Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.20, 2014

Crime Mapping and Analysis in the Dansoman Police Subdivision, Accra, Ghana - A Geographic Information Systems Approach

Mark Brookman-Amissah[1*] Tina D. Wemegah [1] Franz T. Okyere [2]
1.Accra Polytechnic, P.O.Box GP561, Accra, Ghana
2.Department of Geomatic Engineering, KAAF University College, Gomoa-Budumburam, Ghana
*Contact of corresponding author: negussa2000@yahoo.com

Abstract
This work used Geographic Information Systems to create crime maps and analyze crime distribution within the Dansoman Police Subdivision in Accra, Ghana. It was done on a pilot basis and is intended to enable senior officers have a visual framework for prescribing action. Spatial data of 142 crime incidents namely Assault, Causing Damage, Defilement, Fraud, Rape, Robbery, Stealing and Unlawful Entry was analyzed using ArcGis®v10 software. A summary of the attribute table showed that Assault, Causing Damage and Unlawful Entry had the highest counts of 22 each while Rape and Stealing had the least counts of 12 each. Pin maps produced gave a graphical representation of crime locations against a backdrop of roads, existing police stations and district boundaries. Kernel density estimation maps showed the Mamprobi district had a high density of crime even though it was the smallest district. An average nearest neighbor spatial statistics analysis revealed that all incidents exhibited a random nature apart from Rape and Stealing which were statistically dispersed. None of the 8 crime types was found to be statistically clustered. The mean centers of the crimes were plotted and found to be within a 1 km radius.It is recommended that crime spatial data is collected over longer periods instead of a few months and should also include attribute data such as time, date and personal information of the perpetrators. The results of this analysis could be used as a predictive and tactical tool by the Ghana Police Service.
Keywords: Geographic Information Systems, Spatial data, Shapefile, Kernel Density Estimation, Spatial Statistics.

1. Introduction

In general a Geographic Information System (GIS) can be described as a system of hardware, software, data and organizational structure for collecting, storing, manipulating and spatially analyzing geo-referenced data and displaying information resulting from these processes. A more detailed definition describes a GIS as any information management system that can:

- Collect, store and retrieve information based on spatial location
- Identify locations within a targeted environment that meet specific criteria
- Explore relationships among data sets within that environment
- Analyze the related data spatially as an aid to making decisions about that environment
- Facilitate selecting and passing data to application-specific analytical models capable of assessing the impact of alternatives on the chosen environment; and
- Display the selected environment both graphically and numerically either before or after analysis.

The thread that is common to both definitions is that in a GIS, decisions are made based on spatial analyses performed on data sets that are referenced in a common geographical system. GIS has been applied in virtually every imaginable field of activity from engineering to agriculture and from medical science of epidemiology to wildlife management. (Ghilani and Wolf, 2012)

The use of GIS in law enforcement, crime prevention and general policing is therefore not an entirely new phenomenon with much of the innovation in crime mapping being driven in the United States by the National Institute of Justice's Crime Mapping and Research Center (CRMC) later renamed as the Mapping and Analysis for Public Safety (MAPS). This has served as a foundation for the development of crime mapping in many countries worldwide. (Chainey and Ratcliff, 2005)

Crime mapping is the direct application that comes from considering the inherent geography in crime. It combines the skills of people, the practical use of data and information, and the application of technology to capture, analyse, identify and respond to crime problems and improve policing performance. Crime mapping techniques can also be applied to other police data such as incidents, offenders, victims, stops and searches. (https://www.ucl.ac.uk/scs/people/academic-research-staff/spencer-chainey/Slides/Home_Office_CrimeMapping)

Using GIS, crime analysts can overlay other datasets such as census demographics, locations of pawn shops, liquor shops and bars, schools, etc., to better understand the underlying causes of crime and help law enforcement administrators to devise strategies to deal with the problem. GIS is also useful for law enforcement operations, such as allocating police officers and dispatching to emergencies.

GIS has been used in crime analysis to perform the following: (www.esri.com/publicsafety)

- Identifying and highlighting suspicious incidents and events that may require further investigation
- Supporting pattern and trend analysis across multiple jurisdictions
- Enhancing the implementation of various policing methodologies to reduce overall crime and disorder
- Integrating traditional and nontraditional law enforcement data to improve overall analysis
- Educating the public with visual information to clarify crime concerns and enlist community action
- Providing tools and techniques to capture crime series and forecast future crime occurrence

2. Background

Ghana is located of the south-east coast of the Gulf of Guinea and spans an area of 238,535 km^2 lying approximately between latitudes 4° and 12°N and longitudes 4°W and 2°E making it geographically closer to the centre of the earth than any other country in the world.

