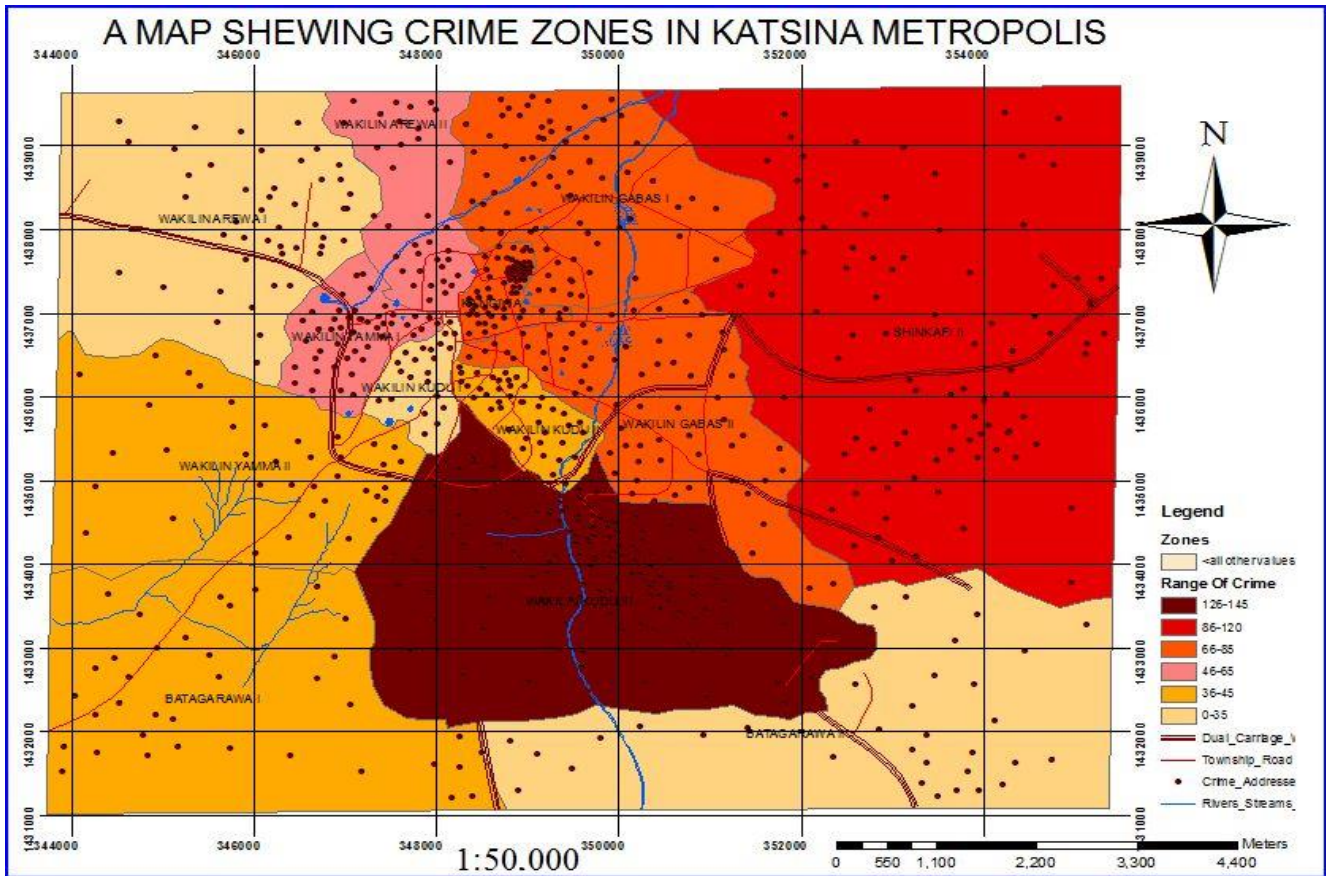


Fig. 1.0: a map showing crime zones in Katsina metropolis.

