

GEO-SPATIAL TECHNOLOGIES FOR NIGERIAN URBAN SECURITY AND CRIME MANAGEMENT - A STUDY OF ABUJA CRIME HOTSPOT MAPPING AND ANALYSIS

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ABSTRACT

Abuja is one of the fastest growing cities in the sub-Saharan Africa. The city lacks the modern management techniques for an effective crime mapping, monitoring and management to meet the attainment of liveable environment despite its aesthetically pleasing outlook of a modern city. The cities of the developed world are managed with the intelligence provided by Geo-spatial technologies. The advances in space technologies have made the onerous task of managing crime possible. However, the availability of these technologies has not been exploited, utilised nor domesticated by various institutions charged with the responsibility of city planning and management to attain secure and safe environment in Nigerian urban and rural communities. Geographic information systems, remote sensing and allied technologies have manifested in various forms in the last four decades particularly since the launch of LANDSAT earth observatory satellites these has provided baseline information for intelligence gathering. The very high resolution images provided by the new generation of satellites have made the integration of GIS/RS for urban crime mapping not only possible but also effective for day-to-day running and management of many aspects of city life. The NigeriaSat-2 and Ortho-rectified Quick-Bird images, basemap, master plan and questionnaires were used to generate the crime dataset which was later aggregated to show the crime hotspots and Coldspots areas within the residential districts of Abuja Federal Capital City, Phase 1. A proximity analysis was later carried out to ascertain the relationship between crime hotspots and Coldspots and police divisional stations, slum settlement as well the various parks and gardens in the study area. The result showed significant correlation between parks and gardens and crime as well as positive correlation between slum settlement and crime in the study area.

KEY WORDS: crime hotspot, geo-spatial technologies, urban planning and management, remote sensing, crime data, feature extraction, city planning

1.0 INTRODUCTION

Geo-spatial technologies have been used to map, analyse and provide real solution to crime globally. In the last decade, GIS has become a powerful crime prevention and investigation tool for mapping and analysing crime patterns (Shillingford and Groussman, 1999). Space-based integrated approach to Nigerian urban security and crime management is multi-faceted robust technology driven solution to various security and crime challenges facing Nigeria urban centres. Successes recorded in advanced countries in crime mapping, monitoring and management is

based on the integration of Geographic Information System (GIS) and Remote Sensing (RS), satellite communication and Global Positioning System (GPS) to achieve Geospatial Intelligence (GI) which is the bedrock of modern city and community policing globally. Boundaries of political entities or legal jurisdictions, such as federal, state and local governments or national administrative divisions are better established and monitored with spatial technologies as well as creation of national database for identification purpose for both properties and individuals.

Over the years development in satellites technology especially the birds-eye view of satellites equipped with high resolution sensors and communication satellites with multi transponders has provided critical datasets as well as the necessary communication means to adequately monitor and managed crime in the country. Globally, this integrated approach has been used successfully from Europe and America to Asia, to assist government agencies in effective, reliable and proper crime mapping, monitoring, management leading to attainment of safety of lives and properties. Crime mapping is an integral and an essential part of crime monitoring, control and management. The success of this is based on development of comprehensive baseline information about dwelling units. It serves as the baseline information and data upon which infrastructure is built. Also, it gives an insight to the nature, types, trend, hotspots and time in which all nefarious activities takes place. It gives information/data on the underlining causes, the group that are fully or partially responsible for different types of criminal activities in a community. It also allow for analysis of vulnerable community and effectiveness of security resources allocation. In addition, crime fuel by cross border illegal immigration can also be properly accounted for. Curbing threats to national security by having baseline data, information and trend of different crime will form an integral part of a robust system, responsive and reliable to meet the security threat of today and tomorrow within and outside of Nigerian urban areas. Advances in space technology brought new innovations to handle crimes such as the flow of illegal commodities, human and arms trafficking, illegal migration and transnational crime, robbery and car snatching, terrorism, oil bunker and many more and thereby making it a very vital weapon that can be easily adopted to ensure smooth attainment of a liveable environment both for urban and rural dwellers.

The use of technological resources has moved the crime mapping and monitoring into the 21st century of law enforcement. Available devices enable both operational and tactical components of strategic planning to effectively apprehend and accurately track the criminals and pattern of the modus operandi. National security is the requirement to maintain the survival of the state through the use of economic, military, political power and exercise of diplomacy in which space technology plays a pivotal role in its attainment. This research is aimed at identifying the crime hotspots in the residential districts of Abuja Phase 1. Several objectives were pursued in the course of the study and these include; to create hot and cold spots maps of the study area; to identify the relationship between the police divisional stations and the crime hotspots areas; to assess the relationship between slummy settlement and crime hotspots areas; and finally to assess the relationship between parks and gardens and crime hotspots areas.

2.0 STUDY AREA

Abuja is located at the heart of Nigeria on Latitude 9° 12' North, Longitude 7° 11' East of the Equator. The FCC (Federal Capital City) has population of about 1.2 million (NPC, 2006). The development of Abuja is divided into 3 Phases for an orderly and coordinated development. At present the city growth has reached Phase 5 though the phase 1 and 2 are not yet fully developed. This study is limited to the phase 1 of the city where the population is concentrated and the actions of urban managers are most required in effective crime mapping, monitoring and management.

The FCC Phase 1 comprises of five (5) districts (Central, Garki, Wuse, Maitama, and Asokoro). Abuja in particular and the Federal Capital Territory in general have experienced a huge population growth. The FCT falls within the Savannah zone vegetation of the West African sub-region with patches of rain forests around the Gwagwa plains. These areas of the FCT form one of the surviving mature forest vegetation in Nigeria.