(http://www.photius.com/countries/ghana/geography/ghana_geography_physical_setting.html)

The task of and crime prevention is primarily the responsibility of the Ghana Police Service and the functions of Ghana Police Service as stated in the Police Service Act, 1970 [Act 350] of the Constitution of Ghana are clearly spelt out as follows:

- Crime detection and prevention
- Apprehension (arrest) and prosecution of offenders
- Maintenance of law and order
- Due enforcement of the law

The Service is divided into twelve (12) administrative regions namely: Accra, Tema, Ashanti, Brong Ahafo, Eastern, Volta, Western, Central, Northern, Upper East, Upper West and the Railways, Ports and Harbours Regions. The twelve regional divisions exercise oversight responsibilities over 51 divisions, which have 179 district divisions under them. The districts have jurisdiction over a national total of 651 police stations. A new division, the Marine Police Unit, has also recently been created to handle issues that arise from the country's offshore oil and gas industry.

Available statistics indicate that as at June 2011, the manpower strength of the Ghana Police Service was twenty three thousand, six hundred and eighty-four (23,684) with a male to female ratio of about 4:1. (www.ghanapolice.info)

The United Nations (http://www.unodc.org/documents/data-and-analysis/Crime-statistics/International_Statistics_on_Crime_and_Justice.pdf) recommends a minimum police strength of 222 per 100,000 people. According to the Ghana Statistical Service (www.statsghana.gov.gh), the population of Ghana was estimated at 25,370,000 in 2012.This implies that even if a non conservative estimate of 25,000 police officers is used against an estimated population of 26,000,000 assuming a growth rate of 2.19% over 2012 census data (www.indexmundi.com/ghana/population_growth_rate_html) it would result in a ratio of approximately 97 police per 100, 000 people at the time of this work. This ratio is well below the UN recommended ratio and hence there is need to devise ways of mitigating the impact of the shortfall and to generally improve efficiency.

Geographic Information Systems have been shown to have immense benefits in the organizations in the areas of 1) aiding better decision making about location and 2) improving communication through GIS based maps and visualizations and 3) allowing for better geographic information recordkeeping.4) enabling senior officers to have a visual framework for conceptualizing understanding and prescribing action. (http://gisandscience.com/2009/09/14/top-five-benefits-of-gis/)

In Ghana, crime data and statistics are normally reported yearly and on a regional basis, mostly in the form of reports with associated tables, graphs and spreadsheets showing rates of reduction or increase in specific crimes (see appendix A1). Maps depicting the same information are not common and the use of GIS within the Ghana Police Service is still in the pilot phase.

This aim of this work is to integrate crime data with other spatial information to come out with meaningful crime patterns and maps and also to analyze crime distribution using tools in GIS. Considering the limited size of the study area and amount of data made available, this study is intended to serve as pilot, so that based on recommendations the methods it can be replicated in future for other parts of the country. The case study area is the Dansoman Police Sub Division comprising the Dansoman, Mamprobi and Korle Bu suburbs/districts in the Greater Accra Region of Ghana with an approximate area of 25 square kilometres. This area lies approximately between latitudes 5º31'03"N and 5º 34'27"N and longitudes 0º13'18"W and 0º16'43"W.

.