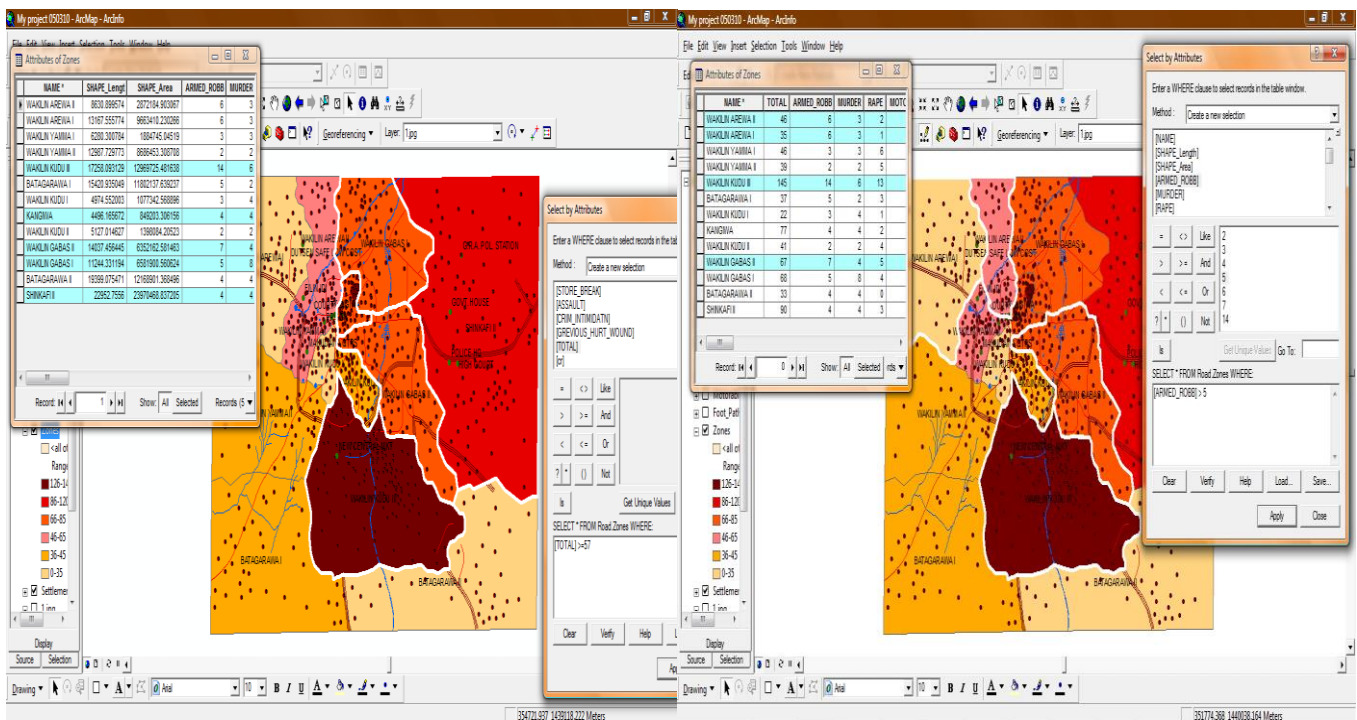


Fig. 2.0: A result of query showing the hot spot zones

Fig. 3.0: query showing the zones with armed robbery cases greater than average.

