

GIS Mobile Application for Crime Reporting and Monitoring*

¹D. Duffour, ²C.Y. Asante, ²A.A. Acheampong

¹Daystar Geodata Consult, Accra, Ghana

²Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana

Duffour, D., Asante, C. Y and Acheampong A. A (2022), "GIS Mobile Application for Crime Reporting and Monitoring", *Ghana Journal of Technology*, Vol. 6, No. 2, pp. 20 - 27.

Abstract

The study utilised Geospatial technology for capturing crime data based on spatial location for monitoring, evaluation and spatial analysis of crime-related data. Understanding the spatial trends of crime prevailing in La-Dade Kotopon municipality, have the potential to depict how to formulate and enforce critical decisions to curb cases of crime in the area. Several database management systems have been implemented by the Ghana Police Service to aid in monitoring crime but the use of Geographic Information Systems within the Ghana Police Service is yet to be implemented fully across all jurisdictions. For this reason, the crime data and statistics report published by the Ghana Police Service do not include maps depicting the crime locations and crime hotspots zones. This has made many people fall victims of various types of crimes at the same places where those crimes occur rampantly. In this study, a geospatial mobile and web application have been developed to capture, monitor and analyse crime data in the municipality. The results of this study showed that, a total of 293 crime cases were recorded for the second quarter of the year 2020. Out of the total, 84 for April, 127 for May and 82 cases for June. Hotspot area for Assault cases in the municipality was La. Tse-Addo was hotspot area for Robbery, rape and Land guards activities/Trespass. Aviation Park was also the hotspot for Possession of Narcotic drugs. The hotspot area for issue of dud cheque crimes was South La. Furthermore, hotspot zone for stealing, threat of harm, offensive conduct, causing unlawful conduct, failing to comply with Restriction orders was La. In recommendation, social media should be used to warn and sensitise the public on dangers and crimes.

Keywords: GIS, Crime, Hotspot, Mobile Application

1 Introduction

Modern societies have been bedevilled with increasing crime rate which causes loss of lives and properties. Several conventional methods of data collection to help combat crime have been implemented, but in this era of advanced computer technologies, the introduction of Geographic information System (GIS) has led to crime-fighting agencies to develop sophisticated models in combating crimes. In reference to the Ghana Criminal Code 1960, ACT 29, a crime is any unlawful act which causes harm to lives and property. It is punishable by death or imprisonment or fine and constitutes a criminal offense against a person or the state. Throughout history, individuals have attempted to understand why a person will commit crimes. Some consider criminal acts to be lucrative than a normal job.

One of the major problems in solving crimes are the lack of spatial data and associated attributes of the crime and for this reason, it becomes difficult to visualize the exact locations of the various crimes on maps. The Ghana Police Service (GhPS) have implemented some computer technologies for crime database management which include an automated criminal records database, fingerprint identification system (The Criminal data Services Bureau-Ghana Police Service, 2011) and the Case Tracker Software (Crime and

punishment, 2018). However, despite the implementation of these database systems, GIS is yet to be implemented fully across all jurisdictions of the GhPS. As a result, the crime data and statistics report published by the Ghana Police Service do not include maps depicting the crime locations and crime hotspots zones. This has made many people to fall victims to various types of crimes at the same places where those crimes occur rampantly.

In the works of Amissah *et al.* (2014), GIS was used at the Dansoman Police subdivision in Accra, Ghana to prepare crime maps and examine the spread of crime. Crime data received from the police lacked spatial reference. In view of this, handheld Global Positioning System devices were used to capture the geolocation of the various crime sites. In conclusion, the researchers averred that crime data should include both spatial and attribute data to assist in GIS crime analysis in future studies.

Adepoju *et al.*, (2014) used GIS during the ASPRS 2014 Annual Louisville Conference in Kentucky on March 23-28, 2014 for crime hotspot mapping and analysis using Abuja State as a case study in Nigerian urban security and crime management. 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.

Arhin and Duffour (2015), GIS was used to generate Graduated symbols, stacked chart, proportional symbol and pie chart methods for hot spot analysis on KNUST campus. In their research, the crime data obtained from the university's security department lacked coordinates, hence the spatial data of the mean centre of the crime sites were captured using Google Earth software. The researchers created a web application which will enable users to report crime incidences on KNUST campus.