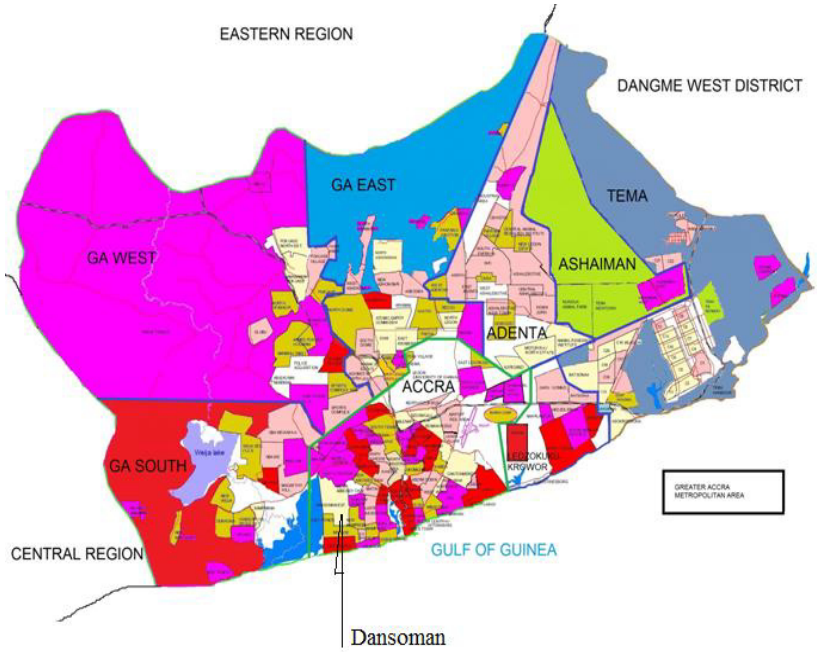


Figure 1: Map of Greater Accra

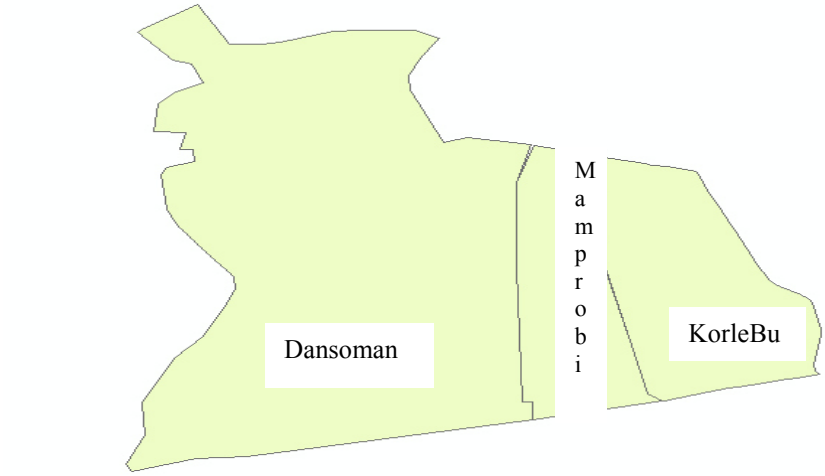


Figure 2. Dansoman Police Subdivision with districts

3. Methods and Results

3.1 Source Data

The source data was obtained from the Ghana Police Service in ESRI® shapefile format comprising the following:

- Crime Incident locations
- Boundaries of the three separate districts making up the Subdivision (i.e. Dansoman, Mamprobi and Korle Bu)
- Existing Roads
- Existing Police Stations
- Boundary of the Dansoman Police Subdivision

The Crime Incident locations were collected via handheld Global Positioning System devices and had a total of 151 records of crimes identified by the police as Assault, Causing Damage, Defilement, Fraud, Rape, Robbery, Stealing or Unlawful Entry. According to the Officer-in-Charge the crime data was collected on a pilot basis and was for the first quarters of the years 2011, 2012 and 2013. No additional information about the crimes was included.

3.2 Data Editing

A search by spatial location revealed that some of the crime incidents were outside the project area boundary. The data was subsequently edited to exclude those lying outside the study area resulting in final count 142

records of crime incidents. It was also observed that the dataset did not have a spatial reference and they were therefore projected into the Accra Ghana Grid projection. These edits/operations were done in the ESRI® ArcGis®v10 software environment.

3.3 Creation of Crime Maps (Pin Maps)

Various crime maps to aid in visualizing the various crime incidents were created for the entire Dansoman Subdivision and also for the individual suburbs, examples of which are shown below in Figures 3, 4 and 5.