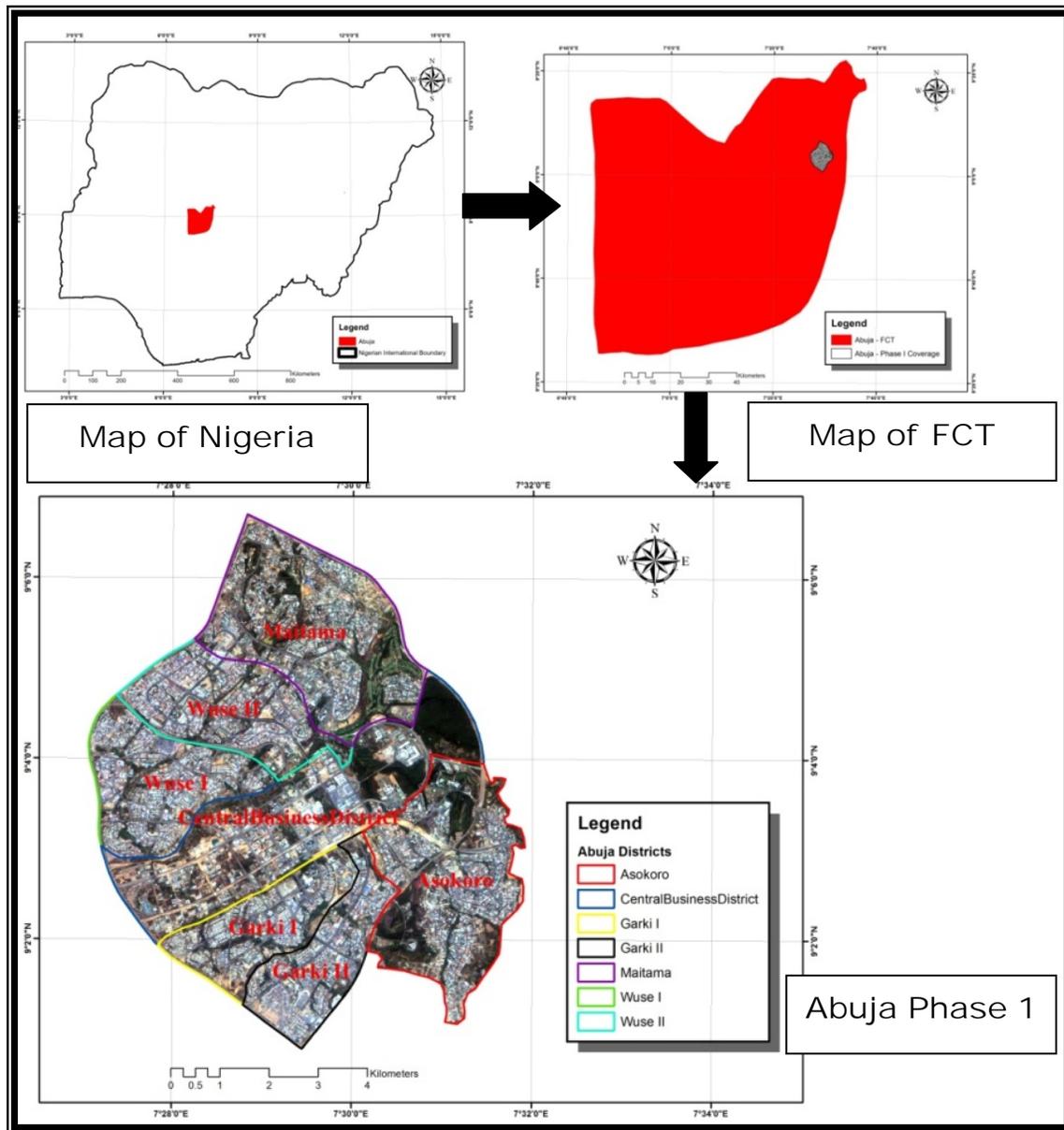


Figure 1: Locational Map of the Study Area - Abuja Phase - 1

3.0 DATA

To accomplish the set objectives of the study, both primary and secondary data which contain both spatial and non-spatial data were used. These include existing documentation like books, journal articles, satellite images, paper maps and other related literature. The GARMIN GPS 76CSx was used to acquire locations (coordinates) of the residential buildings park/gardens as well as the police station.

3.1 Primary Data: Data collection involved the administration of questionnaires across the study area. A total of 585 questionnaires were sampled using the stratified random sampling technique. The questionnaires extracted general information of the inhabitants as well as crime incidence that may

have occurred within the last two (2) years in that location since crimes in two years are fresher in the residents' memories. Thereafter, GPS was used to establish the geographical location of each residence that were sampled in the exercise and later used to identify the house on high resolution imageries. The base map and parks/garden maps were derived from the satellite imageries of the study area.

3.2 The secondary data: The 5m multispectral resolution of NigeriaSat-2 image was acquired from National Space Research and Development Agency (NASRDA), Quickbird 0.65m resolution multispectral satellite image from Digital Globe Inc. USA (2005). Abuja Basemap, parks & Gardens were derived from the satellite images used for this research.

Table 1: Showing both Primary and Secondary Datasets used for the project

S/N	NAME	YEAR	FORMAT	SOURCE	SCALE/RESOLUTION
1.	Nigeriasat 2 Image	2011	Digital	NASRDA	32m
2.	Quick Bird Satellite Image	2005	Digital	Digital Inc.	0.62m
3.	Crime Data	2013	Excel	Questionnaire and GPS	Non
4.	Abuja Base Map	2009	Shapefiles	NASRDA	Non
5.	Abuja Parks & Gardens	2013	Shapefiles	Field work	Non

4.0 METHODOLOGY

The methodology adopted for this research ranges from data conversion, manipulation, analysis and generation of other geospatial datasets for the result and analysis. Survey was carried out to identify residences, utilities and parks and gardens, police stations within the residential areas in Abuja phase 1. The Central Business District of Abuja did not fit into the set criteria since it was not a residential neighbourhood, hence was not included in the sample survey. Only 6 districts were considered in the survey and these include Maitama, Asokoro, Garki I, Garki II, Wuse I and II. See below the flowchart of methods adopted to carry out this research.