Ghartey and Gyabeng (2017) developed an updated interactive web-based map with geocoded address for KNUST campus using GIS technologies such as ArcGIS software, ArcGIS Online and the Web AppBuilder, which enabled users to find paths to specific locations on campus. However, this platform also provided safety information to students, notifying them about the crime spot on campus, the incidence recorded on crime at various spot and information on security emergency dial up numbers and checkpoints, to help fight and reduce crime on KNUST campus.

Prakruthi Prakasha *et al.*, (2018) developed a web-based criminal record system (CRS) using mobile devices with regard to traditional GPS devices in order to enable the police to capture the location of the criminal activity. This online crime detection method was built to mitigate the challenges and hardships that remain in the conventional manual system of practice.

In terms of violence, focused crime zones are often alluded to as crime hotspots (McLafferty *et al.*, 2000). In other words, a crime hotspot is an area with a greater than usual number of violent crimes. The places with more criminal occurrences are described as hot and as such, places with less occurrences will be described as cool. This is due to the fact crime is randomly distributed spatially. (Eck *et al.*, 2005; Chainey and Ratcliffe, 2005).

This article seeks to map crime data, identify hotspots and present patterns using GIS technologies to enhance data collection, visualization and informed decision making. Graduated symbol maps were used to represent the types of crime prevalent in La Dade Kotopon municipality. By so doing, our contribution is an extension of the application of mobile and web GIS technologies in preventing and combating crime. These were achieved by addressing these concerns:

- (i) Determine the spatial locations of crimes

- (ii) Provide a spatial database system for crime records.
- (iii) Use GIS spatial analyst tools to analyse and identify crime hotspots.

1.1 Study Area

The study was carried out in the La-Dade Kotopon municipality. It covers an area of 36.08 km² (13.93 sq. mi) and lies within Latitudes 005°34'19"N and 005°35'27"N and Longitudes 000°11'20"W and 000°7'55"W as shown in Fig. 1. According to the Ghana Statistical Service report (2021), It recorded a population of about 140,264 with 51.4% females and 48.6% males. The area is entirely urban and has a 66.6% young population, reflecting a large base population pyramid that tapers off with 3.9% with a limited number of elderly residents (65+ years). The average age dependence ratio is 70.5%; the infant dependency ratio is higher (66.6 % than that of the old age dependency ratio 3.9).

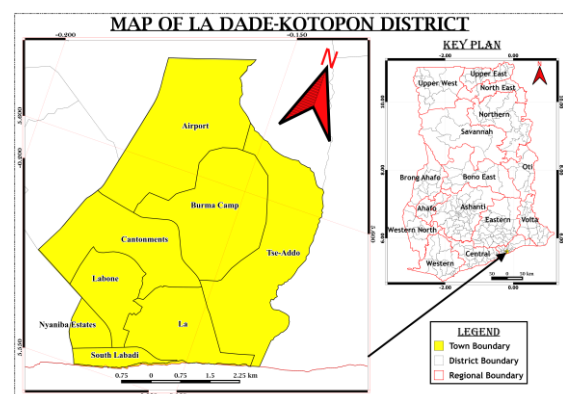


Fig. 1 Map of La Dade-Kotopon Municipal

1.2 Ghana Police Service and Crime Report

The Ghana Police Service is the main law enforcement agency of the Republic of Ghana and is under the jurisdiction of the Ghana Ministry of Interior. The mandate of the Police Service is to maintain law and order throughout the territorial boundaries of Ghana (Police service Act, 1970, Act 350). Some of their duties are: Crime detection and prevention, apprehension of offenders, maintenance of law, order public and safety of persons and properties and due enforcement of the law. (<https://police.gov.gh/>, retrieved on 5th September, 2020).

For research purposes, a sample of a Standard Ghana Police Crime Report in the year 2015 and 2016 as presented in Fig. 2 and Tables 1 and 2 to illustrate how the Ghana Police service report crime data (Source: Statistics & Information Technology Unit (SITU), CID Headquarters,

Accra). All the Commonly Committed Offences registered increased with the exception of causing harm and unlawful entry, which showed decreases of 176 and 387 cases representing 5.3% and 24.4% respectively. As usual, Assault emerged as the most highly Committed Criminal Offence in the country. However, the hotspot locations lack spatial data representations as earlier mentioned.