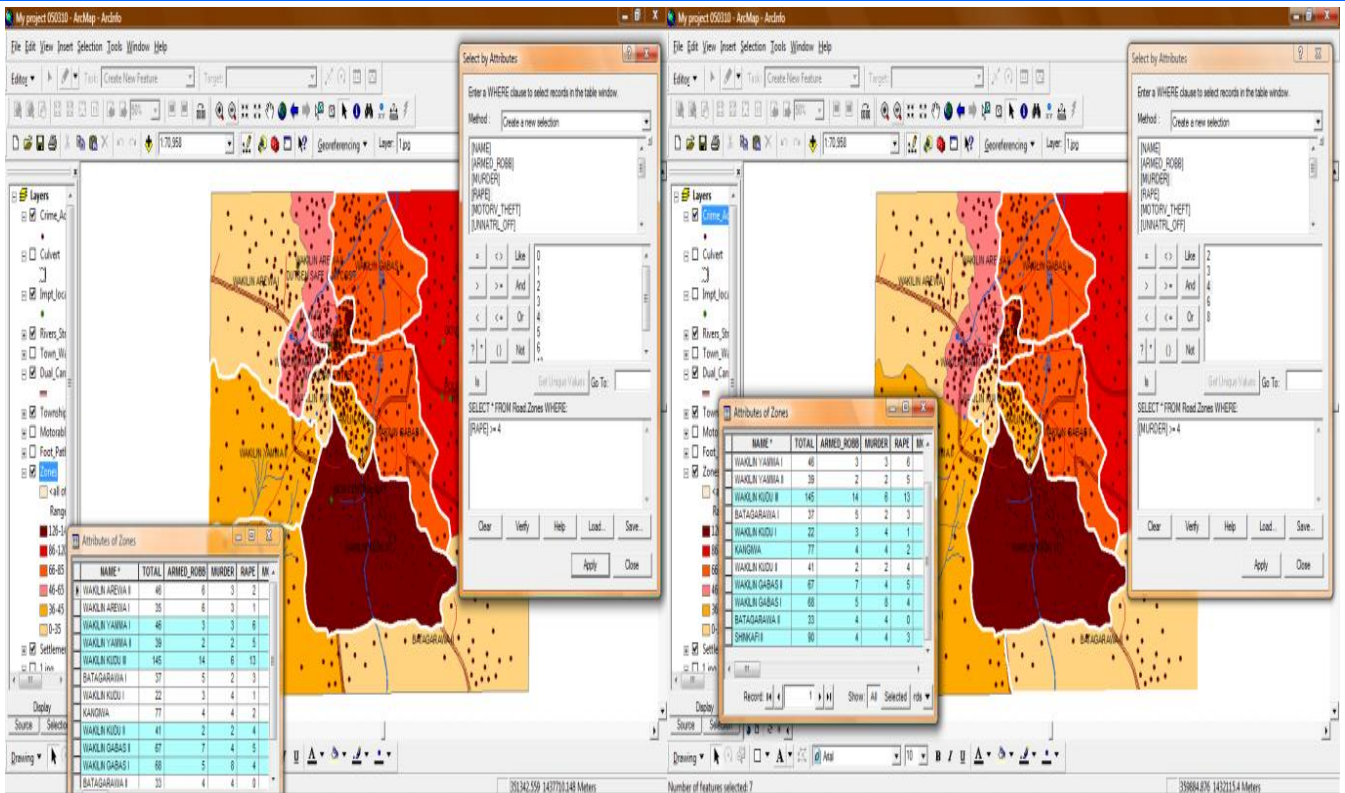


Fig. 4.0: query showing the zones with rape cases greater than average or equal to average

Fig. 5.0: query showing the zones with murder cases greater than average or equal to average

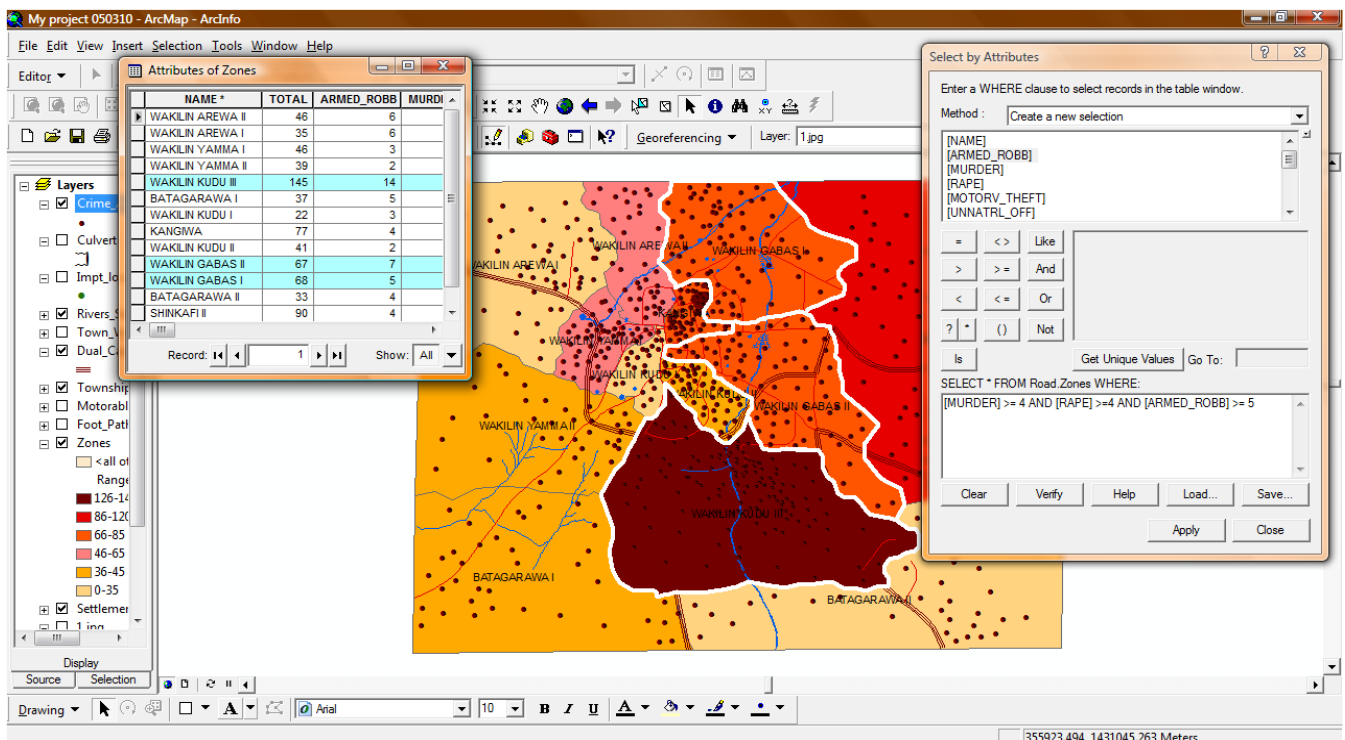


Fig. 6.0: query showing the zones with arm robbery, murder & rape cases greater than average or equal to average.

**Table 3.0:** Zones with high and low crimes

S/N	ZONES	NO OF CRIME CASES	DIFF. BTW AVC AND NO OF CRIME CASES	REMARKS
1	BATAGARAWA I	37	-20	NOT HOT SPOT
2	BATAGARAWAII	33	-24	NOT HOT SPOT
3	KANGIWA	77	20	HOT SPOT
4	SHINKAFIII	90	33	HOT SPOT
5	WAKILINAREWA I	35	-22	NOT HOT SPOT
6	WAKILINAREWAI	46	-11	NOT HOT SPOT
7	WAKILINGABAS I	68	11	HOT SPOT
8	WAKILINGABASII	67	10	HOT SPOT
9	WAKILIN KUDU I	22	-35	NOT HOT SPOT
10	WAKILIN KUDU II	41	-16	HOT SPOT
11	WAKILIN KUDU III	145	88	HOT SPOT
12	WAKILINYAMMA I	46	-11	NOT HOT SPOT
13	WAKILINYAMMAII	39	-18	NOT HOT SPOT

**Table 4:** Rate of Crimes Committed By Type

S/NO.	TYPES OF CRIME	TOTAL NO. OF CRIME	RATE OF CRIME IN %	RANKING
1	THEFT AND OTHER STEALING	337	45.17	1st
2	ASSAULT	66	8.85	2nd
3	ARMED ROBBERY	65	8.71	3rd
4	RAPE	49	6.57	4th
5	MURDER	49	6.57	5th
6	HOUSE BREAKING	44	5.9	6th
7	CRIMINAL FORCE	38	5.09	7th
8	MOTORVEHICLE THEFT	32	4.29	8th
9	CRIMINAL INTIMIDATION	19	2.55	10th
10	GREVIOUS HURT AND	20	2.68	9th
11	UNNATURAL OFFENCE	10	1.34	12th
12	STORE BREAKING	11	1.47	11th
13	KIDNAPPING	6	0.8	13th



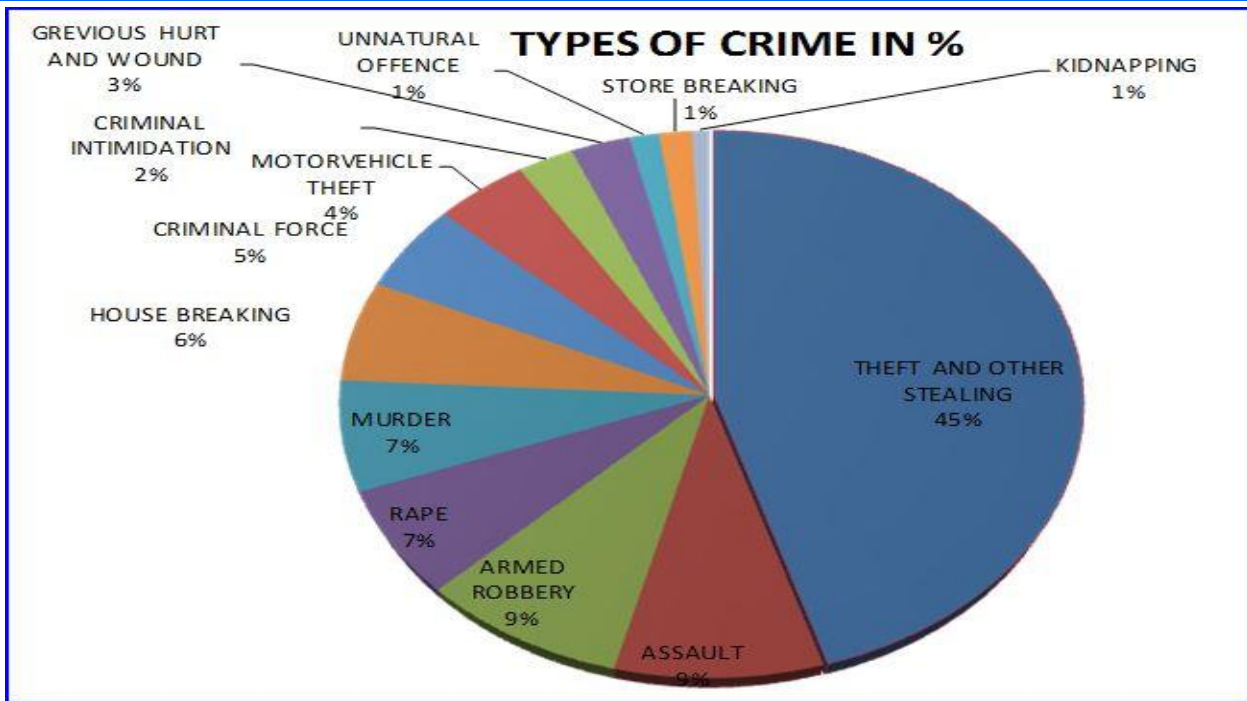


Fig. 7.0: A pie chart showing the types of crime committed in percentages from 2004 to 2009.

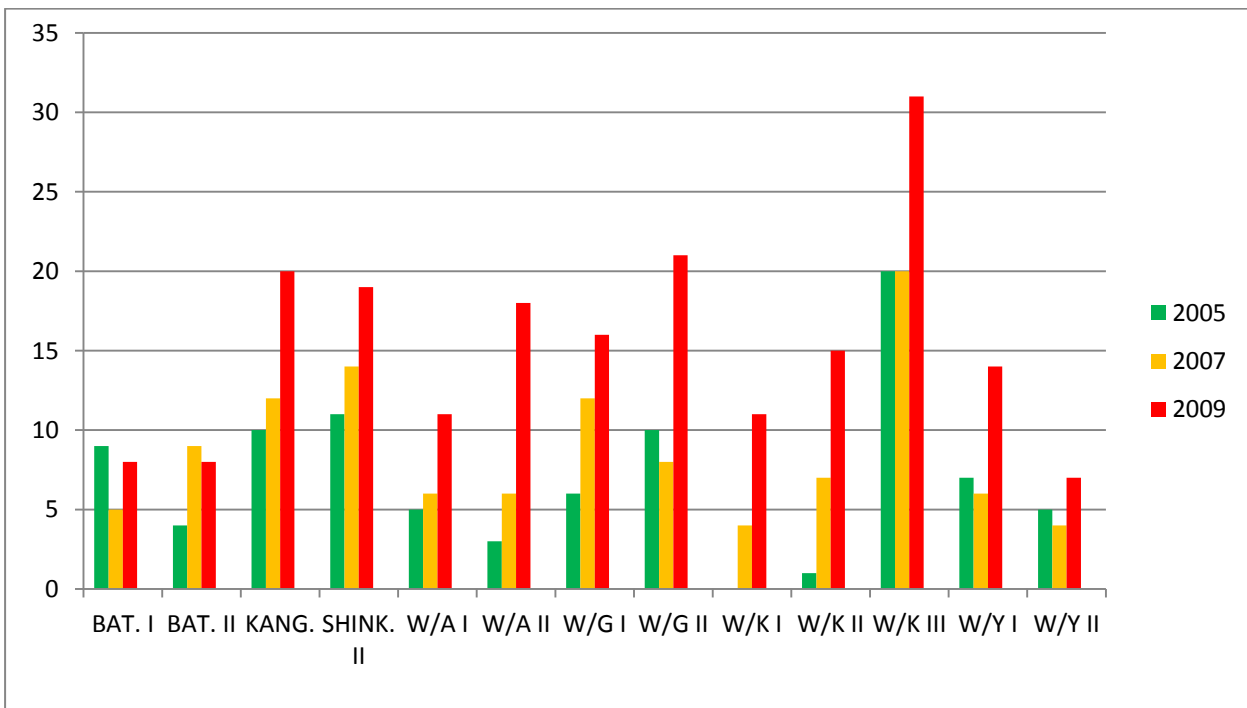


Fig. 8.0: A bar chart showing the total number of crimes (for 2005, 2007 and 2009) against the crime zones.

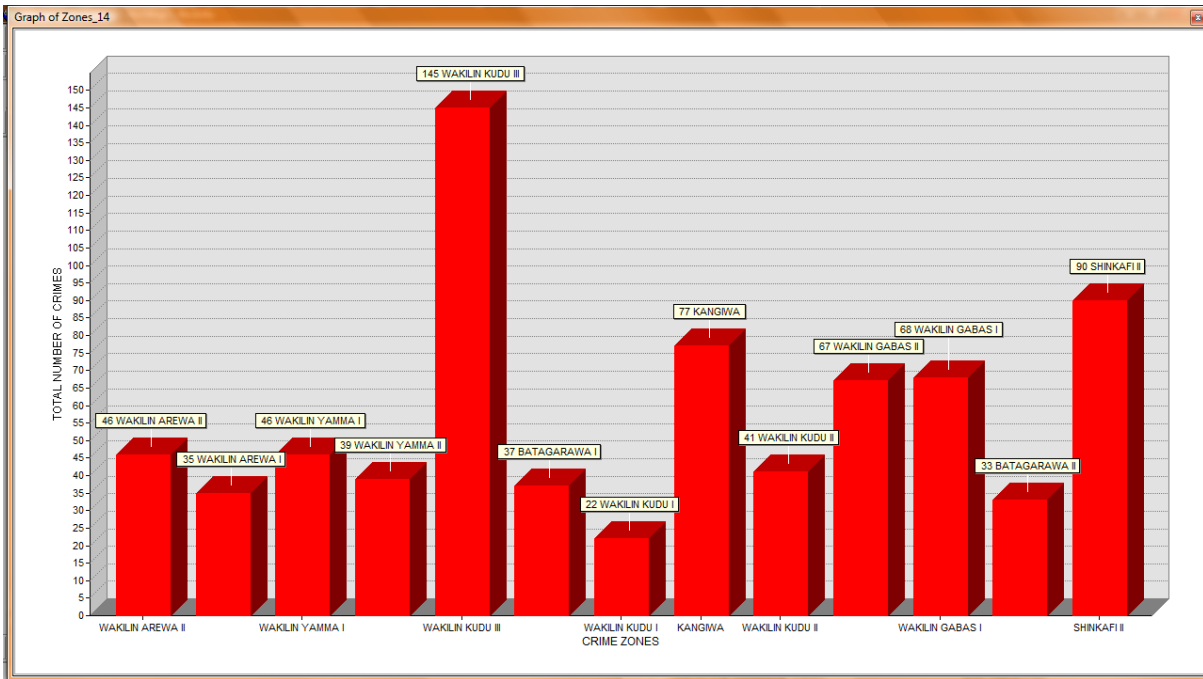


Fig.9.0: A bar chart showing the total number of crimes against zones

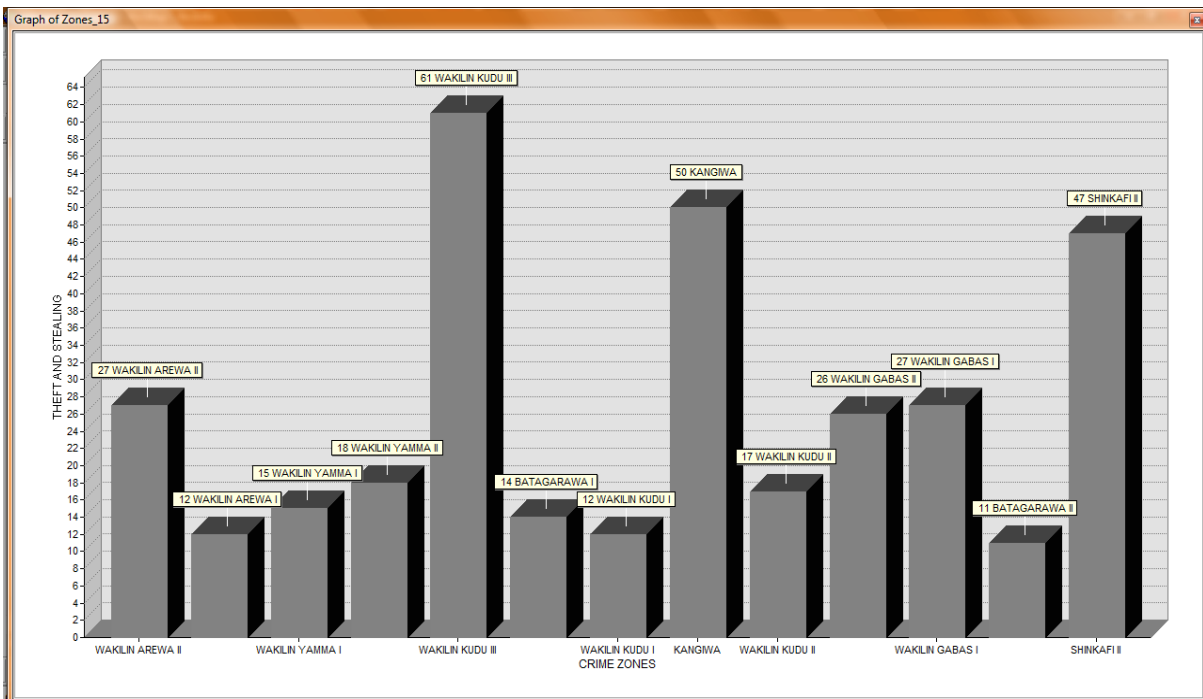
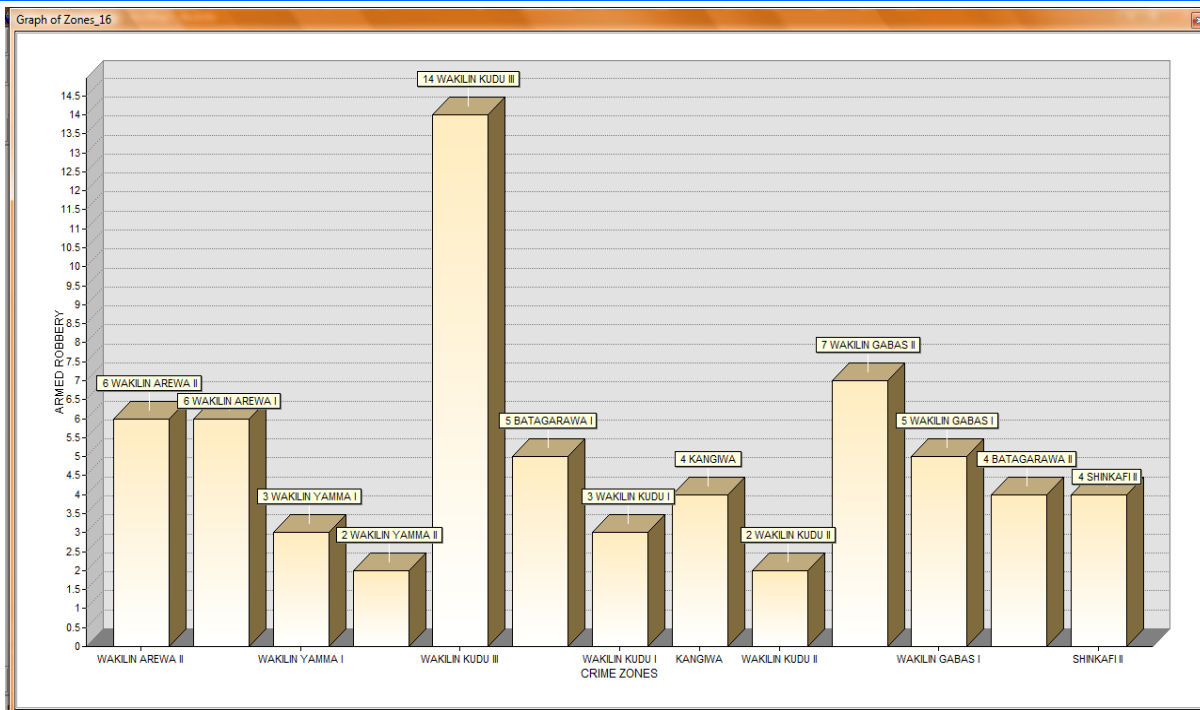


Fig. 10.0: A bar chart showing the total number of theft and stealing crimes against zones





**Fig. 11.0:** A bar chart showing the total number of armed robbery cases against zone

## XI ANALYSIS

The result of the Fig. 1.0 shows the hot spot zones, the colors represent the intensity of the crimes committed. The zone in dark red is the hottest zones with total number 145 cases. From the query in Fig. 2.0 we can see that all the hot spot zones are sharing boundaries among themselves.

The result of the fig. 3.0 shows the areas with armed robbery cases greater than average. It was observed that there are four of such zones (WAKILIN YAMMA I, WAKILIN GABAS, SHINKAFI II and WAKILIN KUDU III) and two (SHINKAFI II and WAKILIN KUDU III) of which are the hottest zones. This is because the average crime incidences are 46-65, 66-85, and 86-120,126-145 respectively for WAKILIN YAMMA I and II, WAKILIN GABAS I and II and SHINKAFI II, WAKILIN KUDU III.

The result in Fig. 4.0 shows the areas with rape cases greater than or equal to average. From the figure we can see that there are six of such zones; three of which are hot spot zones while the remaining three are cool spots.

The result of the query in Fig. 5.0 shows the areas with murder cases greater than or equal to average. From the figure we can see that there are seven of such zones; five of which are hot spot zones while the remaining two are cool spots.

The result of the query in Fig. 6.0 shows the areas that are notorious for armed robbery, murder and rape cases. From the figure we can see that these zones are three in number and all of them belong to hot spot zones. These zones are: Wakilin kudu III, Wakilin gabas I and Wakilin gabas II.

From the Table 3, there are generally five hot spots of crime in the study area, namely Kangiwa, Shinkafi II, Wakilin gabas I, Wakilin GabasII and WakilinKuduIII. It was observed that Wakilin Kudu III is the hottest zone with the difference of 88 from the average.

Table 4 shows that theft and stealing cases alone accounted for about 45.17% of the total crime cases in Katsina Metropolis between 2004 and 2009. Assault accounted for 8.85%, while armed robbery accounted for 8.71% and rape for 6.57%. Murder too has 6.57% while House Breaking and Criminal Force have 5.90% and 5.09% respectively. Other crime categories explain for less than 5% each. This is buttressed with Fig. 7.0.

From Fig. 8.0, the bar chart shows the rate of crimes for the period of study i.e. from 2005 to 2009. It can also be seen that the rate of crime is at increase every year (from 2005-2009).

From Fig 9.0, it can be seen that the zone with the highest recorded cases is the Wakilin Kudu III, with the longest bar, then followed by Shinkafi II. Wakilin Kudu I can be considered to be the coolest spot because it has very few cases recorded.

From Fig. 10.0, Theft and stealing is the highest type of crime committed in the metropolis with 45.17%. It can be seen that the zone with the second highest recorded cases is the Kangiwa zones; this is obviously what we could have expected especially if one consider the fact that this zone has a market known as Yarkutungu where most of the cases were reported to have happened.

Fig. 11.0 shows the rate of armed robbery cases in which Wakilin Kudu III has the highest number of

cases. It was observed that armed robbery cases are not rampant in the whole metropolis because even the zone with the highest recorded cases has just 14 cases within the period of five years.

## XII CONCLUSIONS

The study has effectively used GIS as a tool to develop crime database and map crime zones in Katsina Metropolis. The methodology used includes field work with GPS, police crime records and analogue map. The crime zones were created for the purpose of this study and for effective handling of the data in a GIS environment. Hence, the study posits that application of GIS to crime management in Nigeria will go a long way to aid the prevention and control of crimes as well as to boost the activities of the criminal justice system to fight crime.

From the findings, theft and stealing are the highest type of crime committed in the metropolis, then assaults, followed by robbery, rape and murder, House Breaking and Criminal Force and finally Other crime categories.

## XIII RECOMMENDATION FOR FURTHER STUDIES

Every crime has spatial location, so also does crime offenders have their most probable area of residence. Here, geographic profiling comes in. It is recommended that future studies should embark on finding the most probable residence of offenders. This will help in identifying the Hunter, Poacher and the Troller type of offenders which will aid the authority concerned in devising variety of hunting methods.

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