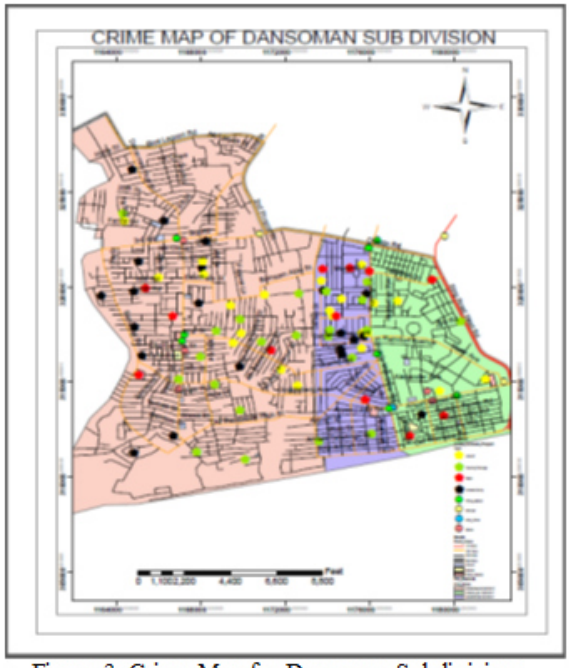


Figure 3. Crime Map for Dansoman Subdivision

Figure 4: Crime Map for Korle Bu District

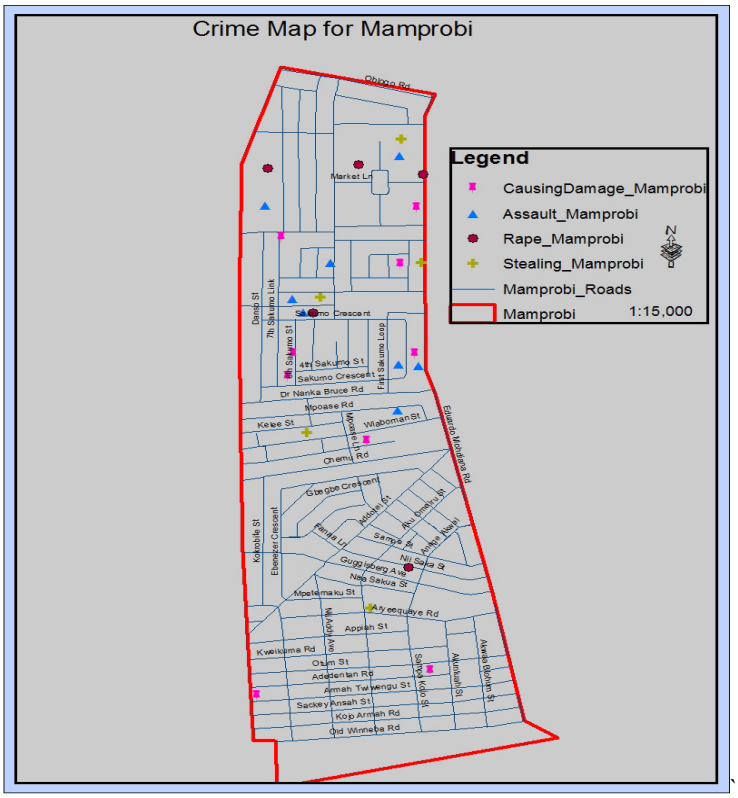


Figure 4: Crime Map for Mamprobi District

3.4 GIS Analysis

3.4.1 Crime Statistics

The individual sizes (in square kilometers) of the three districts were obtained by an automated calculation of the areas of their respective closed geometric polygons. Then from the attribute table of crime incidents the field containing the unique values of the crime types were summarized, the results shown in table below.

Table 1: Summary of Crime Type (Dansoman Subdivision)

Type	Count_Type
Assault	22
Causing Damage	22
Defilement	21
Fraud	17
Rape	12
Robbery	13
Stealing	12
Unlawful Entry	22

Next the total number of crime incidents per each district was obtained, using a GIS overlay and intersection process which selected crime locations found to be lying completely within each district boundary as the source layer.

Table 2: Crime Incidence per district

District	Size (sq_km)	Crime Incidents
Dansoman	17.165	67
Korle Bu	4.555	21
Mamprobi	3.370	54

From the selected features obtained in the previous operations (per district) the crime type field was summarized in order to obtain individual counts of each unique record (crime) for each district. Results are as shown below.

Table 3: Specific Crime Incidence per district

		CRIME INCIDENTS							
District	Size (sq km)	Assault	Causing Damage	Defilement	Fraud	Rape	Robbery	Stealing	Unlawful Entry
Dansoman	17.165	10	12	11	6	4	5	6	13
KorleBu	4.555	4	1	4	4	3	2	2	1
Mamprobi	3.370	8	9	6	7	5	6	5	8

3.5 Kernel Density Estimation

The Kernel Density approach (Spatial Analyst Tool) was used to calculate the density of crime incidents point features within the study area. The same operation was performed for individual categories of crimes. Examples of maps generated are shown below. In theory the Kernel density estimation is a fundamental data smoothing problem where inferences about the population are made, based on a finite data sample. It calculates a magnitude per unit area from point features using a kernel function to fit a smoothly tapered surface to each point.

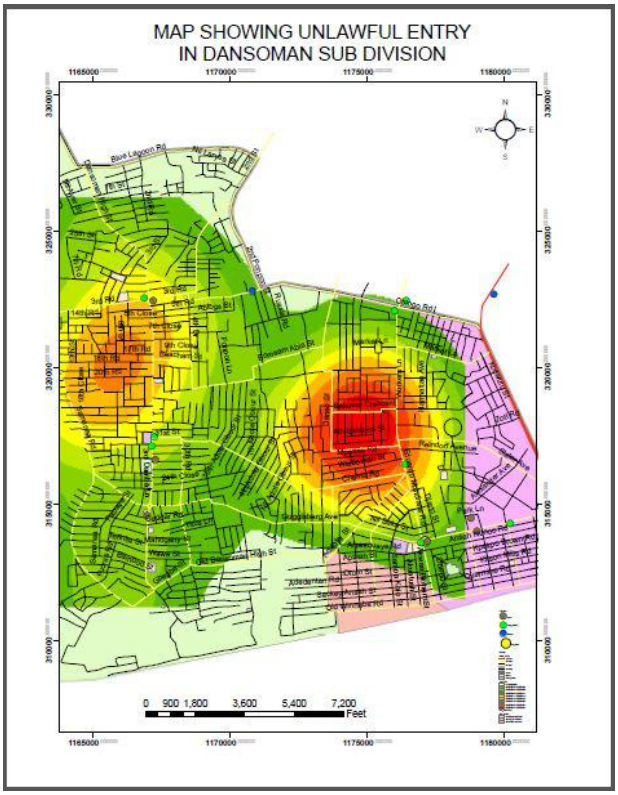


Figure 5:Unlawful Entry Density Map (Kernel Distribution)