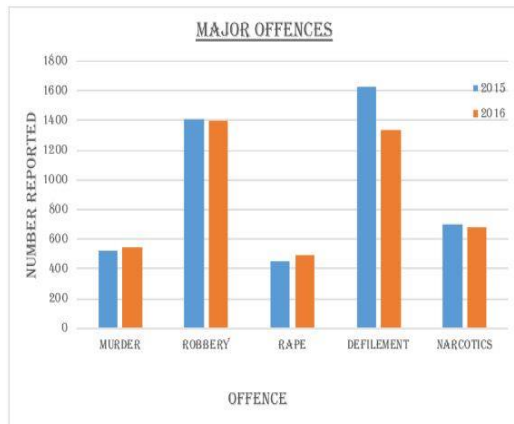


Fig. 2 Graphical Representation of Major Offences Committed

Table 1 Commonly Committed Offences

OFFENCE	NUMBER REPORTED(YEAR)		% CHANGE
	2015	2016	
Assault	55,624	59,158	6.4
Stealing	49,739	54,802	10.2
Threatening	19,662	22,590	14.9
Fraud	16,491	17,667	7.1
Causing damage	9,507	11,012	15.8
Causing harm	3,299	3,123	-5.3
Unlawful entry	1,588	1,201	-24.4

Table 2 Major Offences Committed

OFFENCE	YEAR		% CHANGE
	2015	2016	
Murder	525	549	4.6
Robbery	1,411	1,397	-1.0
Rape	451	497	10.2
Defilement	1,630	1,341	-17.7
Possession, use and distribution of narcotic drugs	698	681	-2.4

2 Resources and Methods Used

2.1 Materials

The criteria requirements were studied and the software design was carried out. Fig. 3 illustrates the design tools used for the study. they include Sublime Text (text editor), Geoserver (for hosting the web maps), Xampp server (for hosting web application), Android Studio (for developing mobile app), Kotlin (for android), Hypertext Preprocessor (for web), Structured Query Language (for database), Secure Sockets Layer (protocol for web browsers and servers for encryption, authentication, etc.). Moreover, Open Street Map (OSM) was used as the base map, fig. 8 and fig. 9 describes the interactive web map platform. It enabled the officer to digitally visualize locations of all the various crimes cases.



Fig. 3 Design Tools

2.2 Methodology

Waterfall model was used in the software development model. It follows the sequential order of development where one phase is completed before the start of another. This model frequently focuses on early-stage planning and is used in initiatives where all the criteria for the framework are defined (Govardhan, 2010). The stages adapted by this project from the waterfall model includes:

- Analysis of specifications: Requirements for the software to be used were obtained. These requirements were gathered in direct consultation with the District Police Crime Officer.
- Functional Requirements: Specific functions expected of the application to be carried out were examined. The framework of the app included:
 - Police officers were allowed to report incidents of crime.

- b. Police officers were allowed to generate statistical charts and hotspot maps.
- c. Police officers were allowed to view on a map the locations of reported crime.

2.2.1 User Requirements

The user specifications define tasks performed on the mobile phones and computers by the users. The Station officer, District crime officer and System Administrators were the users of the software. The specifications for these users were illustrated a use case diagram as given in Fig.4

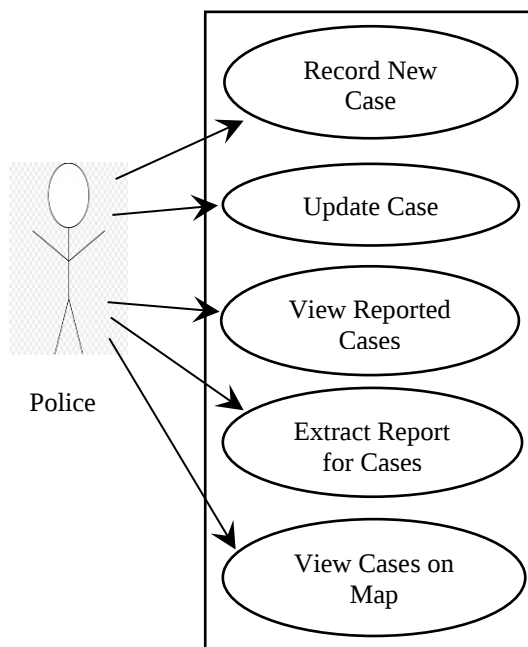


Fig. 4 Use Case Diagram

Below is the Flow diagram for the operation procedures of crime data collection, monitoring and evaluation as presented in Figs. 5 and 6.