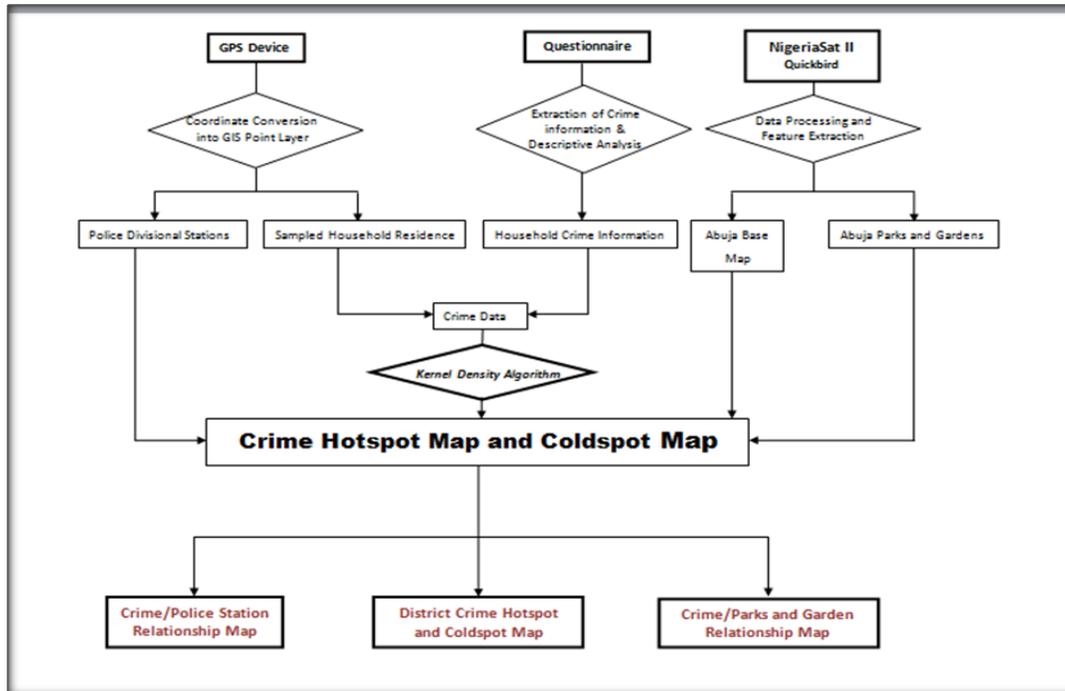


Figure 2: Dataset and Analysis Flowchart

The flowchart (Fig detailed the various steps undertaken in the implementation of the research on crime mapping within Abuja phase 1. The various steps were categorised into three (3) stages:

- i. Data Collection (Primary/Secondary);
- ii. Data Processing and Analysis;
- iii. Information Extraction and crime maps production

4.1 Data Collection

Data collection was categorised into two (2) types.

- *Primary Data*
- *Secondary data (Satellite images and base map)*

4.1.1 Primary Data: Data collection involved the administration of questionnaires across the study area. A total of 585 questionnaires were sampled using the stratified random sampling technique. The questionnaires extracted general information of the inhabitants as well as crime incidence that have occurred within the last two (2) years in that location since crimes in two years are fresher in the residents' memories. Thereafter, GPS was used to establish the geographical location of each residence that were sampled in the exercise and later used to identify the house on high resolution imageries.

4.1.2 The secondary data: The following data were acquired for the successful mapping of the crime hotspots in the study area. The 5m multispectral resolution of NigeriaSat-2 image was acquired from National Space Research and Development Agency (NASRDA), Quickbird 0.65m resolution multispectral satellite image from Digital Globe Inc. USA (2005), GPS Data and Field observation.

4.2 Data Processing and Accuracy: The field data was checked for unreliable measurements and outliers as described by (Puustinen et al, 2007). The acquired questionnaire were categorised into two

separate groups comprising of households who are victims of crimes also known as the **crime data** and those who have never experienced any kind of crime, which were later used to create the crime hotspots and cold spots maps respectively. Outliers were defined as points that exceeded Abuja Phase 1 by more than 20m. Microsoft Excel environment was used for the statistical analysis of information extracted from the questionnaire. Also, data acquired from the GPS were cleaned in Excel software before exporting to ArcGIS software for plotting and interpretation.

4.3 Information Extraction and Crime Maps Production: The ArcGIS 10.0 software package was used to generate the crime hotspot and cold hotspot maps using the Kernel Density estimation method. A bandwidth of 0.10km based on the extent of the study area was the set criteria for generating the maps. Other spatial data required to accomplish the set objectives of these study were carried out at this stage (this include; Abuja base map, settlement map, Abuja parks and garden data and police divisional stations). From the results obtained, an overlay analysis was carried out to establish the relationship between the Crime hotspot areas and parks and gardens as well as the Police Divisional Stations in the various districts.