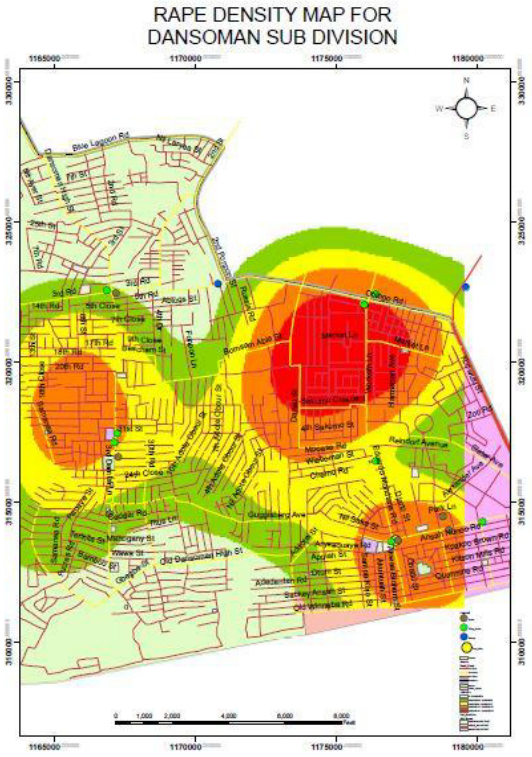


Figure 6: Rape Density Map (Kernel Distribution)

3.6 Average Nearest Neighbor Analysis

The Average Nearest Neighbor (Spatial Statistics) Tool was used to calculate the nearest neighbor index based on the average distance from each feature to its nearest neighboring feature. This was performed for all crime incidents and then separately on the individual crime types. The Average Nearest Neighbor tool returned five values: Observed Mean Distance, Expected Mean Distance, Nearest Neighbor Index (Ratio), z-score which is a

standard deviation and p-value which is a probability. The z-score and p-value values indicate whether the features exhibit a random pattern or statistically significant clustering or dispersion. Sample results are as shown below.