Fig. 5 I-Report App

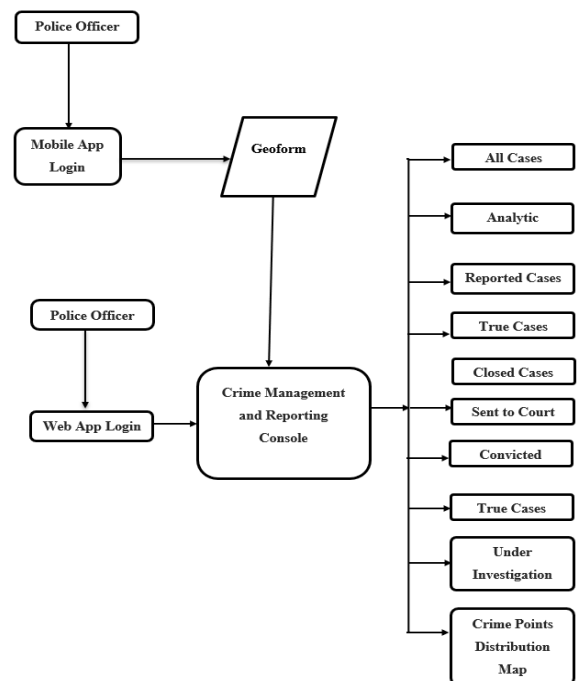


Fig. 6 Flow Diagram

2.2.2 Data Collection

The Mobile app as shown in Figs. 7, 8 and 9 were used to record crime spatial and attribute data when crime cases were reported. The process involved an officer being enrolled onto the central system and then provided with credentials to access the mobile. The officer logged into the application with his Police identification number. The app was used to capture crime data which include: geolocation, type of crime/offence, complainant details (name, gender, age, nationality), suspect details (name, gender, age, nationality), time and date. Upon completion, the data is stored in the cloud in a secured database which can be accessed either on the mobile device or computers by the app administrators.

