INFLUENCE OF GEOGRAPHIC INFORMATION SYSTEMS TECHNOLOGY ON DRUG TRAFFICKING CRIME CONTROL IN KENYA: CASE OF NAIROBI COUNTY

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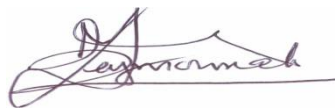
NOVEMBER 2021

DECLARATION

This project is my original work and has not been presented for examination in any other university.

Signature .... Date 7th November, 2021

David Kainga Mathiu

This project has been submitted with my approval as the university supervisor.

Signature .... Date 7th November, 2021

Dr. Martin Ouma

DEDICATION

Above all to the great Almighty God, the creator of knowledge and wisdom for his countless love and care. The completion of this project and the entire program could not have been possible without the participation and support of the lecturers, classmates and particularly my supervisor Dr. Martin Ouma who tirelessly committed himself. Notably, I would like to express my deep appreciation and indebtedness to my family members and particularly my wife Ruth and sister Elizabeth who played a great role to support me throughout my study period. I also dedicate this research project to the National Police Service administration who I appreciate for allowing me to enrol for the Masters' Degree programme.

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ABBREVIATIONS AND ACRONYMS

APS	:	Administration Police Service
COMPASS	:	Community mapping, planning and analysis for safety strategies
DCI	:	Directorate of Criminal Investigation
GIS	:	Geographic Information System
KCGS	:	Kenya Coast Guard Service
KDF	:	Kenya Defence Force
KNBS	:	Kenya National Bureau Statistic
KPS	:	Kenya Police Service
NCIS	:	National Criminal Intelligence Services
NCRC	:	National Crime Research Centre
NIS	:	National Intelligence Service
NPS	:	National Police Service
UK	:	United Kingdom
USA	:	United States of America

1.0 BACKGROUND TO THE STUDY

1.0 Introduction

This chapter sets the stage and creates broader picture for the study to capture the audience's attention. It is organized into different sections that elaborate on the study topic by presenting detailed discussion of the background of the study, which serves the purpose of laying the foundation and framework for the study. The sections of this chapter of the document, in logical order, are; the background to the study, statement of the problem, objectives of the study, research question, the study's significance, scope of the study, limitations and delimitations of the study, the conceptual framework. The chapter also provides a detailed review of previous research studies based on the thematic areas and specific objectives of this study. Also captured in this chapter is the research methodology which essentially details the procedures and techniques the researcher intends to employ to identify, select, process, and analyse research data.

1.1 Background to the Study

Crime control are activities carried out by law enforcement agencies and other authorized individuals, public or private, to eliminate crime prior to it occurring or before any additional crime activities are committed by criminals. Advancements in technology have seen law enforcement agencies significantly move away from the once popular push-pins on paper maps to more advanced approaches and strategies of crime prevention and control. The use of computerized crime mapping technology is one such significant transformation in the field of policing and law enforcement. Dağlar and Argun observed that for a considerable period of time now, the use of computerized technologies such as the Geographic Information System (GIS) to fight crime have continued to gain traction with the diffusion of technology originating from the

developed nations and spreading over to less the developed ones[1]. The computerized crime prevention and control technologies have enabled law enforcement agencies to analyse and correlate data sources to create a detailed snapshot of crime incidents and related factors within geographical areas.

Global trends indicate that developed countries such as USA, Britain and Germany are utilizing GIS technologies in crime management with great success being witnessed[2]. Such countries have complex GIS technology such as CompStat program which is closely linked to crime analysis and police deployment programs. In Asia, Turkey is using GIS tools such as POLNET to fight crime. In 1997, a study by the United States National Institute of Justice (NIJ) on application of GIS approaches in policing indicated that 36% of police departments with more than 100 officers used computer-based crime mapping. By the year 2001, 62% of police departments with more than 100 officers had adopted GIS tools. In Africa, Nigeria, South Africa and Egypt are among the few states that are using GIS tools in law enforcement. In Kenya, the NPS has also been at the forefront on the use of GIS technology and has been able to achieve results.

Crime has become a major challenge in the 21st century. Over the years, crime has grown exponentially posing a serious threat to national security. Crime affects us all regardless of our gender, religion, social status etc. It is a menace that has had serious threats not only to national security but also has ripple effects on socio-economic and political spheres. The threat is dynamic and wide ranging from cyber-attacks, terrorism, fraud and corruption among many others. The use of technology in crime detection,

[1] Dağlar, M., & Argun, U. (2016). Crime Mapping and Geographical Information Systems in Crime Analysis. *Journal of Human Sciences*, *13*(1), 2208–2221. Retrieved April 5, 2021 from https://www.j-humansciences.com/ojs/index.php/IJHS/article/view/3736
[2] Ahmed, A. & Salihu, R. (2013), Spatiotemporal pattern of Crime using GIS Approach in Dala L.G.A. Kano State, Nigeria. *American Journal of Engineering Research*, 2(3).

prevention and management has become necessary to respond to the crime issues in the country. The adoption and use of (GIS) technology by National Police Service (NPS) is an indication of the commitment by the government of Kenya's towards combating crime. Crime has been attributed to fast paced urbanization and growth of cities and towns, a growing number of unemployment amongst the youths and the strain for survival by the majority of people who try to make a living in harsh and difficult economic conditions[3].

The GIS technology are computer applications designed to capture, store, manage, analyse and project data in a visual manner[4]. The technology has been extensively utilized in a number of fields. It has been used in natural sciences especially in environmental studies to link geographic information with descriptive information. Use of GIS technology especially by law enforcers can be traced back in 1990s. However, increased use of computerized technology in the execution of police duties gained momentum immediately after 1990s due to increased computer's capacity to process and store information. From Mid 1990s, to date, the desire and need to use GIS technology in crime mapping, hotspot analysis, resources allocation and strategic planning tremendously grew[5]. The NPS, as stipulated in their mission statement, is mandated with the responsibility to provide professional and people centred police service through community partnership and upholding the rule of law for a safe and secure society. The provision of public safety stands out as a leading function by the police. But to be able to ensure this service is successful, it requires a strategic approach that has a broad dimension on the complexity of the security status in the country. The

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[3] Ghani, Z. A., (2017): A comparative study of urban crime between Malaysia and Nigeria. *Journal of Urban Management, 6*(1), pp. 19-29.
[4] Huisman, O., & By, R. (2009). *Principles of Geographic Information System*: An Introductory Texbook.
[5] Baraka, G. E., & Murimi, S. K. (2019). Stuck in the past with push-pins on paper maps: Challenges of transition from manual to computerized crime mapping and analysis in Kenya. *International Journal of Police Science & Management*, *21*(1), pp. 36–47.

National Crime Research Centre (NCRC) whose primary objective is to carryout research on causes and prevention of crime with a view of disseminating research findings to relevant authorities for policy formulation and planning, has been at the fore front in trying to propose proactive measures to the vice[6]. In order to combat crime, the security apparatus must understand the specific threats in a broader perspective before tackling it. The basic and fundamental question surrounding crime and its prevention is one that informs its mitigation measures. Perpetrators of crime have become highly innovative and determined in pursuing their goals. This means NPS response has to be well informed, highly calculated, resourceful and relentless. In order to understand the risks, there is a need to have a comprehensive idea of the risks that crime trends in the country.

Evidently, many efforts in policing and enforcing law have been made to enhance public security and safety. But to this extent, the scope and depth of the challenge is enormous. In response to this challenge, crime related research is critical to inform ways on tackling the present dynamic crime cases to deliver criminal justice outcomes, recover assets and prevent and disrupt criminal activity. Important to note, three things facilitate crime to occur: a motivated offender, a suitable target, and a location. The presence of the first two areas of the crime triangle makes crime inevitable. The security agencies have had to initiate mechanisms on how to respond to such crime. The NPS through its departments of Criminal Investigations (DCI) and National Intelligence Service (NIS) have adopted technologies and ways to deal with sophisticated crime. Use of GIS technology has been a presumably an effective tool in map crime locations. However, to better comprehend the context within which criminal

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[6] National Crime Research Centre, (2016). National crime mapping study public perceptions of crime patterns and trends in Kenya.

events occur, analysis and comparison with other crime data to derive meaning, detect patterns in the data and draw the bigger picture is very crucial. This becomes the initial stage of understanding the problems to determine whether or not GIS technology delivers on aspects of crime detection, prevention and management.

Nairobi is Kenya's largest city with a population of nearly 4 million people. Being the country's capita, Nairobi is also the hub and epicentre of economic activities in Kenya[7]. It follows therefore, almost naturally, that Nairobi city plays a host to significant criminal activities including drug trafficking. According to available literature, drugs such as heroin from Asia and cocaine from Latin America are transited through Kenya to destinations like Europe, Dubai, South Africa and West Africa; moving the drugs to the capital Nairobi[8]. The aspects therefore make Nairobi County an appropriate region in the country on which to base this study.

1.2 Problem Statement

According to the National Crime Research Centre (NCRC), the NPS and its related crime management agencies consisting of NIS, Directorate of Criminal Investigation (DCI) and the general police unit have experienced enormous challenges as they strive to discharge their constitutional mandate of proving security to its citizens. Government commissioned reports on status of policing in Kenya by Independent Policing Oversight Authority[9] and a joint report by the Kenya National Commission on Human Rights and Centre for Human Rights and Peace[10] revealed that

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[7] Schuberth, M. (2014). The Impact of Drug Trafficking on Informal Security Actors in Kenya. *Africa Spectrum*, *49*(3), 55–81.

[8] Kalekye, M. G. & Kiamba, A., (2018). Drug Trafficking in Kenya: A Case Study of Mombasa County, Kenya.

[9] Independent Policing Oversight Authority (2013). Baseline Survey on Policing Standards and Gaps in Kenya. Retrieved April 2, 2021 from http://www.ipoa.go.ke/wp-content/uploads/2017/03/IPOA-Baseline-Survey-Report_06.09.2013_revised2-1.pdf

[10] Kenya National Commission on Human Rights & Centre for Human Rights and Peace (2015). Audit of the Status of Police Reforms in Kenya. Retrieved April 2, 2021 from

NPS was yet to fully embrace changes in the external environment especially on the technological front with regard to the fight against crime. According to these reports, many of law enforcement officers are still largely stuck in the era of archaic tools of crime measurement, mapping and evaluation at a time when most operations are driven by technology to respond to the dynamism and evolution, and criminals have devised innovative ways of committing crime and reducing their traceability[5]. While some effort has been put to transform the law enforcement agencies' operations from the old-fashioned to modern technological means of operation such as the GIS technology to help in crime detection, prevention and management, the effectiveness of such technologies in combating crime remain unclear. For instance, the NPS Crime Situation Report[11] documented a 4.5% increase in crime incidents from 69,376 in 2014 to 72,490 in 2015, ascribing the upsurge to complexity in modus operandi by criminals. This is attributable to an ineffective and incomprehensive crime data repository system, despite the existence and application of the GIS technology in some operation outlets, which would otherwise lead to an effective policing response strategy. Research to measure the influence of GIS technology in drug trafficking in Kenya is almost non-existent. There is a near total lack of independent evaluations of the effectiveness of the GIS in preventing drug trafficking and related crime in the country.

1.3 Research Questions

This research study seeks to answer the following research questions;

i) What are the main approaches to application of the GIS technology in drug trafficking crime control in Nairobi, Kenya?

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http://www.knchr.org/Portals/0/AllOtherReports/FINAL%20EDITED%20POLICE%20REFORMS%20REPORT.pdf

[11] 9National Police Service Annual Crime Report (2016). Nairobi: Government Printer. Government of Kenya.

ii) How effective is the GIS technology on drug trafficking crime control in Nairobi, Kenya?

iii) What are some of the challenges encountered in the use of GIS technology in drug trafficking crime control in Nairobi, Kenya?

1.4 Objectives of the Study
1.4.1 Overall Objective
The general objective of this research study is to determine the influence of GIS technology on drug trafficking crime control in Kenya.

1.4.2 Specific Objectives
The specific objectives of this research study are as outlined below;

i) To determine the main approaches to the application of the GIS technology in drug trafficking crime control in Nairobi, Kenya.

ii) To establish the effectiveness of the GIS technology on drug trafficking crime control in Nairobi, Kenya.

iii) To identify the challenges encountered in the use of GIS technology in drug trafficking crime control in Nairobi, Kenya.

1.5 Assumptions of the Study
This study assumes that the GIS technology has been beneficial and advantageous in crime detection, prevention and management in other countries across the world and therefore, if applied aptly in the Kenyan context, will go a long way in combating the different types of crimes that the country grapples with including drug trafficking which is the focus area for this study. The study also assumes that dynamic and sophisticated criminal activities in the 21st has warrant the adoption of technology by Kenyan government security agencies if the fight against organized crime is to be won. Finally, assumption is also hereby made that creativity and innovation through the

use of technology in crime control is essential towards combating and reduction of crime levels in the country.

1.6 Literature Review
1.6.1 Theoretical Literature Review
This section provides a detailed review of previous studies based on the thematic areas and specific objectives of this study. It is from the review of the appropriate literature and research related to the specific objectives of this study that knowledge gaps are drawn from.

1.6.1.1 Ecological Systems Theory
Urie Bronfenbrenner's Ecological Systems Theory, published in 1979, posits that the ecology of human development is the scientific study of the progressive, mutual accommodation throughout the life course between an active, growing human being and the changing properties of the immediate settings in which, the developing person lives. In simple terms, the basic tenet of this theory holds that human beings encounter different environments throughout their lifespan and environments which they encounter may influence our behaviour in varying degrees. This theory comprises of five key environmental elements in which individuals interact in complex ways and can both affect and be affected by the person's development. These elements are Microsystems, mesosystem, ecosystems, macro system and chronosystem. The growth process is directly and indirectly affected by the relations between these ecological settings and by the larger contexts in which the settings are embedded[12].

Johnson, asserts that systems approaches to understanding change have become increasingly common[13]. Additionally, there has been a mounting recognition and

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[12] Bronfenbrenner, U., (1986). Recent advances in research on human development. In R. K. Silbereisen, K. Eyferth, & G. Rudinger (Eds.), Development as action in context: Problem behaviour and normal youth development (pp. 287-309). New York: Springer.
[13] Johnson, E. S., (2008). Ecological Systems and Complexity Theory: Toward an Alternative Model of Accountability in Education. Complicity. An International Journal of Complexity and Education, 5(1), 1-10

appreciation of the importance of context that is the environment, in understanding and explaining various aspects of individuals' behaviours and ways of life[14]. This theory shaped this study in terms of the possible reasons criminals engage in drug trafficking. Further, the theory represents a useful theoretical framework for analysing, modelling understanding, translating the processes and interactions involved in drug trafficking. The theory is appropriate in enhancing comprehension of such behaviours and activities. Drawing from the definition of Bronfenbrenner's theory, it therefore follows that behaviours and lifestyle of the individuals who in one way or another deals in this vice can be best comprehended as a developmental outcome that arises as a result of their interactions with the system, that is the environment, in which such individuals resides in and interacts with. The characteristics of a drug trafficker at any given point in time can be appropriately cogitated as a joint function of the characteristics of the individual and the ecological systems over the entire course of the individual's lifetime up to the time of observation. In taking the activities and actions of drug traffickers into perspective and analysing the system relationships within the context of Bronfenbrenner's Theory, the culprits and environments can easily be identified and assigned to the five nested subsystems identified in the preceding paragraph one.

1.6.1.2 Theory of Reasoned Action

Developed by Ajzen and Fishbein, and also in some instances referred to as Theory of Planned Behaviour (TPB), this theory advocates that an individual's action or behaviour is determined by the individual's intention to engage in certain behaviour is a product of the individual's attitudes, subjective norms, and perceived behavioural control[15]. According to Ajzen and Fishbein, relevant and precise knowledge of the

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[14] Phillips, D. C. & Burbules, N. C., (2000). Post-positivism and educational research. New York: Rowman and Littlefield Publishers, Inc.
[15] Ajzen, I. & Fishbein, M., (1977). Attitude-behaviour relations: A theoretical analysis and review of empirical research. Psychological Bulletin, (84), pp.888-918

factors and reasons underlying an individual's resolve to engage in a given activity or behaviour enhances the chances that the decision can be influenced[16]. This brings out the significance of the Theory of Reasoned Action. Comprehending and appreciating the determinants of a person's behaviour is a crucial first step in the designing and developing and putting in place effective measures, strategies, interventions, and strategies that can be used to successfully help the affected person to adjust and change that behaviour. Going by the definition of this theory, an individual's behaviour, that is attitudes, subjective norms, and perceived behavioural control, an individual's intention to drug trafficking is a result of the individual's attitudes, that is, what the believes in relation to the attributes and outcomes of engaging in one or all of the three activities in comparison to the attributes or outcomes of engaging in the said activities. Secondly, the decision to engage in drug trafficking is also shaped by the individual's subjective norms, which refers to the individual's beliefs regarding the approval or otherwise of other people in the society, especially the people that the individual considers important, compared to the individual's drive to conform others' expectations. In kernel, these subjective norms are a culmination of social and environmental surroundings of an individual.

Thirdly, the individual's action of participating in drug trafficking is additionally prompted by perceived behavioural control drug trafficking in the presence or absence of catalysts and impediments to quitting the action. One of the studies that support this theory is that carried out by French and Cooke on using the Theory of Planned Behaviour to understand binge drinking which established that over 72% of this sample of students reported that they had engaged in binge drinking in the week

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[16] Ajzen, I. & Fishbein, M., (2000). Attitudes and the attitude-behaviour relation: Reasoned and automatic processes. *European Review of Social Psychology, 11*, pp.1-33.

prior to the study[17]. The result of the study confirmed that in certain instances, individuals plan to engage in particular activities, such as consumption of use of drugs, for various reasons hence making this theory plausible and robust in predicting people's behaviours and activities[18].

1.6.2. Empirical Literature Review

This section reviews existing literature around the three specific objectives guiding this study: to determine main approaches to application of the GIS technology in drug trafficking crime control in Nairobi, Kenya, to establish effectiveness of the GIS technology on drug trafficking crime control in Nairobi, Kenya, to identify the challenges encountered in the use of GIS technology in drug trafficking crime control in Nairobi, Kenya.

1.6.2.1 Approaches to Application of the GIS Technology in Crime Control

The GIS technology is a system that is typically designed to help in capturing of data, manipulation of data, analysing of data, managing of data and how to present the different types of geographical data. GIS can be applied in the police department for the purposes of crime identification and control. By using GI, one can be able to create a map with the intention of identifying places where crime is occurring and also being able to clarify the type of crime happening in a specific region[19] [20]. With the application of GIS, an individual or an organization can fully put their focus and

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[17] French, D. P. & Cooke, R., (n.d).Using the Theory of Planned Behaviour to understand binge drinking: The importance of beliefs for developing interventions. Journal of Health Psychology, 17, 1-7.

[18] Cooke, R., Sniehotta, F. & Schüz, B., (2007). Predicting binge-drinking behaviour using an extended TPB: Examining the impact of anticipated regret and descriptive norms. Alcohol and Alcoholism 42, pp.84-91.

[19] Gachie, B. E. (2017). Preparedness of the Kenya National Police Service to adopt geographic information systems technology in crime measurement, mapping and evaluation. Unpublished research thesis, Kenyatta University, Kenya.

[20] Ulvi, K., (2014). The Use of Geographic Information Systems by Law Enforcement Agencies and Its Impact on Police Performance.

respond on that particular location having been informed of the type of situation they are intended to handle.

There are different approaches used by different enforcement agencies across the world. Although these are different agencies, their main objective was basically to reduce crime rates in their own regions though GIS application in enforcement agencies may be used for different purposes. According to Baller, law enforcement agencies started to adopt the use of computers in their day to day activities since the 90s to help them in the control off crime though at that time they had limited resources to help them curb crime[21]. The first application of GIS was conducted by an Italian geographer Adriano Balbi in collaboration with a French lawyer Andre-Michel. They used the system on the French national system crime analysis so as to draw a conclusion to French crime[22]. By using their research, they were able to reveal the geographic patterns of various crimes in relation to each other. Also, they were able to know the different indicators of social economic for example the level of education in a specified area.

Some of the approaches that can be used in the use of GIS technology include: how to identify crime. Through the use of GIS, law enforcement can be able to determine coordinates of a specific location. A study conducted carried out in the city of San Bernardino County, California, identified how the County Sheriff department used and applied the use of GIS in identification of a where exactly the county's registered child sex offenders live[23]. The sheriffs were able to know exactly where all these offenders live and through the system, they were able to know the hot spots of

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[21] Baller, R. (2012). Structural covariates of U.S. County homicide rates: incorporating spatial effects. Criminology.

[22] Smith, S., (2011). History, current state and future trends in GIS in law enforcement and corrections in the US. Keynote speech at the National Conference on GIS Applications in Police.

[23] Braziel, R., Straub, F., Watson, G. & Hoops, R., (2011). Bringing calm to chaos. A critical incident review of the San Bernardino public safety response to the December 2, 2015, terrorist shooting incident at the Inland Regional Center.

that specific crime and can be able to respond to any crime pertaining that immediately by apprehending those offenders with a history of that crime in the area of occurrence. In addition, the agency was able to create a buffer zone around all schools around the location to identify how close those offenders live in conjunction with these "hunting grounds". In Africa, a country like South Africa has adopted the use of the GIS technology in identification of crime and 'hot spot' areas of specific crimes. In the study conducted, the South Africa Police Service has been using GIS to identify and curb guns around the country[24]. The agency, with the help of the technology ware able to identify where crimes relating to guns or where guns are used regularly. This is done through mapping the areas in a specific geographic area and the agency would deploy police to patrol the areas and apprehend persons sighted with guns. Also, they were able to keep track of individuals known for dealing guns and know their locations at all times.

In Kenya, the National Counter Terrorism Centre (NCTC) is a multi-agency organization consisting of different security agencies with their aim being to strengthen coordination in counter terrorism. The agencies were able to apply the use of GIS ion 21 September 2013 when the country experienced one of its worst terrorist attacks when gunmen attacked the Westgate Shopping Mall in Nairobi. The NCTC were able to coordinate with other security agencies with the help of GIS, to evacuate the innocent civilians in the mall. The agency was able to give the other ground agencies enough information about that specific location, location of the terrorists and hostages by the use of images by use of drones. Furthermore, the agency was able to use satellite visualization and the images taken to derive a suitable plan to curb the terrorists and at

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[24] Breetzke, G. D., & Horn, A. C., (2008). Key requirements in the development of a spatial - ecological theory of crime in South Africa, *South African Journal of Criminology 21*(1), pp. 123-143.

the same time save the hostages. According to Petrecca, the drones are integrated with the GIS technology, were able to give NCTC real time images and locations of the terrorists and hostages[25].

GIS are also used in crime investigation and most law enforcement agencies in the world use the technology mainly for this purpose. With the use of small and portable small computer devices that are integrated with GIS as well as GPRS to help agencies track crime. This was established by in a study of how police departments across USA have adopted the use of GIS in crime investigations and solving. In particular, the New York Police Department (NYPD)[26]. They use maps and GPS/GIS technologies to be able to follow and trace suspects of a hijacking crime that had happened. They used the GPS of the vehicle involved to trace the movements of the criminals. At the same time, GIS was also used in South Africa to defend a police officer[22]. The system was used when one suspect was arrested and later convicted. The suspect though filed a lawsuit against the city of Pretoria with accusations that the arresting officer used excessive force during the process of apprehending the convict. The arresting officer used GIS to creating a map showing that the suspect was driving at high speed especially in highly populated areas, ignoring the traffic lights. This helped the officer boost his testimony.

As revealed through the various literature reviewed herein, the GIS technology is widely and variably applicable in addressing drug trafficking crime in Nairobi. The law enforcement agencies can apply the technology to map out geographic patterns of various crimes in relation to other crimes, identification crime hot spots, locate and evacuate victims of crime and trace crime suspects for apprehension and arrest.

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[25] Petrecca, L. (2013). Americans among injured in deadly Kenyan mall attack. USA Today.

[26] Wang, F., (2012). Why Police and Policing Need GIS: An Overview. *Annals of GIS, 18*(3), pp. 159-171.

1.6.2.2 Effectiveness of the GIS Technology in Crime Control

Crime control can be explained as specific methods or tactics used by law enforcement agencies as well as the community to reduce crime levels in a specific location. GIS technology can be used by law enforcement agencies to create maps showing where different crimes are occurring and offer a clear clarity which crimes are not related. This can be seen all over the world with different agencies being created to handle specific crimes. By so doing, the agencies can put their full attention on a specific kind of crime. Therefore, GIS has enabled the agencies work effective by making it easy to handle using the different components of GIS[27]. In the US, the New York Police Department has improved the way they operate greatly[22]. For example, in crimes like bank robberies where most banks security system has been integrated with the police system hence alerting police of the crime. The same system is then integrated with the GIS technology and therefore the officers are able to manoeuvre around the city even in times of high traffic. Also, the department are able to get a clear image of the crime pattern knowing where most bank robberies happen and therefore they can deploy their officers to patrol the areas. An evaluation of empirical assessments of research studies carried out in different part of the world reveal that GIS technology has largely been efficient and effective technology in policing. The technology has been credited with effective identification of crime hotspots, crime reduction, decline in residential burglaries, tracking convicts released on parole as well as serious habitual offenders[28].

There are two functions of the GIS as a communication tool used by law enforcers namely: one to enable facilitation of inter-jurisdiction and cross-department

[27] Davis, A., (2016). In the US, concern about crime climbs to 15-year high. Gallup's Poll. NCJRS Abstract – National Criminal Justice Reference Service.

[28] Zhang, Y., Hoover, L., & Zhao, J. S., (2014). Geographic Information System Effects on Policing Efficacy. *International Journal of Applied Geospatial Research*; 5 (2), p. 30.

data sharing and second by enhancing information sharing with the people/public. With countries growing economically and experiencing growth in transportation and communication so are the criminals they try to adapt. Therefore, law enforcement agents need to share the data they have even if it's over different jurisdictions. Baller observed that in the United States of America (USA), the different agencies and also the many law enforcement fusion centres have abled the integration of data from the different agencies which at the end has made it possible for the facilitation of country, state, local and federal to share the same data[21]. This way, if one agency is looking for a certain criminal but not in their region of jurisdiction, they can access the information from GIS from the agency of that particular location. This has made effective workforce by the agencies. We can therefore see the major role GIS is playing by breaking down barriers that are there between jurisdictions and agencies. In the city of Chicago, the Chicago Police Department used their Citizen Law Enforcement Analysis and Reporting Map which is a web-based application all integrated with MIS allowed the citizens to do a search of various crimes committed in a specific location. This way if a citizen believes someone committed a crime he can search to see if the issue has been reported.

In Africa, the law enforcement agencies are also trying to learn and adopt the need of using GIS in data sharing. Most African policing agencies believe in working individually and not sharing data to avoid exposing their weaknesses or ongoing cases. But with the few agencies that have adopted the use of GIS technology are giving testimonies of how their work have become easy and also, they are able to execute their tasks with ease. For example, when NCTC adopted the use of GIS, they pleaded with the citizens to help them in passing on information of suspicious people or objects.

Meaning the agency can get live updates from the citizens and this can help them avoid great catastrophes.

With the availability of enhanced Information Communication Technology integrated with GIS, changes both the criminals and law enforcement agencies. ICT opens up opportunities for people to commit crime and hence bringing crime rate high. Police on the other hand can use ICT to their advantage and learn how to use it to control crime. This has led to a more effective policing. He states that GIS helps the police especially in Pretoria and Soweto use tactical and operational methods of preventing crime by mapping and identifying crime series[21]. They are also able to develop and use strategic decision-making in how to tackle different crimes. This is made possible by using to locating police precincts as well as patrols, able to target areas that are identified as hotspots or high risk and also using GIS in the development of projects concerning police. Therefore, we can see how by adopting GIS, the South Africa police agencies have been able to work smoothly and effectively.

In Kenya, the NCTC agency has adopted the use of GIS to be able to control terrorism. Petrecca states that the agency though doesn't have the enough resources to help counter terrorism have adopted the use of GIS[25]. Through the information that they receive from their ground agencies, they map that in information to the GIS to get the kind of threat posed and also pin point the location. With that, the agency is able to predict the crime intended and exact location targeted by the terrorists. The same case with the Directorate of Criminal Investigations (CID) where they use the GIS technology to evaluate if an individual has committed a crime before and also know their location. When your information if entered into the system, a police officer in another location can see if the individual he/she has arrested has any criminal acts

before and therefore giving the officer the best way to handle the individual. If the person is a wanted criminal, the officer will get to know.

The findings of different studies indicate that the GIS technology can equally be applied by the various law enforcement agencies in Kenya to address the problem of drug trafficking. The technology can be applied to deter drug trafficking criminals from engaging in the activities and also tracking down and arresting traffickers on transit, during which the illicit drugs are confiscated and destroyed.

1.6.2.3 Challenges Encountered in the use of the GIS Technology in Crime Control

One of the challenges of using GIS is when it comes to the mapping of crime incidents. As said before, police departments can be able to identify those areas that they believe are hotspots to specific crimes. According to Anselin, Griffiths and Tita, hotspot location is an area in an identifiable boundary known for its regular occurrence of crime and criminal incidents. Main limitation of mapping a crime is that it does not explain or offer a more understanding why that area has more concentration of crime[29]. It is said that the pattern needs to be studied further to offer an understanding if the data reflected if of a real nature[30]. To have as comprehensive understanding of this issue, one ought to understand the core purpose of mapping crime as to understand the related catalysts and patterns appearing in certain crimes and crime scenes. If GIS technology does not show any patterns relating to certain to similar crimes tend to bring incorrect solution.

Another challenge that police officers can encounter is the lack of qualified personnel to handle the system. Baller noted this happens to be one of the main problems as well as limitation when it comes to GIS technology. This challenge has

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[29] Anselin, L., Griffiths, E. & Tita, G., (2008). Crime mapping and hot spot analysis. *Environmental Criminology and Crime Analysis*, pp. 97-116.
[30] Wilson, E. (2012). Mapping & analysis for public safety program. U.S.A.

been experienced by many agencies across the world. For starters, GIS hardware and software are mainly produced in US and Europe meaning other continents have little or no clue of how to around the technology[21]. An example is here in Africa where it's important to offer training of new products. In Nigeria for example, the technology was introduced in police departments and other agencies but only a few had the knowledge to operate the system. Therefore, training and acquiring skilled people is a needed requirement when adopting the technology.

Data limitation is another challenge in GIS technology especially the users all over the world. Being able to acquire the necessary data especially set in a digital form. The main issue with data is the rising issues of security and confidentiality which tends to delay the whole process. This challenge is huge especially if GIS technology is to be used and utilized fully[30]. If agencies cannot be able to share information and data to control crime them minimizes the point of the system. Data sharing especially in African countries is a huge problem because of the issue of security and maintaining their confidentiality.

Another challenge is the financial implications especially in hardware and software procurement. It is understood that the software and hardware used in GIS especially in crime data collection, mapping and even analysis are very costly hence making it difficult for people to learn and understand the software. This may be applicable especially if an agency is trying to procure the software especially in these times of Covid-19 and the economy is not favourable[27]. Lastly, the challenge faced by the failure to comprehend and understand the application of GIS especially for decision makers. Policy and decision makers who are not aware of the different potentials that the system offers can lead to poor decision making. Also, this makes any policy formulation and financial support intended for GIS be limited.

The problem of misinterpretation of results or the staff not comprehending the scale can be related to the lack of proper training for the employees. It is possible to find sources offering the best trading but the system is more complex and difficult for most staffs to get the proper training to understand how GIS can be used in crime. According to Baller, the recent issue that has been experienced is that the system is not able to perform spatial. The technology cannot handle adequate spatial statistics. He says that according to the GIS mother company the development of spatial statistics is in the early development[21]. Most of the GIS systems around the world originates from USA or Europe. There are cases of other companies trying to copy the software and also offering adequate support to the customers. This is a major cause since the companies copy the software appearance but the operations and how it executes data is different from the real GIS.

Another challenge encountered is the damages that can be done in case there is an internal fault. Putting in mind that GIS system does contain complex components internally. This can cause damages to the machine especially if the damage has occurred internally. The integration with traditional maps has also been identified as a challenge encountered when dealing with GIS systems[22]. This problem arises because GIS is made up of complex map structures thereby making it difficult for staffs to integrate with traditional maps. Meaning GIS only works with and interpret information collected by the systems. Lastly, some of the data analysis are almost impossible to perform because of the complexity of their data structures recorded and captured by the system. This makes it impossible for spatial data to be analysed leading to information not being conveyed properly[25].

Similar to other countries, application of the GIS technology is bound to face numerous challenges which would affect it effectiveness toward realization of intended

objectives in drug trafficking. Poor application of the technology, financial constraints to constantly update the system and train its users, possible misinterpretation of the data collection through the system thereby wrong analysis and inadequacy of properly trained personnel to appositely implement that system are some of the potential challenges that are bound to affect the use of GIS technology to address the scourge of drug trafficking in Nairobi County.

1.7 Gaps in the Literature

Various gaps arise from the literature reviewed. One of the glaring gaps is with regard to paucity of studies on how the GIS technology has been applied to address crime in Kenya. Despite Nairobi city being an epicentre of various crimes including drug trafficking, human trafficking and fraud, there are very few studies if any, conducted to establish the effectiveness of the study as well as its shortcoming and challenges facing its application. Additionally, the various previous studies fail to identify ways in which the GIS technology could be applied to address the challenges that the system face. This is an area that forms part of the recommendations of this study based on its findings. The study is therefore relevant in bringing into focus and shedding light on influence that use of GIS technology has had in crime control in Kenya with an aim of establishing existing gaps, inadequacies and challenges thus areas for improvement by the relevant authorities.

1.8 Justification of the Study
1.8.1 Policy Justification

The use of technology is regarded as an important tool in crime management; and GIS technology is one of those technologies which have helped in crime detection, prevention and management globally. The changing trends in crime have posed a great challenge within the security cycles thus the need for police agencies to adopt innovations such as GIS technology to address these challenges. The findings of the

study may be useful to policy makers and implementers in community cohesion among other various stakeholders such as the Anti-Narcotics Unit which is a unit under the Directorate of Criminal Investigations (DCI) and the National Agency for the Campaign against Drug Abuse Authority. The institutions play critical roles in formulation and implementation of policies aimed addressing illicit drugs in Kenya. The Anti-Narcotics Unit plays a further critical role in gathering and disseminating drug intelligence to other law enforcement agencies locally and internationally, liaising with local and international organizations dealing in drug related cases, investigating cases of illicit drugs, detecting and preventing drug offences, and apprehending and prosecuting drug offenders.

1.8.2 Academic Justification

Theoretically, this research contributes to the understanding of the policy framework on the use of GIS technology and also unearth some of the gaps resulting from the use and application of the technology in combating crime. This research is therefore anticipated to be valuable to the academia and researchers as it will serve as a data bank for further research on the value of GIS technology in controlling crime in Nairobi, Kenya and in deed beyond the country's boundaries.

1.9 Hypothesis

H_0: Geographic information systems technology does not influence drug trafficking crime control in Nairobi, Kenya.

H_A: Geographic information systems technology does influence drug trafficking crime control in Nairobi, Kenya.

1.10 Scope and Limitations of the Study

Geographically, the study was limited to Nairobi County. This is because, as explained in the third chapter of this document under study site, Nairobi provides an

ideal setting for criminal activities due to its position as the country's economic hub bustling with a lot of business activities both legal and illegal. The period of focus was the last eleven years, form 2010 when the country began significantly investing in technological systems to combat crime, to present[31]. The study sought to find out how GIS technology has contributed to crime detection, prevention and management by senior and junior officers of the police departments mandated with dealing with crime which includes NIS, DCI and general police unit as enshrined in the constitution of Kenya, 2010. The study's content scope was limited to approaches to application of the GIS technology, effectiveness of the GIS technology and challenges encountered in the use of GIS technology in drug trafficking crime control in Kenya.

Limitations of a study refer to potential weaknesses that are usually out of the researcher's control that may influence outcomes and conclusions of the research. In most instances these potential weaknesses place restriction on the chosen research design, methodology, funding constraints, and time among other factors. It is imperative therefore that these limitations are acknowledged clearly by the researcher from the onset in the research document[32]. The potential of the researcher to influence how participants respond to their questions, especially when guiding and translating questions to respondents who are illiterate, may affect the outcomes of the study. The findings and conclusions of the study may also be affected by social desirability bias, this could arise from survey participants who may provide biased responses by answering to questions they believe are favourable to the researcher rather than providing authentic and objective response. Another factor that may affect the outcomes of this study is political biasness by officers of the security agencies while

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[31] Sigilai, 2018). Assessing the Impact of Information Technology on the Gathering of Crime Intelligence by DCI Investigators (2011-2016).

[32] Ross, P. T., & Bibler Z., N. L. (2019). Limited by our Limitations. *Perspectives on medical education*, *8*(4), pp. 261–264.

responding to questions. This is because, at the point of collecting data, some of the officer respondents may decide to give information that is untrue in order to paint either a good or bad picture of the country's security agencies depending on their personal biases.

1.11 Definition of Key Terms

Crime control: this refers to the methods, strategies and approaches taken to reduce crime in a society using various instruments and techniques at their disposal.

Crime mapping: this is a technique employed by crime analysts in law enforcement agencies to map, visualize, and analyse crime incident patterns.