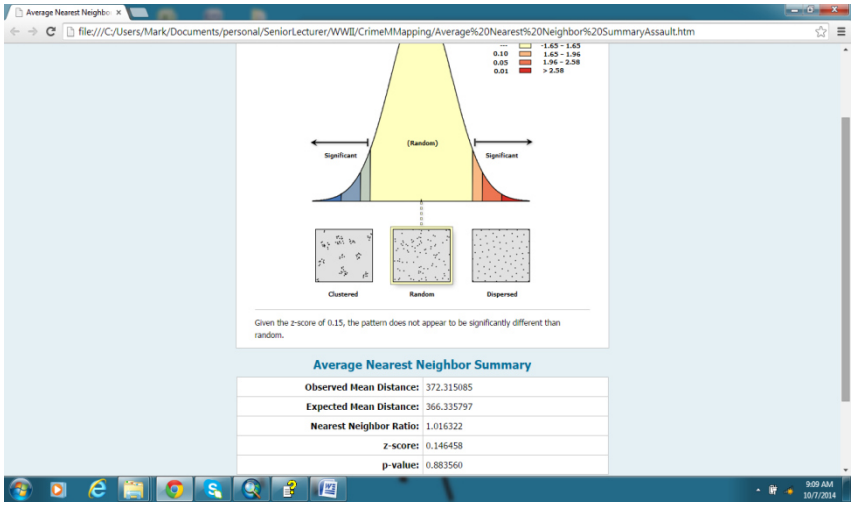


Figure 7: Average Nearest Neighbor Summary for Assault

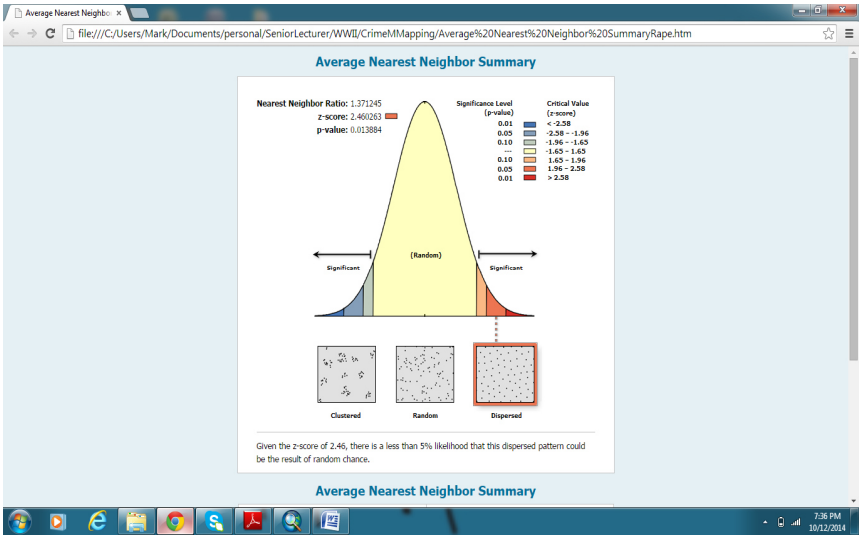


Figure 8: Average Nearest Neighbor Summary for Rape

3.7 Mean Center Analysis

Mean Center Analysis was performed on all crime incidents as well as on each of the eight categories of crimes. This procedure calculated the average X and Y coordinates of the specified crime incident dataset and a resultant map is as shown in Figure 9.

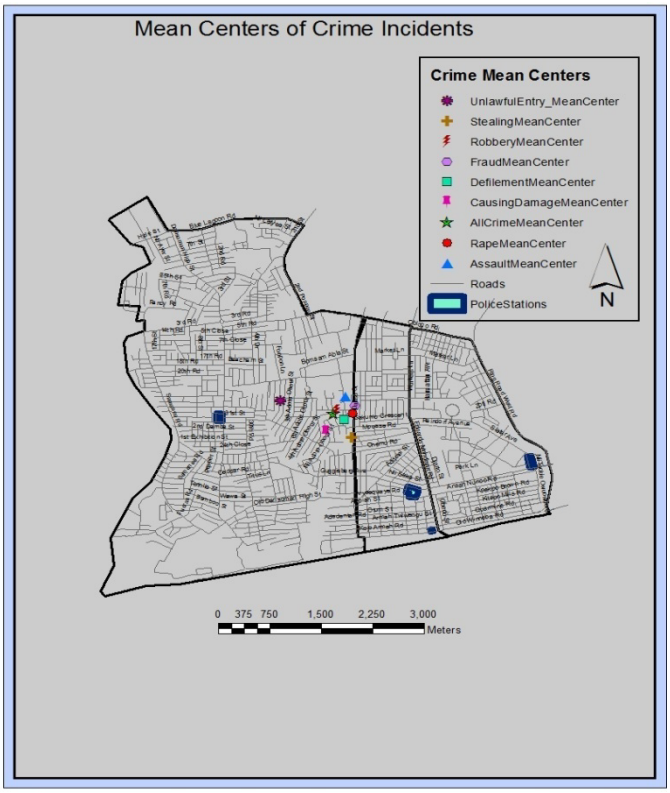


Figure 9: Mean Centers of Crime v Police Station Locations

4. Discussion of Results

The various crime maps (pin or point maps) generated help to create visual framework for conceptualizing, understanding and prescribing action and allows a better recordkeeping of spatial data. Pin maps are the most common approach for displaying geographic patterns of crime (Jefferis, 1999). Point mapping is popular, mainly because it is a simple digital version of a familiar and traditional method of placing pins representing crime events onto a wall map. However, trying to interpret spatial patterns and hot spots in the crime point data can be difficult, particularly if the data sets are large.

Summary tables generated from the crime incident data set shows that Assault and Causing Harm are the most frequently occurring crimes (see Table 1). The tables also reveal that the Mamprobi District has a high crime density when one considers its size. It is approximately one fifth of the size of the biggest district (Dansoman) and yet has only about 20% less crime.

To further buttress this, it is seen from the kernel density maps generated for rape there is a high density around the northern portion of Mamprobi District in an enclave bounded by Oblogo Road on the north and Sakumo Crescent on the south, Harmattan Avenue on the East and an unnamed road to the West. This high density area (Figure 6) has a radius (buffer) of approximately 1200 metres and covers also Market Lane, Workers Lane, Abia Lane, Alhaji Avenue and the central portion of Eduardo Mohdiana Road.

Similarly a high count of crimes identified as Unlawful Entry crime is also visually represented around the central part of Mamprobi District, between Danso Street on the West, Eduardo Mohdiana Road on the East, Sakumo Crescent on the North and Chemu Road on the South. This region has the highest density of Unlawful Entry crime with a radius of about 700 metres as shown by the kernel density map in figure 5.