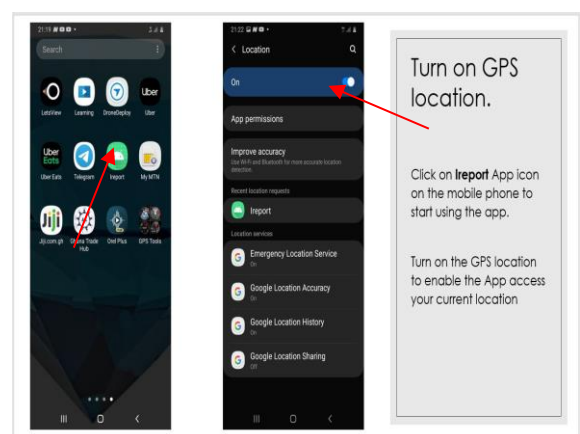


Fig. 7 Officer Mobile App

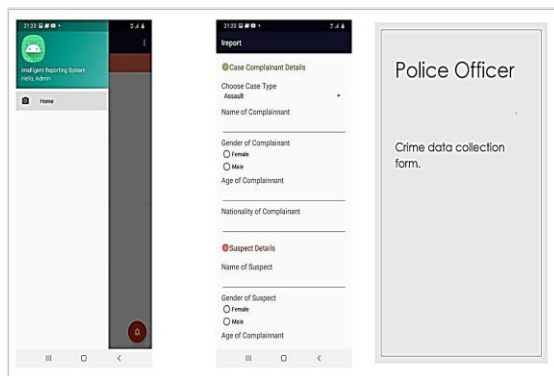


Fig. 8 Officer Mobile App Geo-Form

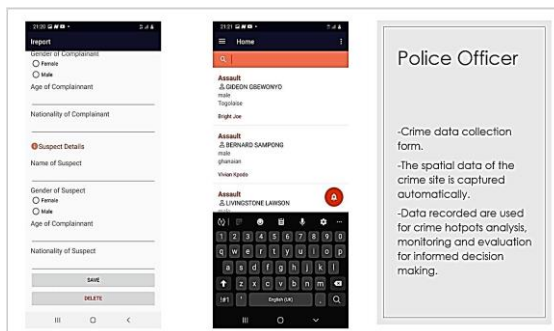


Fig. 9 Officer Mobile App Geo-Form

3 Results and Discussion

3.1 Data Analysis and Output

The web portal helped cases from crime scenes to be viewed, updated and analysed. Figs. 10, 11 and 12 enabled the officer to perform graphical statistical analytics using charts such as bar, pie and line charts. The reported crime cases were automatically quantified into case types and number of cases reported and locations data noted. In addition, Fig. 13 enabled the officer to view the list of cases reported. In view of this, updates on the cases are effectively done where necessary. The output enabled the officer to view the demographic information of the crime suspect and the complainant which include name, gender, nationality, age, date and time.

Figs. 14 and 15 also enabled officers to visualize crime cases on an interactive web map.



Fig. 10 Web App Login Interface

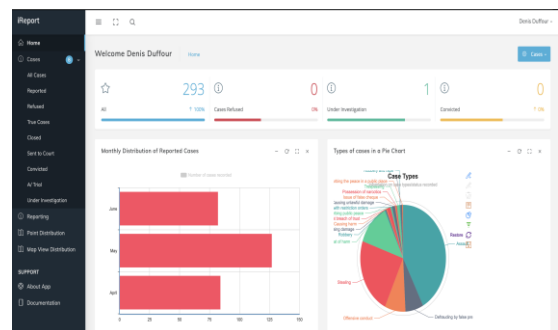


Fig. 11 Crime Case Analytics Graphs

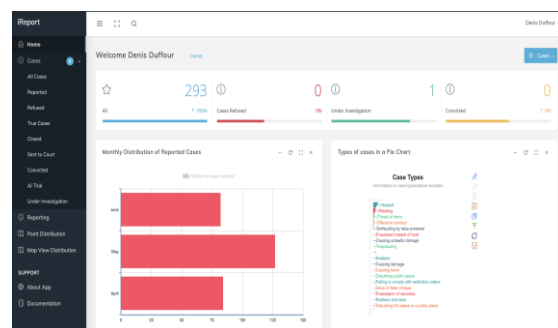


Fig. 12 Crime Case Analytics Graphs

Type	Complainant Name	Complainant Sex	Complainant Age	Complainant Nationality	Suspect Name	Suspect Sex
Assault	JOEL MATE	male	59	Ghanaian	Lucas	male
Assault	AGBON LUCAS	male	45	Togolese	Bright Joe	male
Assault	J. OGDEN GRENWYD	male	52	Ghanaian	Vivian Kpodo	male
Assault	BERNARD SAMPOING	male	49	Ghanaian	Vivian Kpodo	male
Assault	LIVINGSTONE LARSON	male	37	Ghanaian		
Assault	ADONIS-KARE DENNIS	male	27	Ghanaian		

Fig. 13 List of Cases

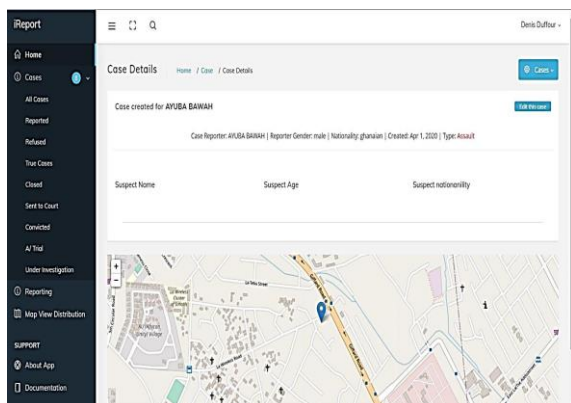


Fig. 14 Visualise Individual Crime Cases on Interactive Web Map

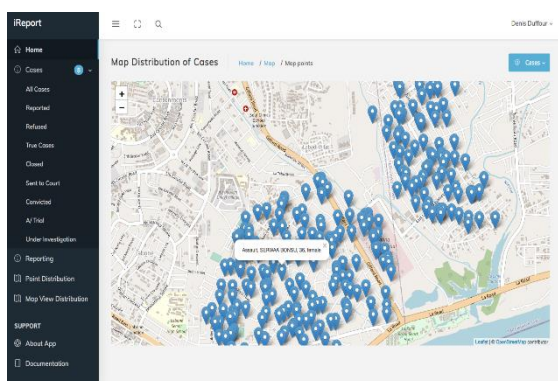


Fig. 15 Visualise All Crime Cases on Interactive Web Map

The results of this study showed that, a total of 293 crime cases were recorded for the second quarter of the year 2020 as shown in Table 3. Out of the total, 84 for April, 127 for May and 82 cases for June. Assault cases were identified to be a general problem in the municipality. Consequently, La was the major hotspot for assault followed by Tse-Addo. Hotspot area for robbery and rape, Land guards/Trespass was Tse-Addo. Aviation Park is also notified for Possession of Narcotic drugs. The hotspot area for issue of false cheque crimes was South La. Furthermore, hotspot zone for stealing, threat of harm, offensive conduct, causing unlawful conduct, failing to comply with Restriction orders was La. The data were used to prepare graduated symbol maps to depict crime hotspot areas as shown in Figs. 16, 17 and 18 using QGIS software to enhance map visualization and inform decision making.

Table 3 Summary of Monthly Report

CRIME TYPE	APRIL		MAY		JUNE	
	COUNT	HOTSPOT	COUNT	HOTSPOT	COUNT	HOTSPOT
Assault	36	La	62	La	29	Tse-Addo La
Stealing	21	La	29	La	18	La
Threat of Harm	13	La	14	La	10	La
Offensive Conduct	9	La	8	La	6	La
Defrauding by False Pretense	4	Tse-Addo La	8	Tse-Addo La	8	Tse-Addo La
Robbery and Rape	1	La	0		1	Tse-Addo
Fraudulent Breach of Trust	0		2	Tse-Addo	2	Tse-Addo
Causing of Harm	0		1	La	0	
Causing Unlawful Damage	0		1	La	3	La
Failing to comply with Restriction orders	0		1	La	0	
Possession of Narcotic drugs	0		1	La	1	Aviation Park
trespassing	0		0		3	Tse-Addo
Issue of false cheque	0		0		1	South La
TOTAL	84		127		82	

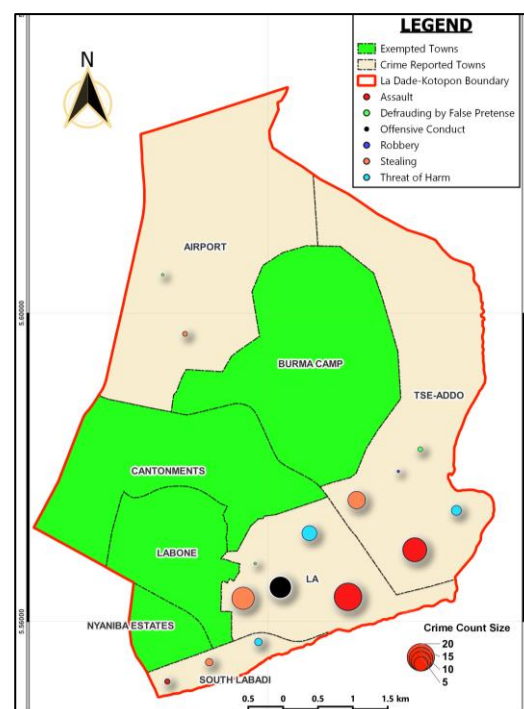


Fig. 16 Map Showing Proportional Distribution of Reported Crime Cases in April, 2020

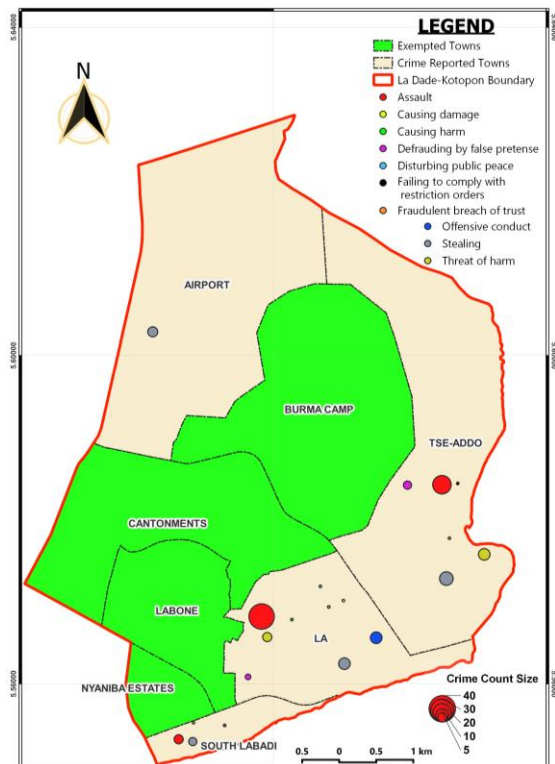


Fig. 17 Map Showing Proportional Distribution of Reported Crime Cases in May, 2020

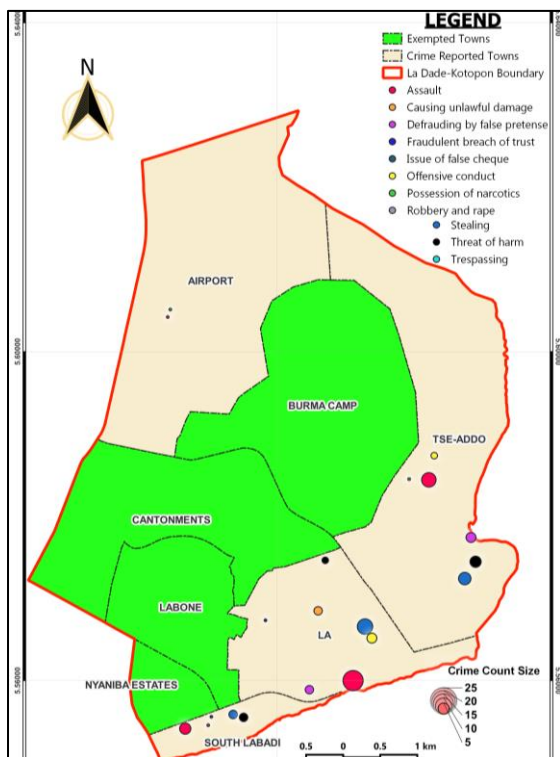


Fig. 18 Map Showing Proportional Distribution of Reported Crime Cases in June, 2020

4 Conclusions and Recommendations

4.1 Conclusion

This study provided the police officers in the La-Dade Kotopon district Police headquarters with a user-friendly software for capturing crime data based on spatial location in real-time for hotspot maps, crime detection, classification, crime spatial dissemination and allocation of resources. GIS mobile and web application were developed to satisfy the aim and objectives of the study with various functional tools or widgets configured. Hotspot analysis were made using proportion symbol maps to enhance visualization. The use of this tool helped to identify crime hotspots and enhanced effective crime spatial planning and analysis in the La-Dade Kotopon municipality.

4.2 Recommendation

- (i) Users of the mobile app should visit the crime scene before capturing the data. This will assist in identifying the exact location of crimes.
- (ii) The mobile and web application should have access to internet and Global Positioning System (GPS) embedded in the mobile to enable the application to function
- (iii) In future research, crime data based on spatial location should be collected over a long period to determine the spatial trends of crime within the municipality instead of the short period used in the data collection of this research.
- (iv) Spatial information on crime hotspot areas should be made available to the general public. This will ensure that people do not fall victims of the same crime at the same places thereby reducing the crime rates in our communities.
- (v) The use of Geospatial Technology should be integrated into the operations of the Ghana Police Service. These include mobile and spatial database management systems as demonstrated in this research. This application will help combat crime by assisting them to locate the exact position of the various crimes present in their jurisdiction.

Acknowledgements

Acknowledgement to DSP. Joseph A. Afoakpah and all other staff members of La District Police

Headquarters for the warm welcome and also assisting the researchers with the data collection.