5.0 ANALYSIS AND RESULT

The analysis of the generated crime dataset for the residential districts of Abuja was carried out to reveal the various types of criminal activities within the city and to show the hotspots areas where majority of the crimes are committed as well as the Coldspots areas where crimes are least committed. This was followed by an auxiliary analysis to show the relationship between crime activities and their proximity to the nearest divisional police stations and recreational areas (Parks and Gardens). DeMotto & Davies (2006) in their research concluded that deprived neighbourhoods generally serve as potential hideouts for criminals and that the number of crimes tend to increase in close proximity to parks and gardens and urban green spaces which are supposed to function as social benefit while less deprived neighbourhoods have less number of crimes associated with them. The perceived public opinion that a huge number of crime are committed around open recreational areas, some opined that open recreational areas such as gardens could serve as hide out for criminals while adjacent residential and commercial dwellings may constantly fall victim of such crimes.

5.1 Crime Typology Map: The crime typology map is a descriptive map that shows the point location of where various types of crimes were committed across the study area. This is the first analysis that was carried out in this research. Symbologies were used to annotate and represent the diverse crime activity in the study area. The crime typology map generated from the crime data clearly shows that five predominant types of crimes (Rape, Theft, Robbery, Aggravated Assault and Drug Related Crime) are mainly perpetuated in Abuja city (Fig 1). Although there are cases where two or more different crimes were committed. An Example of this case is household residence that suffered assault before being robbed (aggravated assault and robbery) and household residence that suffered assault and thereafter suffered aggravated assault and theft. This information were all collated and mapped.

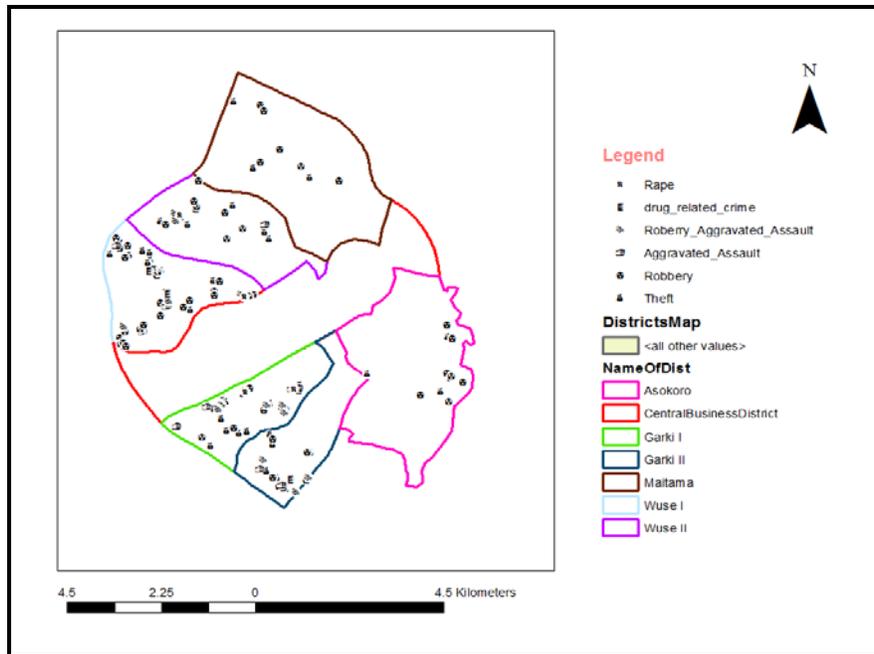


Figure 3: Types of Crime Activities in Phase I

Furthermore, the percentage of the different types of crimes recorded amongst household residence in the study area was represented in a pie chart (Fig 4). This clearly shows that Robbery and theft crime were mostly the predominant crimes that household residences suffered most, with a percentage of 35% and 33% respectively. Similarly, the analysis also shows that drug related crimes and rape had the lowest count among the list of the various crimes with 4% and 2% respectively. Other offences such as Burglary, Aggravated Assault, Robbery and Aggravated Assault, and Robbery and Theft had a percentage figure of 7%, 6%, 7% and 6% respectively.

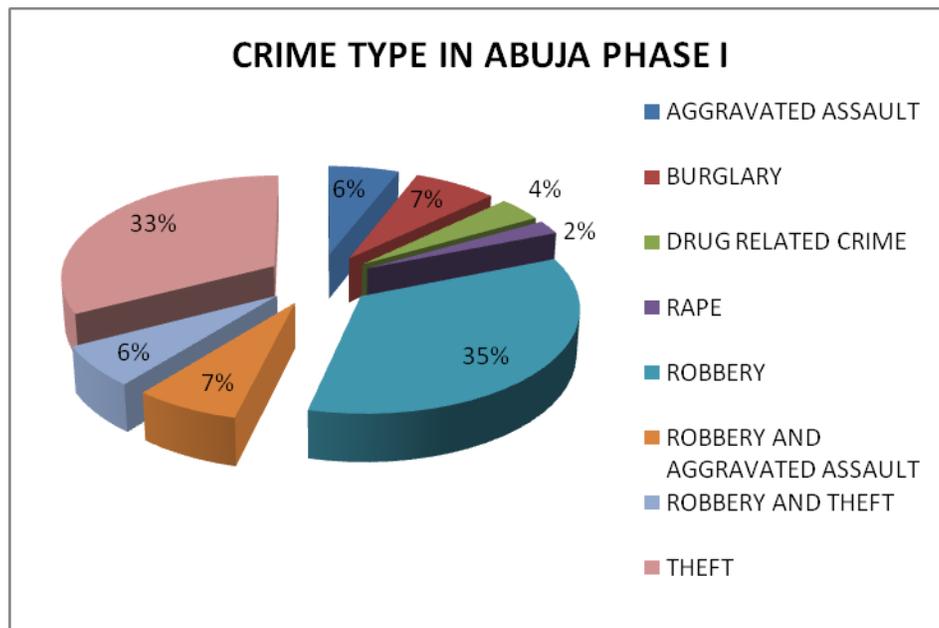


Figure 4: Pie-Chart of Percentage of the Different Crime in Abuja Phase I

However, efforts were also made to discern the distribution of crimes at the district level of Abuja phase I. This shows that Wuse I have the highest number of crime activities with 36%, while Maitama District has the lowest count with 6% of different crimes committed. Other districts such as Asokoro, Garki I, Garki II and Wuse II all have 7%, 22%, 15% and 14% respectively (Fig 4).