The most suitable method for visualizing crime data as a continuous surface is by the kernel density estimation (Chainey et al., 2002; McGuire and Williamson, 1999). The kernel density method creates a smooth surface of the variation in the density of point events across an area.

From the average nearest neighbor calculations, it can be seen that with the exception of rape and stealing which were dispersed, all the other crimes did not appear to have a pattern significantly different from random. None of the crimes exhibited a significant spatial cluster. The mostly random nature of crime would suggest that equal attention in terms of police preparedness should be given to all types of crimes within the subdivision even though some have higher counts than others. Assault had the least observed average mean distance of 372.31metres between incidents while Rape had the greatest observed average mean distance of 674.27 metres.

An analysis of the mean centers of the crimes established that all but one of the centers were within an

approximately 400 metre radius area, close to the western boundary of the Mamprobi district. Currently all four police stations in the Dansoman Sub Division are not within the mean crime center cluster with closest police station to the mean centers being approximately 2.5 kilometres away. The maps generated by using the mean center GIS tool can be used to aid better decision making in siting any future facilities within the Dansoman Sub Division. It is expected that any future facility will be sited in a central location so that law enforcement officers can easily be dispatched to crime scenes in a timely manner.

Generally there are three primary types of crime analysis that can occur through crime mapping (http://geography.about.com/od/understandmaps/a/crimemapping.htm):

- **Tactical Crime Analysis –** which looks at the short-term in order to stop what is currently taking place. For example, a crime spree used to identify one perpetrator with many targets or one target with many perpetrators and provide an immediate response.
- **Strategic Crime Analysis -** which looks at the long-term and on-going issues. Its focus is often on identifying areas with high crime rates and problem solving ways to decrease the overall crime rates.
- **Administrative Crime Analysis -** this type of crime analysis looks at the administration and deployment of police and resources and seeks to find out if there are enough police officers at the right place and time and then works to address a shortfall if any.

This analyses conducted could be described as being strategic since the source data provided allows for the identification of areas with high crime rates. The attribute information in the source data does not allow for a tactical analysis since it is silent on the perpetrators and victims or targets. Also information regarding the actual number of police officers and resources available to the Dansoman Sub Division is not provided and hence from an administrative analysis point, the question of an adequate or inadequate number police officers/logistics cannot be analyzed.

5. Conclusion and Recommendation

Pin maps of various crimes have been created to give a visual overview of crime within the entire study area and within districts. The study also successfully integrated crime incidence data with other spatial information to come up with meaningful crime patterns by (1) establishing crime counts within specific district boundaries and (2) depicting crime density through the use of kernel density estimation. It is seen from a summary of the attribute table that of the eight crime types analysed, Assault, Causing Damage and Unlawful Entry had the highest incidence with Rape and Stealing having the lowest counts. The results from the kernel density estimation maps and the summary of crime incidents per district, suggests that the Mamprobi district has a high crime density. It is the smallest district but has a relatively high count as compared to the much larger Dansoman and Korle bu districts.

Results obtained from the average nearest neighbor calculations points to a random nature of the crimes incidents and for majority of the individual crime types. None of the crime types showed a statistical pattern of clustering.

The mean centres (X and Y coordinates) of all the crime types were calculated and a spatial representation shows that seven out of the eight crimes types are all within a relatively small radius of less than 1 kilometre.

In view of the above results and the advantages that GIS offers in performing analysis, the following recommendations are made to the Ghana Police Service:

- Spatial data of all crimes should be collected on regular and sustained basis instead of short period spanning only a few months as was the case in this study
- Attribute data associated with crime locations should include date and time to allow the analysis to have a temporal dimension. (Certain crimes may be found to happen at specific times during the day)
- Personal data and peculiar traits of perpetrators (especially repeat offenders) should be captured in the database
- Other types of demographic data, example age, gender and income of the people within the districts should be included in analysis