References

- Adepoju M. O, Halilu S. A, S.O. Mohammed, Ozigis S. M, Idris I, Blessing A, Adeluyi O. A (2014), "Geospatial technologies for Nigerian urban security and crime management. A study of Abuja crime hotspot and mapping analysis". ASPRS 2014 Annual Conference Louisville in Kentucky on March 23-28, 2014. *National Space Research and Development Agency Strategic Space Application Department*, pp 1-14
- Anon. (1970), "Police service Act, 1970 (Act 350)", <http://elibrary.jsq.gov.gh/> Accessed: August 3, 2021.
- Anon.(2009),The Most Important Part of a GIS. (n.d.),ESRI: <https://www.esri.com/news/arc-user/0309/trainplan.html>. Accessed: June 5, 2020.
- Anon.(2016), Statistics & Information Technology Unit (SITU), C., "Annual Crime Statistics,Accra",<https://police.gov.gh/en/wp-content/uploads/2018/08/ANNUAL->, Access: December 18th, 2020.
- Anon.(2018), "Crime and punishment". <https://www.modernghana.com/news/855903/policestations-across-the-country-to-go-paperless.html>, Accessed: December 14, 2020.
- Anon.(2020),"Ghana Police Service", <https://police.gov.gh/>, Accessed: May 5, 2020.
- Anon.(2021), "La Dade-Kotopon municipal". https://www.citypopulation.de/en/ghana/adm/in/greater_accra/0312_la_dade_kotopon_municipal/, Accessed:January3, 2022.
- Arhin, A. K., & Duffour, D. (2015), "GIS as an essential tool in crime mapping and hotspot analysis".*Unpublished BSc Project Report*, Kwame Nkrumah University of Science and Technology, Kumasi, pp 35-38.
- Chainey, S., & Ratcliffe, J. (2005), "GIS and Crime Mapping". *Social Science Computer Review (SSCR)*, Vol.25, issue:2 pp. 279-282.
- Eck, J. E., Chainey, S., Cameron, J. G., Leitner, M., & Wilson, R. E. (2005), "Mapping crime: Understanding hotspots", *U.S. Department of Justice, National Institute of Justice., Washington, DC.* pp.8.
- Ghartey, E. C., & Gyabeng, B. A. (2017), "KNUST Map Locator, *Unpublished BSc Project Report*, Kwame Nkrumah University of Science and Technology, Kumasi, pp. 4-9.
- Govardhan, N. M. (2010), "A Comparison Between Five Models of Software Engineering", *IJCSI International Journal of Computer Science* , Vol. 7, Issue 5. pp. 95-96.
- Mark, B.-A., Tina, D. W., & Franz, T. O. (2014). "Crime mapping and analysis in the Dansoman Police Station Subdivision, Accra-Ghana. A Geographic Information Systems Approach". Crime Mapping and Analysis in the Dansoman Police Subdivision, Accra, Ghana - A Geographic Information Systems Approach", *Journal of Environment and Earth Science*, Vol.4, No.20, pp. 28-37.
- McLafferty, S., Williamson, D., & McGuire, P. G. (2000), "Identifying crime hot spots using kernel smoothing", (V. Goldsmith, P. G. McGuire, H. M. J, & A. R. & T, Eds.) *Thousand Oaks, , CA: Sage.* pp.77-86.

Authors



Dennis Duffour is a Geospatial Engineer at Daystar Geodata Consult Limited and Eagle Eye Survey Consult Limited. He holds M.Phil. degree in Geographic Information Systems and BSc degree in Geomatic Engineering from the Kwame Nkrumah University of Science and Technology (KNUST), Ghana. He is a member of the Ghana Institution of Surveyors. His research and consultancy works include GIS and Remote Sensing applications in Land information management, Security intelligence, Agriculture, Health, Transportation, Water resource management and Environmental management.



Cosmas Yaw Asante is a Lecturer at the Department of Geomatic Engineering in College of Engineering at Kwame Nkrumah University of Science & Technology, Kumasi, Ghana. He holds a PhD degree in Geomatic Engineering from the Kwame Nkrumah University of Science & Technology, Kumasi, Ghana. He is a member of the Ghana Institution of Surveyors and a Licenced Surveyor. His research interest includes Height Systems in Physical Geodesy, Hydrographic Surveying, land and Geographic Information Systems.



Akwasi Afrifa Acheampong is a Snr. Lecturer and Land Surveyor with the Geomatic Engineering Department at Kwame Nkrumah University of Science & Technology (KNUST) and a Council Member of The Ghana Institution of Engineering. He received his PhD at Geomatic Eng., KNUST. His current research focuses on using GNSS technologies for precise applications, low-cost receiver applications, GIS & Location-based Services and 3D cadastre.