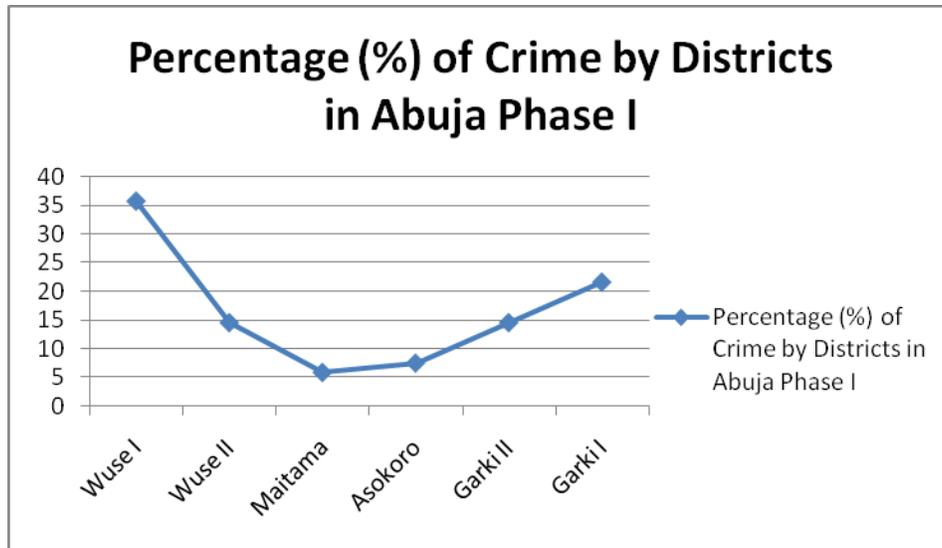


Figure 5 : Histogram Chart of Crime Distributions in Abuja

5.2 Crime Hotspot Maps: 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 (Fig 6). The kernel density itself calculates a magnitude per unit area from crime point features using a kernel function to fit a smoothly tapered surface (Chainey, 2001).

This infers that for an area to be classified as a crime hotspot zone the number of crimes committed around any given area must meet certain threshold within a specified search radius. For the purpose of this research the search radius of 100M was used to ensure that all recorded GPS point of the various crimes falls within the stipulated radius, which may have fell short due to the error margin of the Garmin GPS used ($\pm 5m$). Several crime hotspots areas have been identified from the hotspot analysis, which invariably cuts across four out of the six residential districts of Abuja phase I. namely are Garki I, Garki II, Wuse I and Wuse II. The result shows that there are traces of an increased crime rate in Asokoro but the clustering and the actual figures of the recorded crimes are not significant enough to form a viable hotspot. However the crime hotspots analysis clearly depicts that Garki II has the highest concentration of the identified types of crimes within the set spatial coverage. A further effort was carried out to unravel the reason behind this trend by overlaying the NigeriaSat-2 and the Landuse map of Abuja phase I on the crime hotspot to ascertain any relationship amongst the landuse type and high crime incidence in that area.

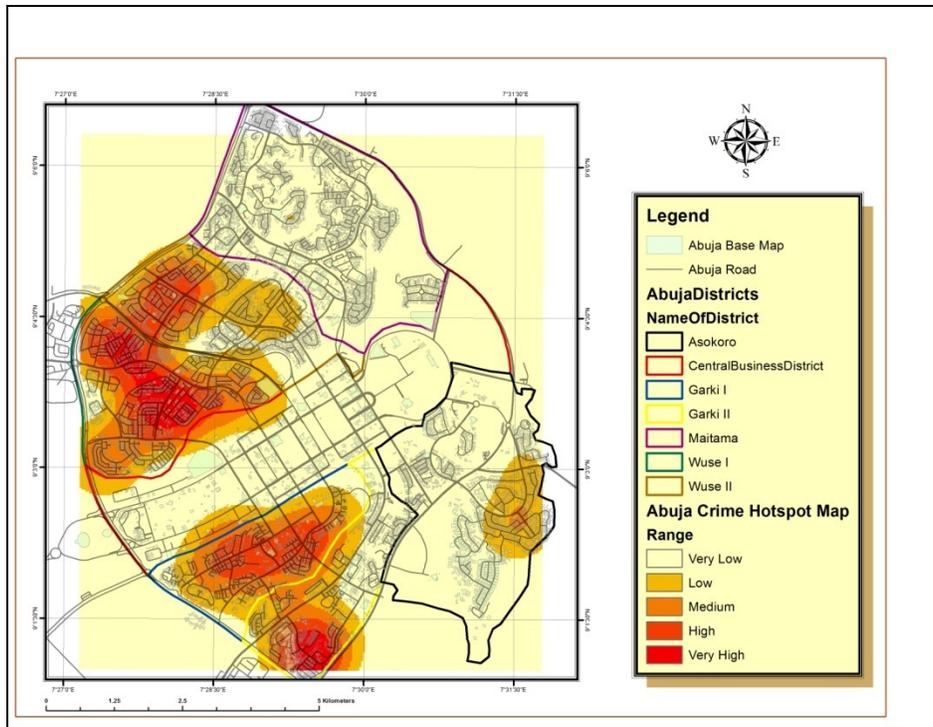


Figure 6: Crime Hotspots Map of Abuja Phase I

This shows that the area in question is adjacent to the Garki village, which is one of the oldest slum settlements that have been in existence since the inception of the city and the area is still known for its notorious social vices (Fig 7).

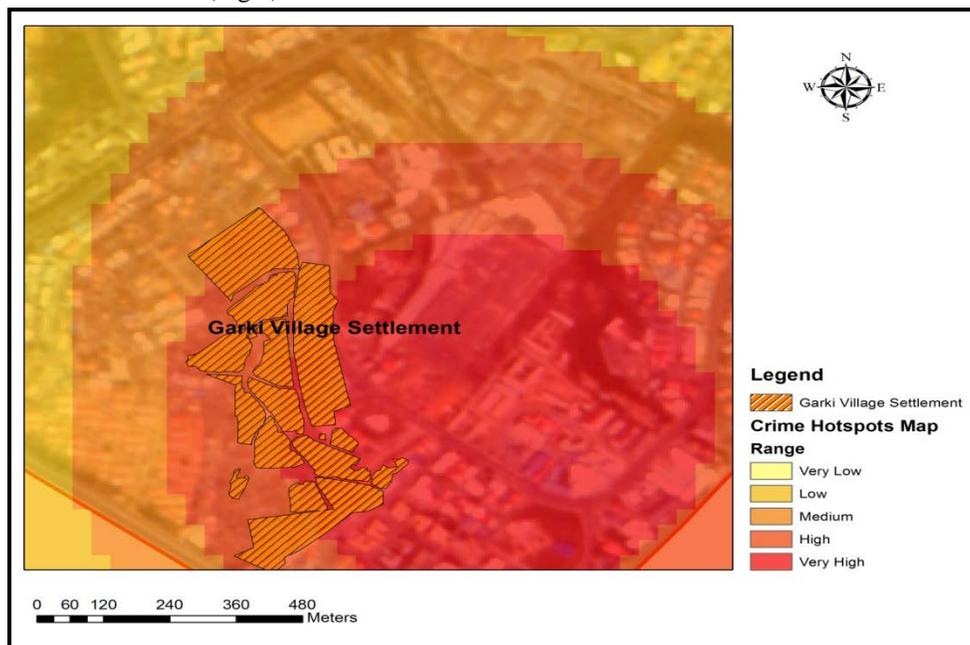


Figure 7: Focused Crime Hotspots Map of Garki Village Slum Settlement in Abuja Phase

5.3 Crime Cold Spot Maps: Following the crime hotspot analysis and map generation was the cold spot analysis. The crime cold spot analysis represents cluster areas where there is little or no crime incidents. The same method, that is, the kernel density smoothing was also utilised for the crime cold spot mapping. And this generally depicts areas that are somewhat safe to live within the Abuja phase I. The result of this analysis as presented in Fig 8 shows that parts of Maitama, Wuse II, Garki II and Asokoro have the lowest incidents of crime compared to their Garki I and Wuse I counterpart.

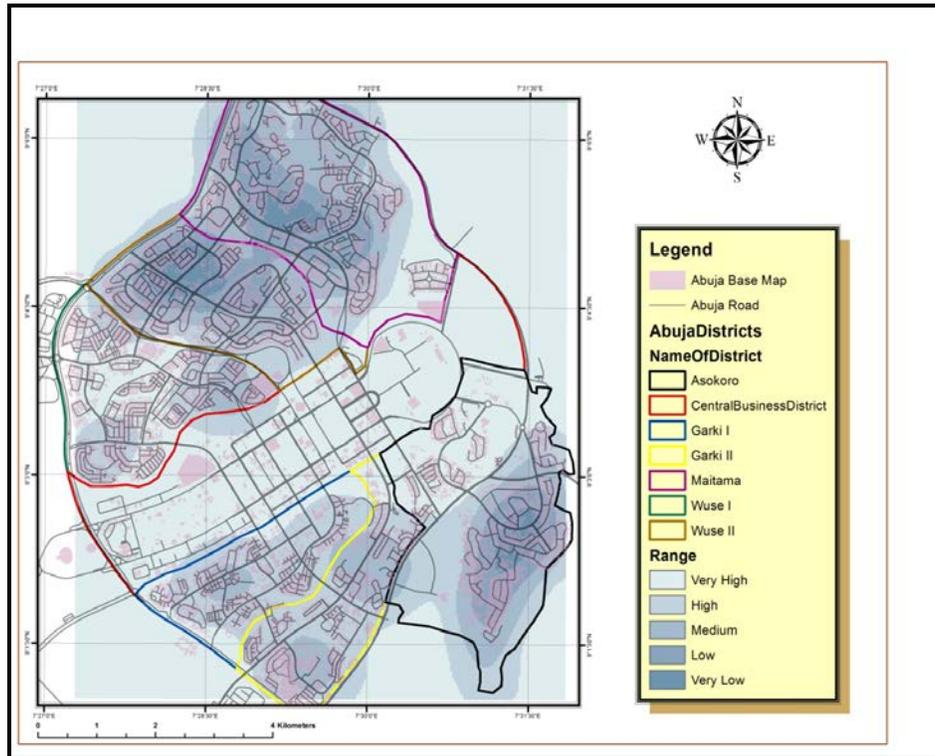


Figure 8: Crime Coldspots Map of Abuja Phase I

5.4 Crime Hotspots Areas and the Police Divisional Stations: The crime hotspot map and police divisional station in each of the Abuja phase I district was aimed at establishing the relationship between high crime density areas and their proximity to the police stations (Fig 9).

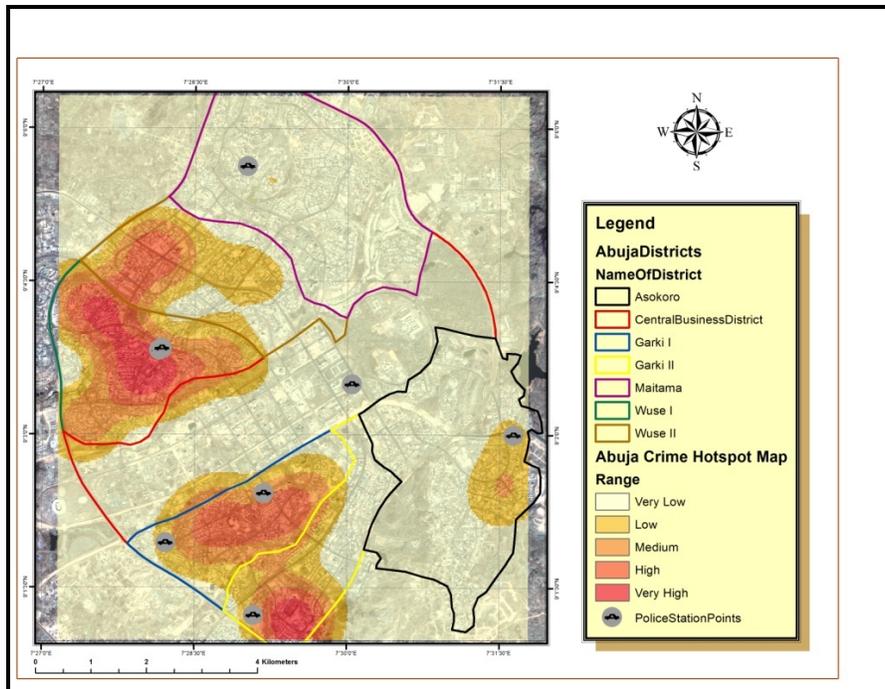


Figure 9: Crime Hotspots Map of Abuja Phase I and the police divisional stations

This clearly shows that two (Wuse I and Garki I) out of the six divisional police stations are directly embedded within the established high crime density cluster. It can therefore be inferred that the lack of an effective community policing as propelled by this divisional stations can be attributed to increase of crime incidences in these areas. Survey revealed that there are a number of police mini posts in the study area, however, these mini posts were not included because of operational inefficiencies with respect to manpower and equipment. Hence, may not serve to reduce crime activities in the area.

5.5 Crime Hotspots Areas and Abuja Parks and Gardens: The result of the overlay analysis of crime hotspot areas and the parks and gardens data was carried out in order to establish the presence or absence of any fervent relationship between this high crime areas and green open space. This is because recent studies (DeMotto & Davies, 2006) and experiences of some of the residents interviewed during the field work suggests that green areas such as parks and garden within the federal capital city (FCC) which original function is to serve as comfort zone and relaxation spot for Abuja inhabitants have suffered in the hand of criminals.

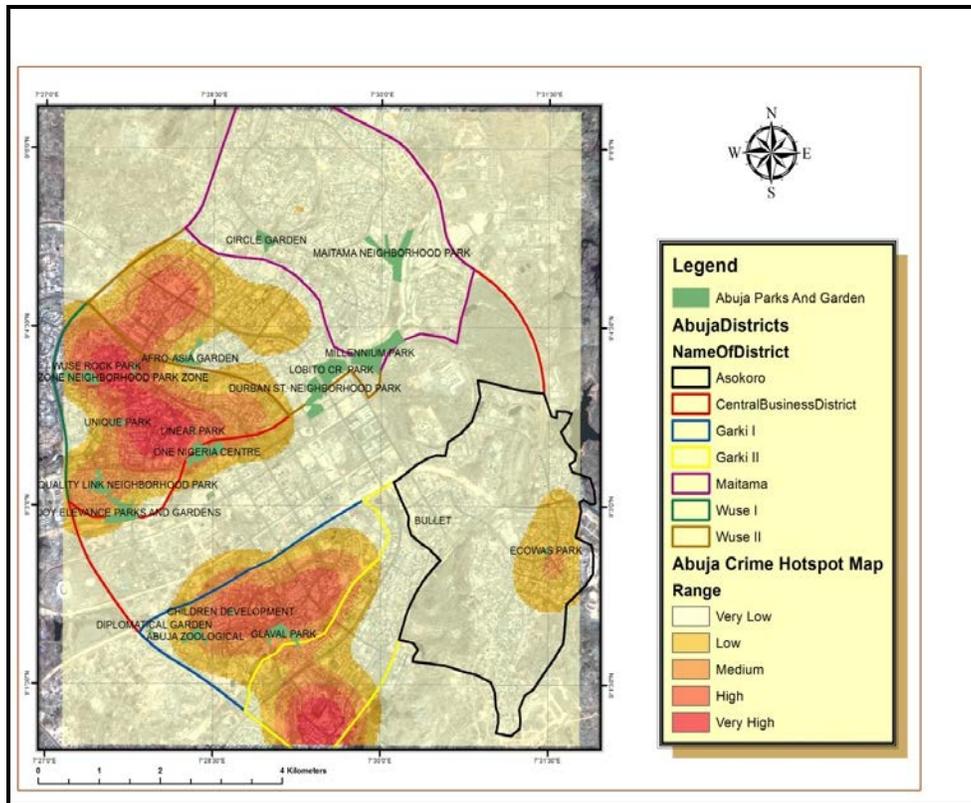


Figure 10: Crime Hotspot Map of Abuja Phase I and the various parks and gardens

These areas have consistently been abused and used as a meeting point among several various criminal groups such as drug dealers, car snatchers, thieves and other criminals alike. (Fig 10). The map is a representation of the crime hotspot map overlaid on the Abuja parks and garden data. This however shows that most established parks and gardens are at a considerably long distance from the crime hotspots areas suggesting that there is no direct spatial, neither significant nor concrete relationship between the two variables. Studies from (Erdogan, 2011) have also suggested that tendencies of obtaining a direct relationship are very uncommon as perpetrators of certain crime activities do not necessarily reside within the vicinity of where such crime activities have been committed especially case of robberies found so high.

6.0 CONCLUSION AND RECOMMENDATIONS

Crime hotspot maps are efficient method of mapping high intensity of crime prone areas and the use of GIS/RS techniques in spatio-temporal analysis proved as an effective tool to comprehend the implicit correlation among events. The results of the spatial analysis proved that districts such as Wuse and Garki areas of the city are the major hotspots where there are higher concentrations and incidences of crime within the city. Maitama and Asokoro districts are the safest as revealed from the cold spots maps. It is pertinent to note that more crimes occur frequently in high and medium densities areas of the city.

It is hereby recommended that the government should carryout cities and nation-wide crime mapping and analysis in the face of current security challenge facing the whole country for an effective policing. Also, adequate resources such as budgetary allocation, personnel recruitment and training should be given priority by the government for the police and other law enforcement agencies to perform better in ensuring safety of lives and properties. Modern sophisticated gadgets should be provided to have a responsive police that can tackled the treat that has become

potent to peaceful living at the hotspots. Crime data should be made available as well as training of police officers in crime mapping should be encourage to aid decision making process, once the law enforcement officers are taught spatial techniques of crime hotspots analysis, it will assist them in performing spatial analysis functions queries to display crime prone areas in order to maximise available resources to abate crime.

The study revealed that crime incidence increases in slum area development as well as in areas where land use conversion have taken place, therefore, it is suggested that an effective physical planning will seek to put an end to this problem. Finally, it is also recommended that there should be improvement in lightning within the neighbourhoods which will go a long way to abate crime as suggested by some of the residents that were interviewed whom attributed crime in their neighbourhood to erratic power supply.

Conclusively, further study with a spatial coverage of Federal Capital Territory is recommended to ensure lasting solution to this problem.

REFERENCES:

- Ayeni, O., Saka D.N, and IKwumesi, G. (2002) *Developing GIS database for tourism in Nigeria*. (Proceedings 4th international conference, African Association of Remote sensing of the environment.
- Batty, M., Xie, Y., and Sun, Z. L. (1999) *Modelling urban dynamics through GIS based cellular automata*, Computers, Environment and Urban Systems, Vol. 23, 205-233.
- Burroughs, P. A. (1986) *Principles of Geographic Information Systems for Land Resources*. Clarendon Press: Oxford, UK.
- DeMotto, N., and Davies, C. (2006) *A GIS Analysis of the Relationship between Criminal Offenses and Parks in Kansas City, Kansas*, *Cartography and Geographical Information Science*, Vol. 33, No. 2, 2006, pp. 141-157.
- Erdogan, S., Dereli, M. A. and Yalcin, M. (2011) *Spatial Analysis of five Crime Statistics in Turkey*. May 2011.
- Fadausi, J. T., (2009) Department of surveying and Geoinformatics, Faculty of Environmental studies, Osun state college of Technology, Esa-oke, Osun state
- FIG Regional Conference (2006) Resettlement Issues, Squatter Settlements and the Problems of Land Administration in Abuja, Nigeria's Federal Capital: 5th FIG Regional Conference Accra, Ghana, March 8-11, 2006. Available: *fig.net*.
- Gorr, W, L. and Kurland, K. S. (2012) *GIS Tutorial for Crime Analysis*. ESRI Press California, U.S.A. 2012
- Hilbert, K.W. (2006) *Landcover change within the Grand Bay National Estuarine Research Reserve: 1974-2001*, *Journal of Coastal Research*, 22, 1552-1557.
- In a Dream City, a Nightmare for the Common Man* (2006) New York Times, 13 December 2006. Available at: *nyt.com*.
- Jantz, P., Goetz S. J and Jantz, C. A. (2005) *Urbanization and the loss of resource lands within the Chesapeake Bay watershed*, *Environmental Management*, 36(6): 808-825.
- Kalgo, M.S.U. and Ayikila, O. (ed.) (2001) *The review of Abuja Master plan*. Ibadan Fountain publications, pp.1-10.1994.ISBN 0-8018-4723-0.
- Life of poverty in Abuja's wealth (2007) BBC News, Tuesday, 13 February 2007. Available at: *News.bbc.co.uk*.
- Mendis W.T.G & Wadigamangawa, A. (1996) *Integration of Remote Sensing and GIS for Land Use/Land Cover Mapping in Nil Wala Basin*, Survey department, Sri Lanka. Available at: *GISdevelopment.net*
- Njegus.A, (2007) *Tourism destination management information systems*, tourism management, Singidunum University, Belgrade, Serbia.
- Puustinen, A., Hameri, K., Pekkanen, J., Kulmala, M., de Hartog, J., Meliefste, K., ten Brink, H.M., Kos, G., Katsouyanni, K., Karakatsani, A., Kotronarou, A., Kavouras, I., Meddings, C., Thomas, S., Harrison, R., Ayres, J.G., van der Zee, S., Hoek, G., 2007. *Spatial variation of particle number and mass over four European cities*. *Atmospheric Environment* 41, 6622-6636.
- Racheal, B. (2011) *Introductory Guide to crime Analysis and Mapping*. Director, crime mapping laboratory, police foundation. November 2011.
- Spencer, C. (2001) *GIS and Crime Mapping*. Director of Geographic Information, UCL JILL, Dando Institute of crime Science.

World Bank Conference (2000): *African Regional Roundtable on Upgrading Low-income Settlements*.
Johannesburg, South Africa October 3-5 2000, p. 16. Available at: www.citiesalliance.org.