References

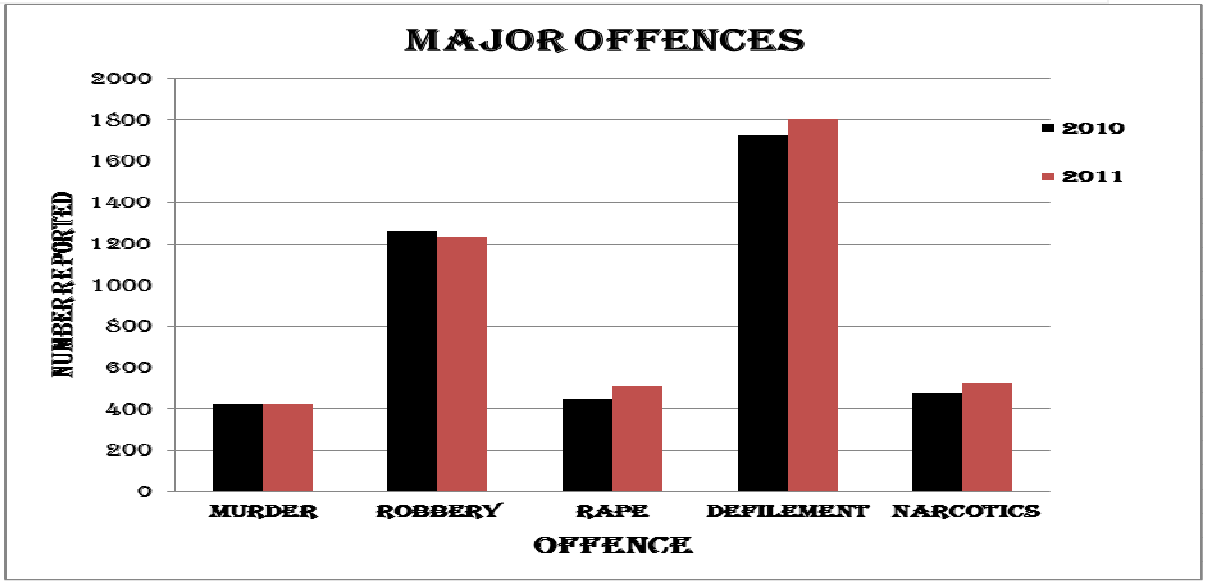
1. Chainey, S. and Ratcliff, J., 2005. *GIS and Crime Mapping*, John Wiley &Sons, Inc.
2. Chainey, S.P., .Reid, S. and Stuart, N., 2002. *When Is a Hotspot a Hotspot? A Procedure for Creating Statistically Robust Hotspot Maps of Crime.* In Innovations in GIS 9. London: Taylor & Francis
3. Jefferis, E., 1999. *A Multi-Method Exploration of Crime Hot Spots: A Summary of Findings*. Washington, DC: U.S. Department of Justice, National Institute of Justice, Crime Mapping Research Center.
4. Ghilani, C.D. and Wolf, P.R., 2012. *Elementary Surveying-An introduction to Geomatics, 13ed*. Pearson Education Inc. pgs 843-844

5. McGuire, P.G., and Williamson, D., 1999. *Mapping Tools for Management and Accountability*. Paper presented to the Third International Crime Mapping Research Center Conference, Orlando, Florida, December 11–14, 1999
6. http://www.unodc.org/documents/data-and-analysis/Crime-statistics/International_Statistics_on_Crime_and_Justice.pdf *International Statistics on Crime and Criminal Justice, 2010*[Accessed on April 4 2014]
7. https://www.ucl.ac.uk/scs/people/academic-research-staff/spencer-chainey/Slides/Home_Office_CrimeMapping. *Crime Mapping:Improving performance. A good practice guide for front line officers*. Home Office, Communications Directorate, Police Standards Unit [Accessed on 16 April, 2014]
8. www.esri.com/publicsafety [Accessed on 20 May, 2014]
9. www.ghanapolice.info [Accessed on 27 December, 2012]
10. www.statsghana.gov.gh [Accessed on 9 June, 2014]
11. www.indexmundi.com/ghana/population_growth_rate_html [Accessed on 10 June, 2014]
12. http://gisandscience.com/2009/09/14/top-five-benefits-of-gis/ [Accessed on 15 February, 2014]
13. http://geography.about.com/od/understandmaps/a/crimemapping.htm [Accessed on 10 December 2013]
14. http://www.photius.com/countries/ghana/geography/ghana_geography_physical_setting.htm. [Accessed 24 July 2014]

Acknowledgement
The authors would like to acknowledge Francis Ayamga Adombila (Survey and Mapping Division, Ho, Ghana) and Abubakar Burma Abdul-Karim (Hathaway Engineering Limited, Accra, Ghana) who helped with gathering and processing the data used for this study.

Appendix A
A1. Sample of Standard Ghana Police Crime Report
CRIMES COMMONLY COMMITTED
Assault, stealing, fraud and causing harm went down by 1.8%, 2.6%, 4.1% and 1.1% respectively. Nevertheless, threatening, causing damage and unlawful entry went up by 0.1%, 9.9% and 3.7% respectively in their commissions as compared to that of the year 2010. Assault cases maintained its position as the most highly committed Criminal Offence in the country in the year 2011.
Below is the tabular representation of the Commonly Committed offences for the years 2010 & 2011:

OFFENCE	NUMBER REPORTED (YEAR)		% CHANGE
	2010	2011	
Assault	84,551	83,005	-1.8
Stealing	59,547	57,987	-2.6
Threatening	24,912	24,927	0.1



The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar