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THE USE OF GEOSPATIAL TECHNIQUES IN CRIME MAPPING AND ANALYSIS IN PARTS OF MINNA METROPOLIS, NIGERIA.

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Abstract
Crime an act of commission or omission that disrupts peace, tranquillity, norms, values and rules of society is considered to be injurious to the society and punished by the state. Crime management has gone scientific and thus crime mapping using geo spatial techniques was utilised and applied to Minna, Nigeria. Data acquisition and import was carried out using police records, Ikono Satellite imageries, Nearest Neighbour Index and Kernel Density Estimation tools were used and adopted respectively. The result shows the spatial distribution of crime incidence, identification of crime hotspots and location of Police stations, vehicles and other infrastructures in map format of the study area. Conclusively, the study provides crime database for processing, storage and analysis for planning purposes. It is therefore recommended that, Police and other security agencies can adapt GIS technology, integrate it with the traditional approach to crime management for effective service delivery in the study area.

Keywords: Hotspot, Crime, Police Station, Crime Mapping, Crime Incidence Spot

Introduction

The Law Dictionary defined crime as an act commission or omission, in violation of a public law, either forbidding or commanding it; a breach or violation of some public or duty due to a whole community. The global upsurge in crime and criminality has continued to gather momentum such that efforts are upgraded continuously to combat the menace. The increasing wave of crime in the society, internationally and locally, calls for immediate concerns in terms of documentation, investigation, analysis and prosecution of offenders. This will provide the needed data bank for effective crime policing aimed at prevention and management. Crime mapping is a very broad topic that 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 provides information concerning the location of hotspots or high level of reported crime. Effective crime control and management requires the collection, organization and retrieval of a variety of data. Multiple types of data such as texts (criminal data, property data, gang information, case profile), graphics (photographs of criminals, pictures of crime scenes) and geographic (crime locations, details of the area) need to be accessed (Narayan, 1999). The application of Geographical information System (GIS) helps to manipulate data in the computer to stimulate alternatives decisions (Narayan, 1999). An area containing dense clusters of criminal incidents is referred to as a crime hotspot (Block, 1995). This could be a point such as a building or classroom or an area, a sample tract or a municipal constituency. It can also be defined whereby the occurrence of crime is so frequent that it is highly predictable, at least over a one-year period. Hotspot is determined only by the geometry of previous events thereby reflecting the role of time. Identification of hotspots could help public safety institutions, allocation of resources for crime prevention activities (Michael, 2014). In a developing country like Nigeria, there is virtually no strategic

control of inflow of people in and out of major cities. Minna being the state capital, has attracted people and business such as banks, markets, hotels, guest houses and industries (macro and micro). These activities in economics are indications of growth. This results in continuous urban expansion that correlates with population increase, which results in all sorts of persons with different characters taking abode in the city. The increase in the rate of crime in recent time in the country and particularly in the study area, necessitated the restriction of time limit from 6a.m to 6p.m daily on both private and commercial motor bike riders; popularly called Okada, by the Government of Niger State. This restriction seems to be a step towards the control of crime especially at night. However, it leaves much to be desired. The traditional method of collection, analysis, dissemination and retrieval of information, which are usually filed and stored in filing cabinets, is poor, inadequate and primitive. Police Departments in most developing countries still collect crime data using police forms and books, a practice inherited from the colonial times. This is not only prone to errors but create lapses in the efficiency of the law enforcement agencies to quickly and readily retrieve data. This study, therefore, utilised Geospatial techniques with the specific objective of analyzing and mapping crime hotspots and to create spatio- temporal database for crime management in the study area.

Study Area

Minna, is the Capital of Niger State in the North Central of Nigeria. It has an estimated population of 202,151 (NPC, 2006). It is located on latitude 9° 33' N and 9° 45' N and longitude 6° 34' E and 6° 42' E. The city is traversed by a major express road which is the Abuja - Zungeru road that seems as the entrance and exit route to the city especially from Abuja. It is encircled by the eastern and western bypass roads that serve as connecting and alternate routes to other major towns in the state such as Bida, Jos, Kaduna and Ilorin. Minna is an agglomeration with most of its zones exibiting nucleated pattern and a few dispersed. Minna is the administrative capital and also the seat of the Local Government Council it is made up of 11 wards which are Minna central, Limawa A, Minna South, Limmawa B, Nassarawa "A", Nassarawa "B", SabonGari, Tudunwada North, Tudunwada South and Nassarawa C with its dual role as seat of government for the state and local government. Minna attracts people from all works of life for both business and pleasure. Hence, different language groups from all over the country are found here. However, the majority ethnic groups are the Gwaris, Nupes, Yoruba, Hausa and Igbo.

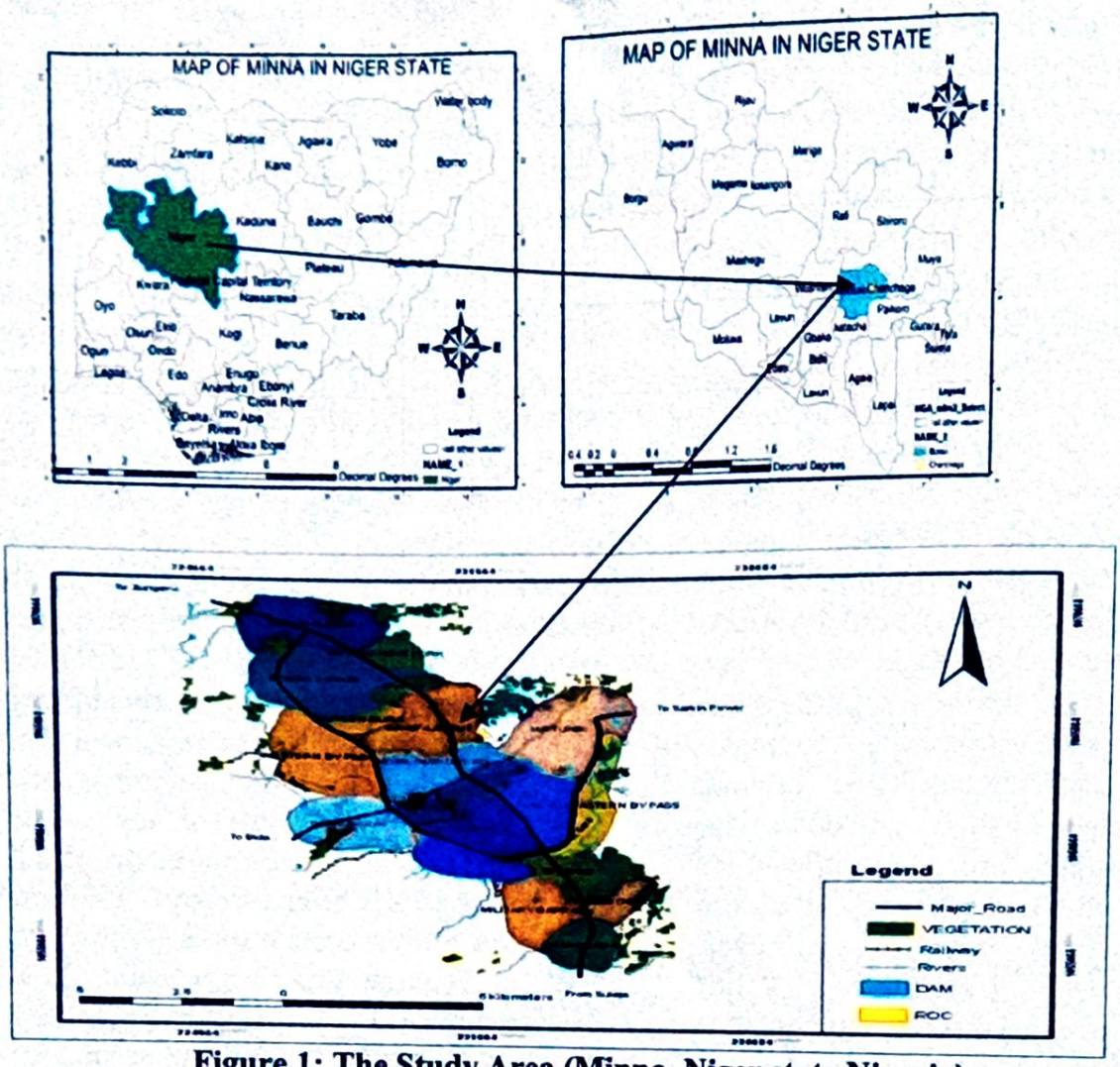

Figure 1: The Study Area (Minna, Niger state Nigeria)

Materials and Methods

This session discussed the type of data employed in the study, the sources of the data and the method of collection, the device for data acquisition and procedure used for the analysis in order to arrive at a conclusive decision. Table 1 show the summaries of data used in the study.

Table 1. Summaries of Data Used

Data	Data Source	Data source type	Year
Ikonos Image	Google Earth	Secondary	2009
Administrative Map	NASRDA	Secondary	
Questionnaires	Field	Primary	
Coordinate of Incident Points	Field and Police Stations	Primary	

Data Acquisition and Import were carried out by dividing the study area into four sectors or zones which comprised of Bosso, Maitumbi, Tunga and Chanchaga. The Police records crime activities and coordinates of crime spots were generated based on these zonations. The Garmin GPS hand held receiver was used to obtain coordinates of the study area. These coordinates were referenced to WGS84_UTM_Zone_32N and Ikonos satellite imagery of about 0.8 meter resolution were utilized. Identification of the pattern of crime hotspots and locations

of crime incidents were carried out using the Nearest Neighbour Index (NNI) analysis. The CRIME STAT III and ARC GIS 10.1 software were used to determine the correlation between crime incident points and distances of the incident points in the study areas, hence the use of Nearest Neighbour Index (NNI). This was computed using the coordinates of the crime incident for the four Zones. The Nearest Neighbour Index (NNI) measures the degree of spatial dispersion in the distribution based on the minimum of the inter-feature distances. Such that the distance between points features in a clustered pattern will be smaller than in a scattered (uniform) distribution with random falling between the two. The equation for NNI is given as:

$$(NNI) = \frac{d\,(NN)}{d\,(ran)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

Where:

d (NN) is observed Nearest Neighbour Distance;

d (ran) is mean random distance.

The values of NNI range between two theoretical extremes, 0 and 2.1491. When all the points in a pattern fall at the same location, the pattern represents the theoretical extreme of spatial concentration, in this case, Ad = 0 and NNI = 0. The more closely the points are clustered together, the closer to zero NNI will be, since the average Nearest Neighbour Distance decreases. The closer NNI gets to 1, the more randomly spaced the points are. The value of NNI approaches 2.1491 for perfectly uniformly spaced points. Hence, the closer NNI is to 2.1491, the more uniformly spaced the data area. The proximity analysis was carried out to determine the distances between police post or stations to crime incident scene. This is to determine the time lap for police response to crime cases and also to determine if there are sufficient police posts to manage the crime occurrence cases in such vulnerable area. This was achieved via the process of buffering. Hence coordinates of the police infrastructure were mapped on the layer then a circumference buffer of about 500 meters was performed to see incident spots that fall within the region.

Kernel Density Estimation (KDE) was also used as an interpolation technique for generalizing incidents locations to an entire area hence this involves placing a symmetrical surface over each point and evaluating the distance from the point to a referenced location based on a mathematical function, and summing the values of all surfaces for that reference location. Figure 2 illustrates the methodology flow chart utilized in the study.

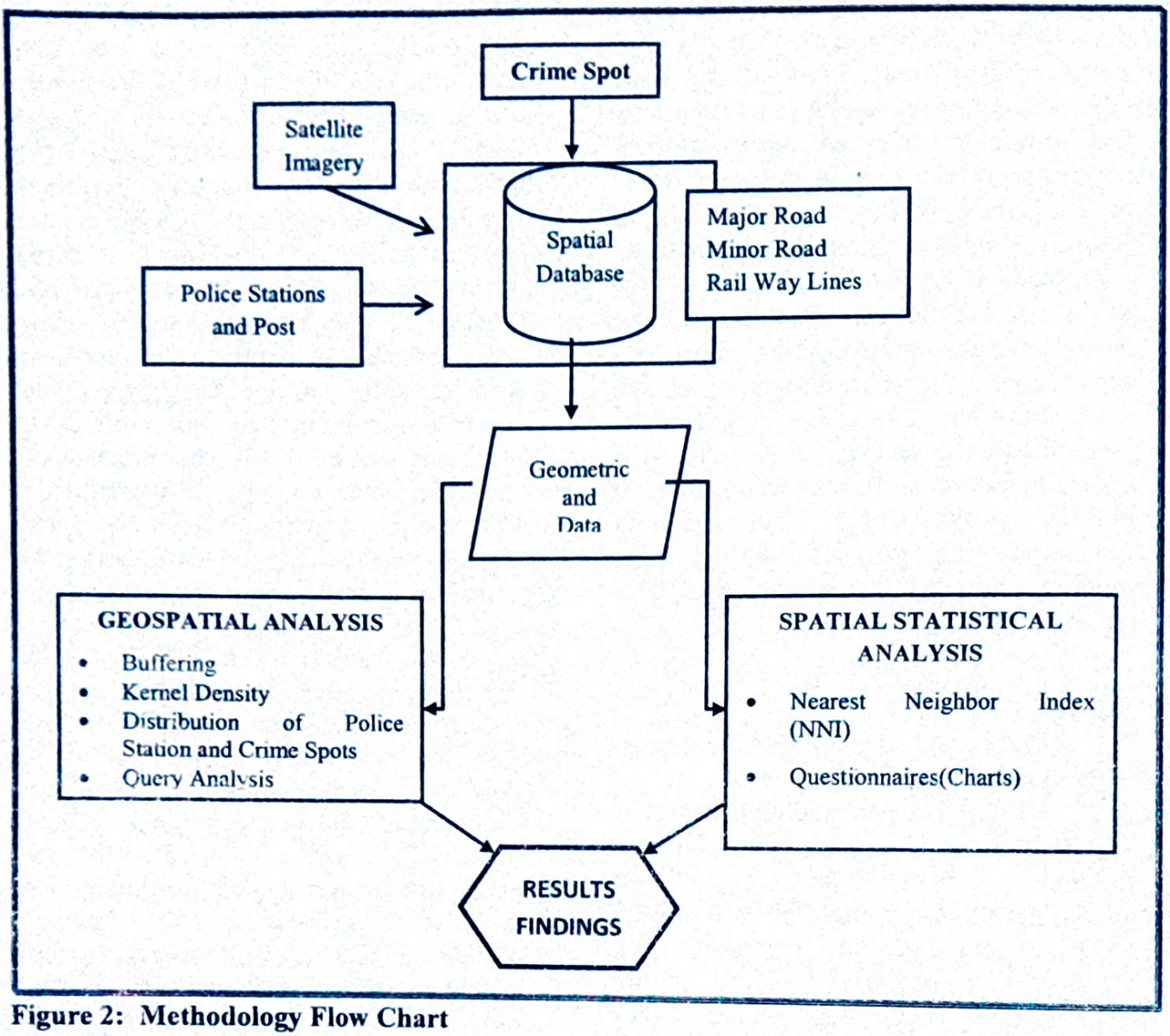

Figure 2: Methodology Flow Chart

Results and Discussion

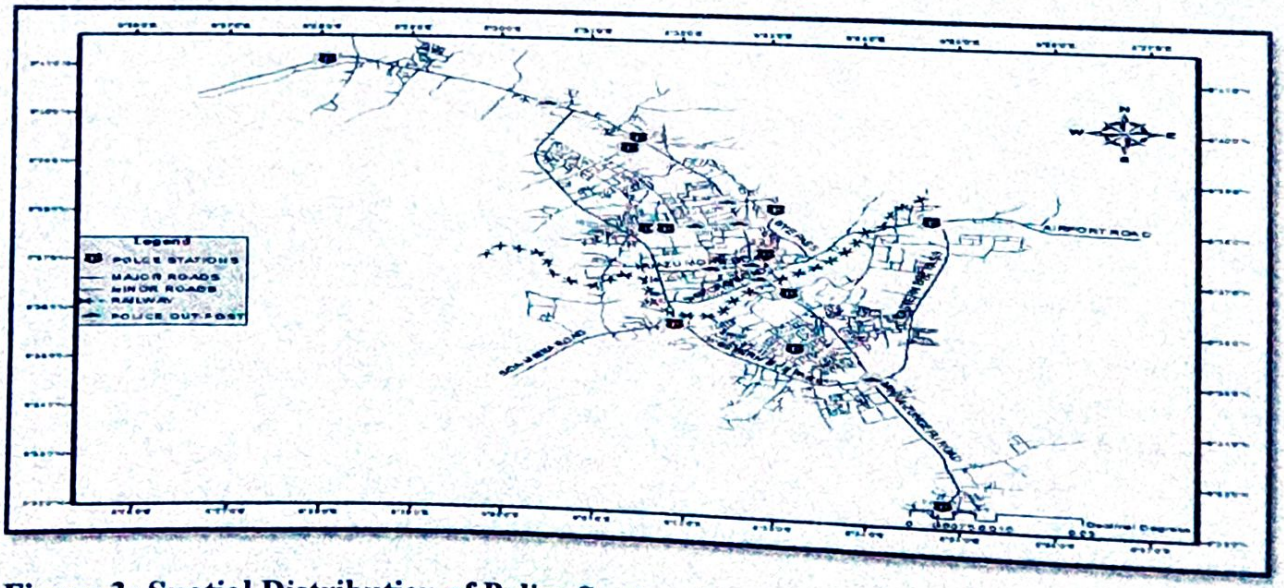

Figure 3: Spatial Distribution of Police Stations/Outpost of Police Vehicles in Minna

Figure 3 shows the distribution of police facilities and the position of their outpost vehicles which are situated at some strategic major road junctions. They also provide in and outlet for moving vehicles. Also, most of the Police station facilities are more concentrated in TungazonethanBosso, Chanchaga and Maitumbi put together.

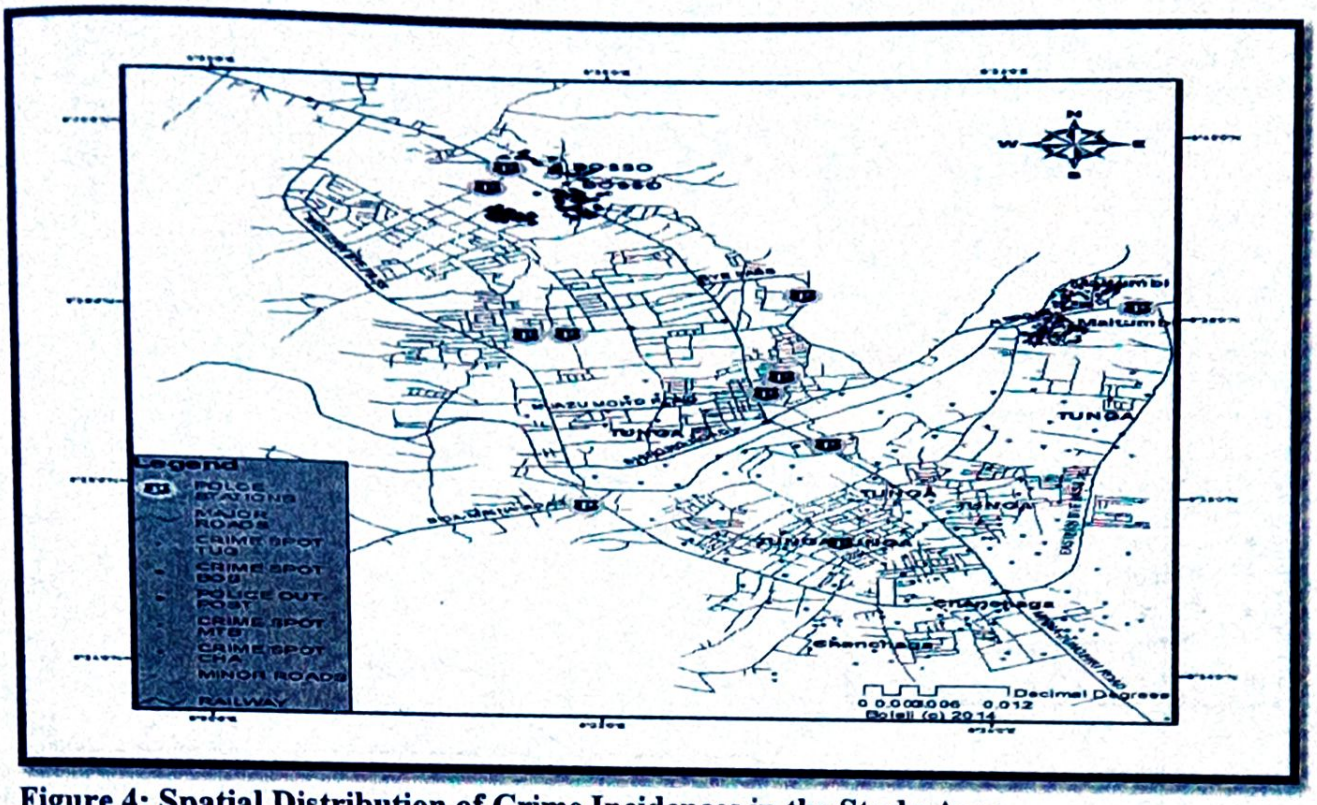

Figure 4: Spatial Distribution of Crime Incidences in the Study Area

Figure 4 depicts the spatial distribution of crime incidences in the study area. It is evident that most crime incidences are clustered in three out of the four zones which are Bosso, Maitumbi and Chanchaga while in Tunga the crime incidences are almost evenly distributed across the zone.

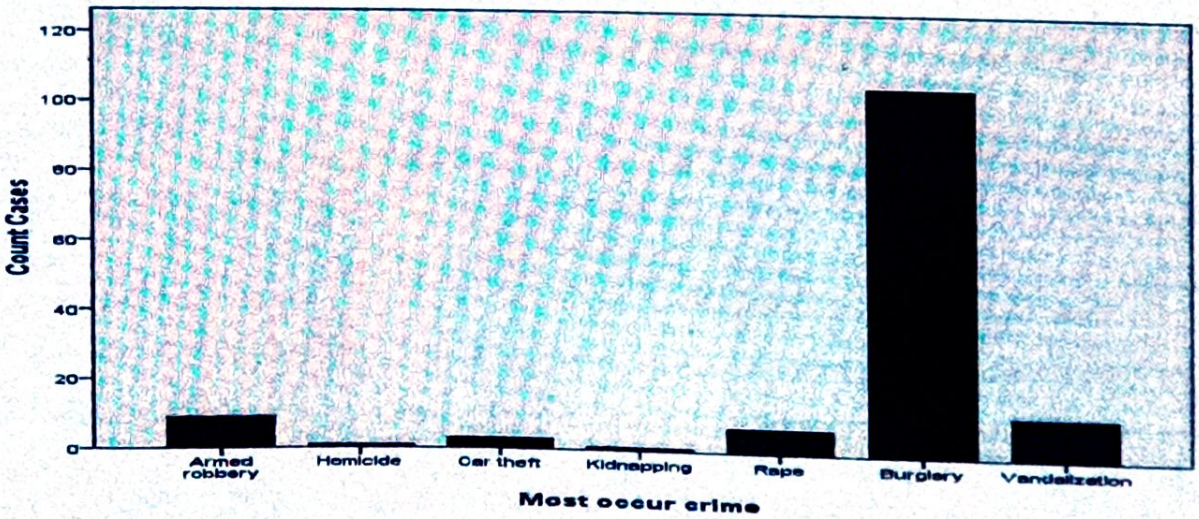

Figure 5: Distribution of Crime Types Maitumbi

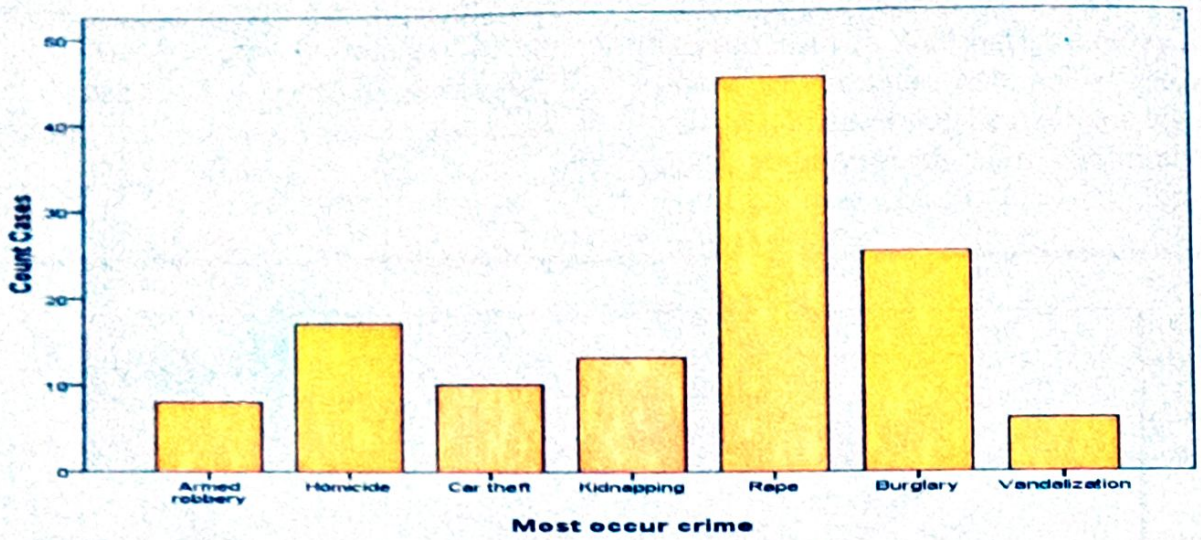

Figure 6: Distribution of Crime Types in Tunga

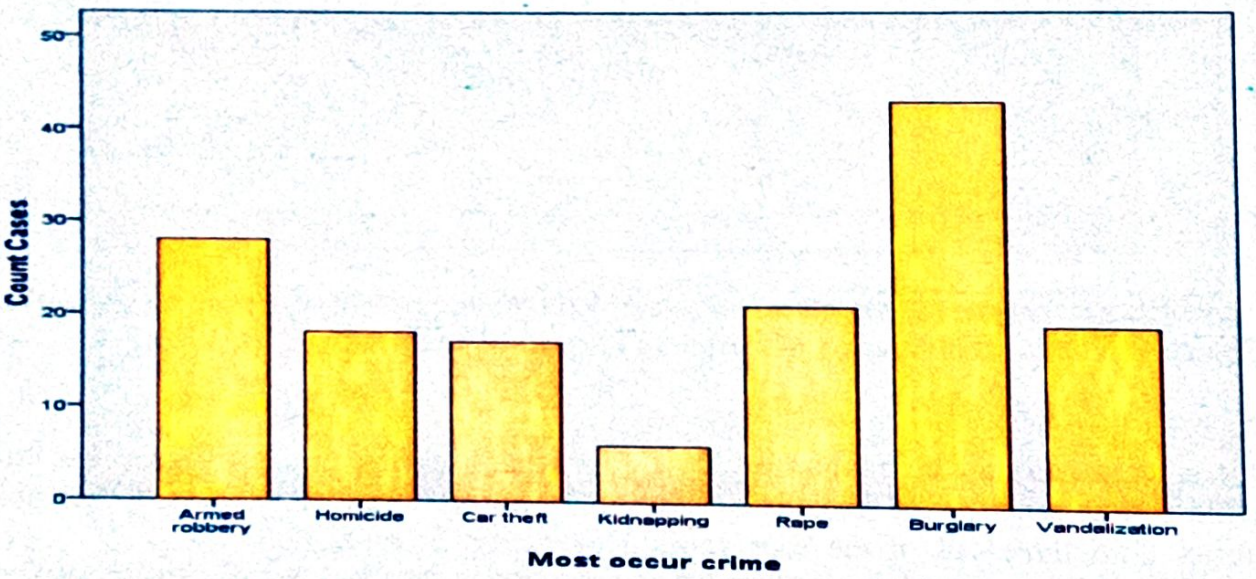

Figure 7: Distribution of Crime Types in Bosso

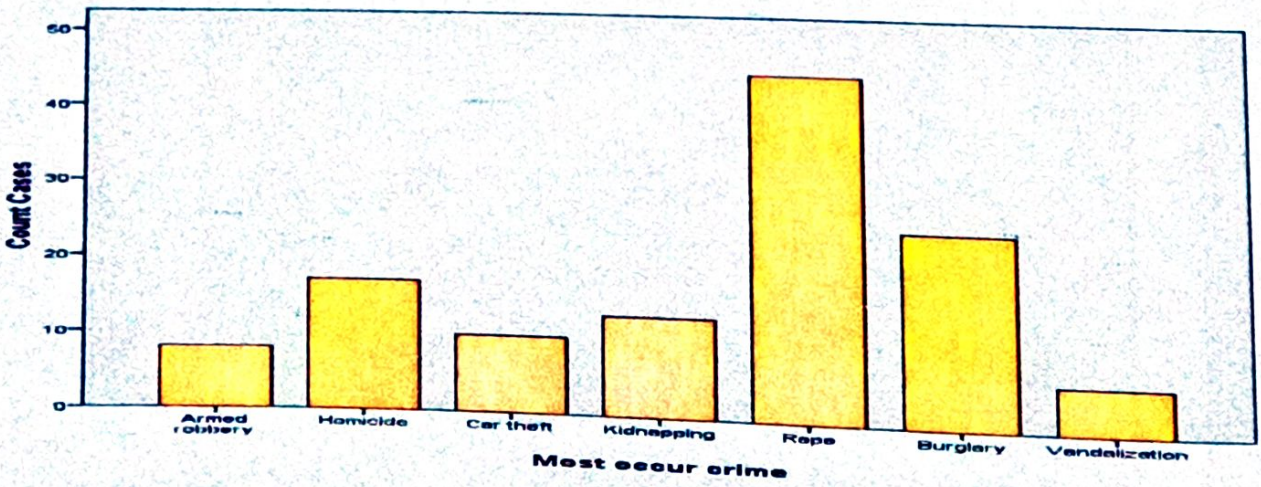

Figure 8: Distribution of Crime in Chanchaga

Figures 5, 6, 7 and 8 shows the description of crime types in Maitumbi, Tunga, Bosso and Chanchaga Zones. Figure 5 show that 43 counts which is the highest represents recorded and burglary while 28 counts of the total represents armed robbery. Also rape and vandalism falls between 18 and 20 counts respectively. Figure 6 depicts that the highest occurring crime in Tunga district of the city is Rape accounting for about 47 counts of the crime cases in the area, also followed by Burglary which shows about 26 counts respectively while homicide accounts for 18 counts. The distribution of these crime types can be attributed to the dispersed settlement pattern and also distribution of more police stations around Tunga. Figure 7 depicts that the highest perpetuated crime in Bosso zone is burglary with a dominant percentage of about 100 counts with the rest of the crime types relatively minute. This distribution is related to the type of settlement and the class of people living there. These are mainly Students. These houses are ill built with little or no security, except for places with vigilante groups that function mainly at late nights. Figure 8 shows the highest occurring crime in Chanchaga zone of the city is rape and this agrees with police statistics accounting for about 47 counts of the crime cases in the area, this is followed by burglary cases which account for about 23 counts, and homicide is next with 18 counts and the rest contributed to the remaining 25 count.

Table 2:Summary of NNI for the four zones

Location	Z-Score	P- Value	Nearest Neighbourhood Ratio (NNR)	Result Description
Maitumbi	-4.836192	0.000001	0.821690	Clustered
Tunga	2.337515	0.019412	1.098782	Dispersed
Bosso	-8.802130	0.000000	0.625572	Clustered
Chanchaga	-6.844533	0.000000	0.70884	Clustered

Table 2 shows the results of the Nearest Neighbour Index for the Four Zones, which are Maitumbi, Tunga, Bosso and Chanchaga. Maitumbi, Bosso and Chanchaga Zones have clustered pattern of crime incidences, while Tunga is dispersed.

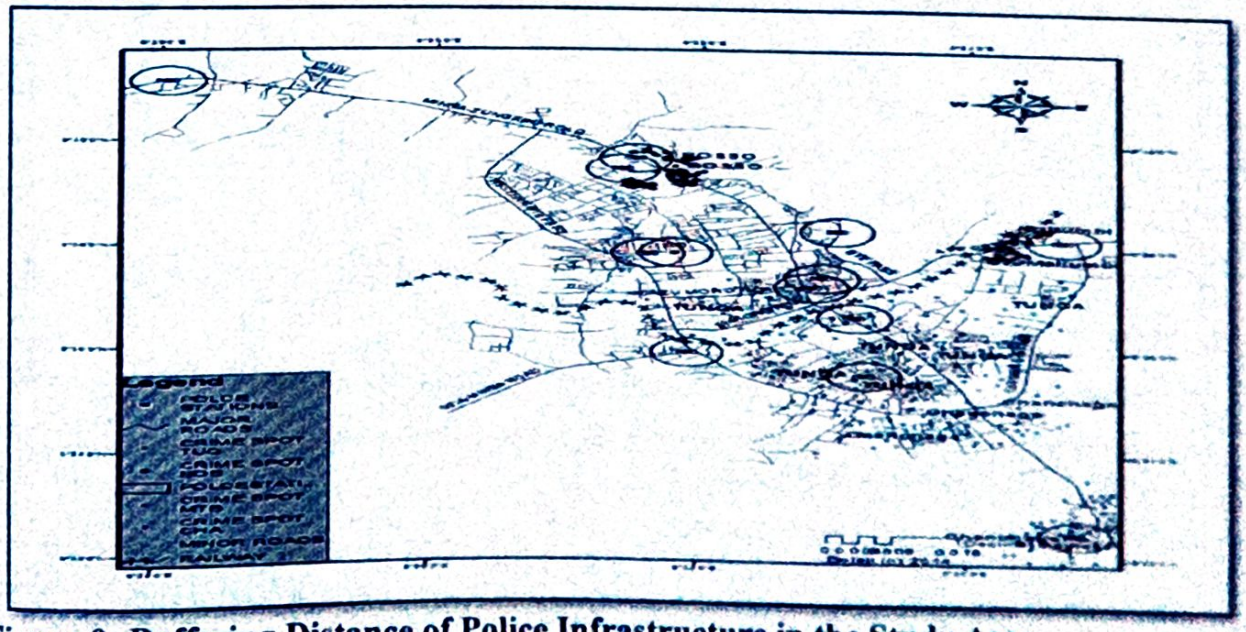

Figure 9: Buffering Distance of Police Infrastructure in the Study Area

The Kernel Density Estimation (KDE) provides an estimate of the proportion of total incidence that can be expected to occur in any given location. Thus, this is visually represented by the aggregation of the incidence points in a clustered form to show high density or hotspots in crime scenarios. It further shows the pattern of the distance from each crime incidence point to the nearest police station in case of emergency or distress call. The distances range from 1 kilometer, 500 meters, and 250 meters respectively to the nearest Police station.

Figure 10: KDE of Crime Spots in Maitumbi Zone

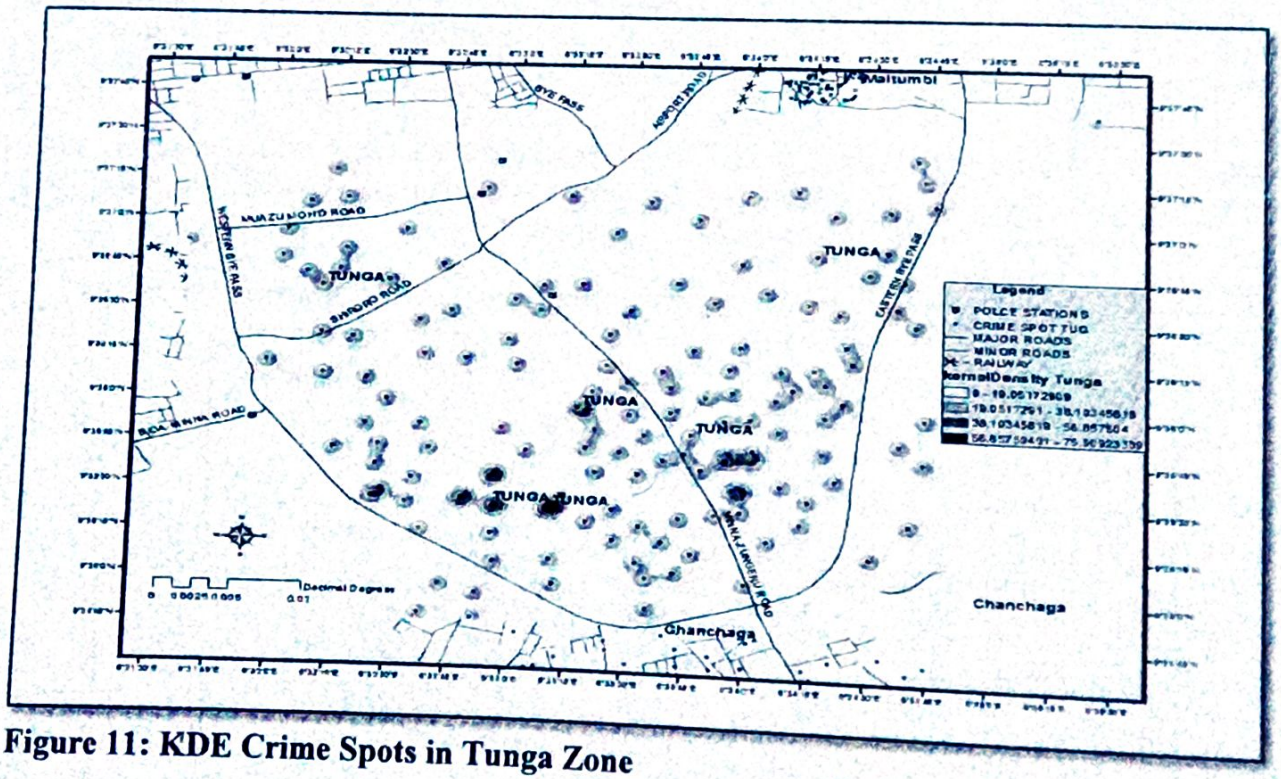

Figure 11: KDE Crime Spots in Tunga Zone

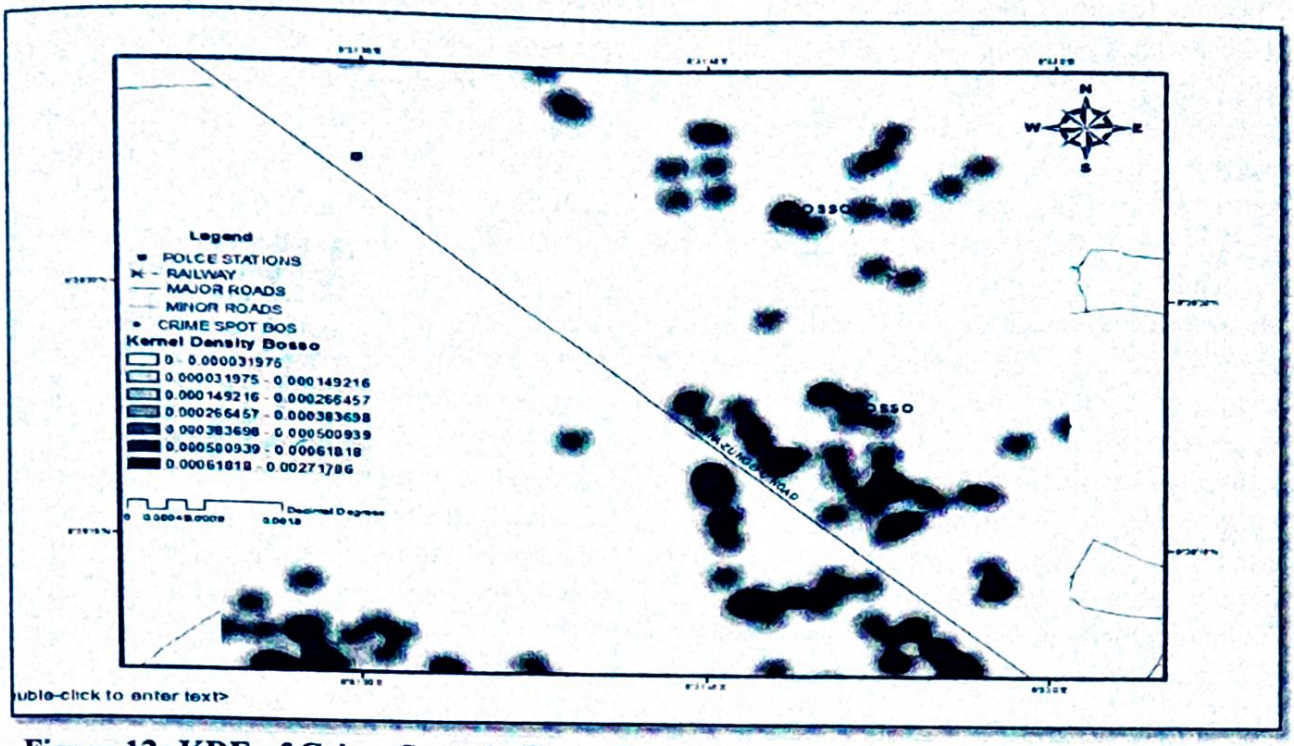

Figure 12: KDE of Crime Spots in Bosso Zone

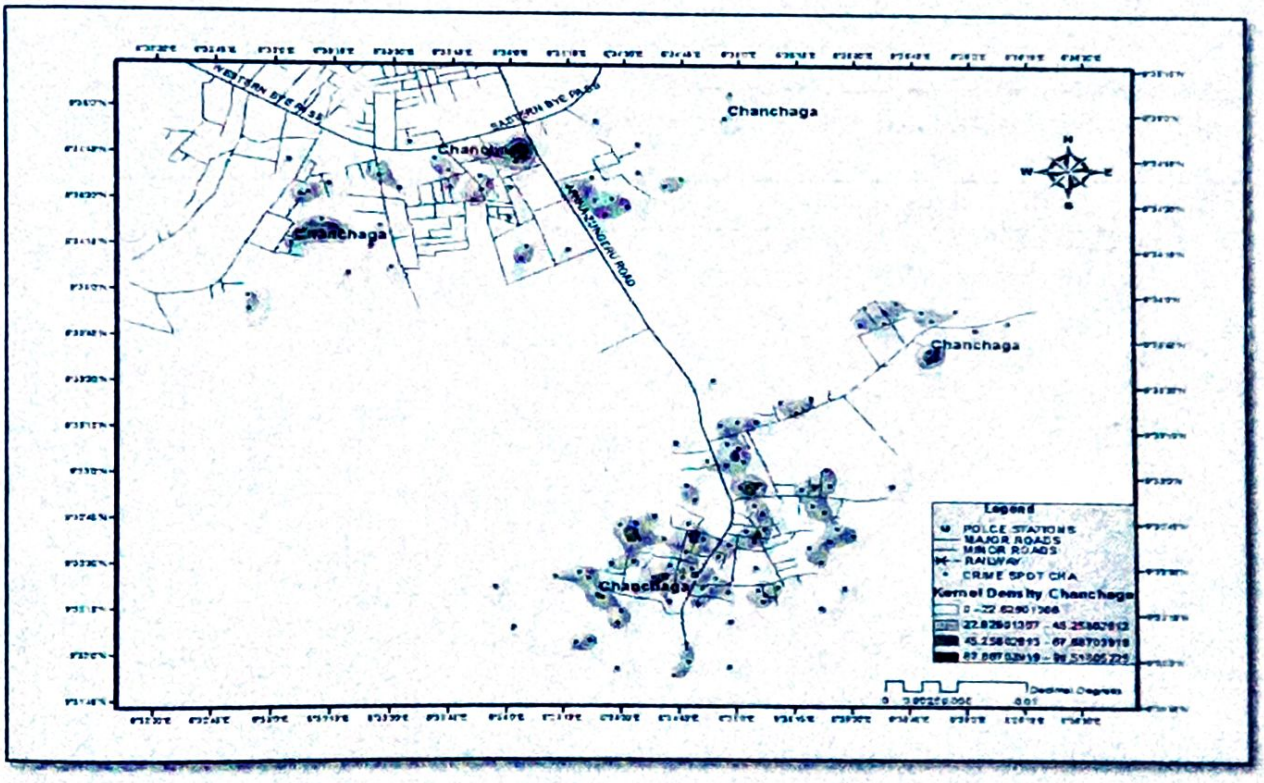

Figure 13: KDE of Crime Spots in Chanchaga Zone

Figures 10, 11, 12, and 13 show that the areas within each zone with colouration (lighter shade) depict no incident or cold spot while the areas with colouration (darker shade) indicate crime hotspots. It is common knowledge that crime prevention, detection and investigation is the primary responsibility of the Police. The incessant occurrence of crime in our society, particularly in urban centres has continued to be challenging for both the security agencies and the civil society. The Factors

responsible for these crimes include widespread poverty, unemployment, youth restiveness and the corresponding deficiencies in crime fighting manpower and facilities of the security agencies.

The traditional methods of policing in use seem to portray more of ceremonial duties than intelligent pursuit of crime reduction. Many studies have been carried out in the area of crime. To combat crime, the accuracy and reliability of these technologies is more reliable when compared to traditional methods that are used in modern crime management.

Conclusion and Recommendations

The benefits derived from using GIS technique in crime management are enormous. The proximity/NNI indicates that some Police stations may be closer to a crime hotspot, but the length and complexity of the roads to such hot spots constitute a hindrance to arresting offenders. The study reveals that digital and detailed outline for processing, storing and analyzing information on crime pattern and security outfit for planning purposes. Therefore, for effective crime mapping and management in the study area, the security operatives (especially the Police) should enhance their crime fighting techniques to adopt the modern standard of policing by applying GIS technology in order to improve service delivery.

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