Geographic Information System technology: this is a framework for gathering, managing, and analysing data. The system integrates many types of data to analyse spatial location and organizes layers of information into visualizations using maps.

1.12 Theoretical Framework
1.12.1 Crime Pattern Theory

Explanations for the causes of person and community criminal propensity, as well as when and where criminal events occur, are needed for a comprehensive understanding of crime. The Crime pattern theory, advanced by Brantingham and Brantingham suggests that criminals commit crimes in places of which they are knowledgeable[33]. The theory explains the difference in the spatial and temporal distribution of criminal events given a variety of predispositions. Both sporadic and chronic offenders spend the majority of their time engaging in the same legal daily tasks as anyone else. These routine behaviours, as well as the individual criminal's behaviour, form the location of criminal events in space–time. Offenders, both occasional and

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[33] Brantingham, P., & Brantingham, P. (2021). Crime Pattern Theory. *Oxford Research Encyclopedia of Criminology.* Retrieved 5 April 2021 from
https://oxfordre.com/criminology/view/10.1093/acrefore/9780190264079.001.0001/acrefore-9780190264079-e-8

serial, create activity and knowledge spaces[34]. Human settlement structures, which channel and restrict movement patterns in time and space, affect the shape and dynamics of these spaces. The built environment, as well as the socioeconomic and cultural settings in which people live, work, or go to school, and in which they spend their social, leisure, and shopping time, are examples of these systems.

The Crime Pattern Theory is applicable to this research study because it explains the mechanism of criminal target search, proposes crime control techniques, and identifies possible displacements of criminal activities in space and time as a result of shifts in the suitability of targets or target locations at specific locations and times. To explain crime driver and crime attractor sites, as well as the creation of repeat areas of offending for individuals and groups, Crime Pattern Theory uses the major components of the built and social environment – activity nodes, paths between nodes, neighbourhoods and neighbourhood edges, and the socioeconomic backdrop – together with the regular movements of the community in general to comprehend the positions of crime drivers and attractors, as well as the creation of repeat offending areas for individuals and groups of criminals, as well as more aggregate crime hotspots and cold spots. This data is transformed into a crime geometry, using technology such as the GIS technology, which depicts the paths taken by individual criminals, groups of criminals, and their victims or targets on their way to committing crimes.

1.13 Methodology

This section details the procedures and techniques the researcher employed to identify, select, process, and analyse research data. Specifically covered in this section is the research design that was used to carry out the study, identification and

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[34] van Sleeuwen, S.E.M., Ruiter, S. & Steenbeek, W. (2021). Right place, right time? Making crime pattern theory time-specific. *Crime Science,* 10(2).

justification of the research site, and the target population. Additionally, the sampling procedure, the sample size as well as the data collection instruments are explained in the section. The section concludes by specifying how the collected data was analysed and the ethical considerations that the researcher observed during and after the study.

1.14 Research Site

Nairobi County, being the capital city of Kenya, can certainly and defensibly be termed as the epicentre of crime in Kenya. The city has the highest rate of crime compared to other regions of Kenya such as Mombasa and Kisumu which are also cities and developed urban areas. Nairobi, given is position as the country's economic hub among other factors, is an ideal transit point and route for various criminal activities and for illegal vices being moved into and out of the country that rely on its extensive and well-developed infrastructural transport and communication network. Additionally, both extremes, the sprawling informal settlement and posh residential area and everything in between provide safe havens for criminals to carry out their activities and hide after carrying out their heinous crimes[7]. Among the major crimes carried out in the Nairobi, drug trafficking is one of them. The city is a hub for drug trafficking. It is a major operation point for terrorist from the horn of Africa who find the county an easy target for radicalization. A combination of these and other factors have increasingly made Nairobi City a hub for drug trafficking thus its ideal setting for this study.

1.15 Study Design

Bernard[35] affirms that research design, which refers to framework or blue print that a researcher intends to use in a study to collect, measure, and analyse data, is a very

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[35] Bernard (2013). Social Research. Methods: Qualitative and Quantitative Approaches. (2nd ed.) Thousand Oaks.

important element of the entire research project. In this study, both quantitative and qualitative designs were used. Descriptive research design was therefore used to provide further insight into the area under study. The quantitative approach was important in generating and understanding statistical results and using such results to collect actionable insights. The qualitative design was essential in deriving findings that communicate information that underlie respondents' values and perceptions about the research subject and how such values and perceptions influence their behaviour.

1.16 Study Population and Unit of Analysis

Target population in research refers to the units/objects of groups of people for that a study is interested in researching and which the findings of the study are meant to generalize[36]. This research study specifically targeted the following government security agencies based in Nairobi County; officers from the NPS in the county, officers from the NIS, and officers from the Kenya Defence Forces (KDF). The following offices placed under National Government Administration Officers (NGAO) are fundamental and were also engaged in the study; County Commissioner, Deputy County Commissioners and the Administrative Chiefs. Also essential to this study was the office of the governor of the county. Officers drawn from the various government security agencies were targeted to provide insightful information on the two GIS approaches covered in this study namely the community-oriented and the collaborative approach and the implications the approaches have had so far. In addition to expressing their experiences regarding GIS in the county, the general public was largely important source of information on implications of these approaches and how the approaches have

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[36] Mohajan, H. K., (2018). Qualitative Research Methodology in Social Sciences and Related Subjects. *Journal of Economic Development, Environment and People, 7*(1), pp. 23-48.

been applied in the county so far. From the description of the study population targeted thus, the unit of analysis was individuals from the county.

1.17 Sample Size and Sampling Procedures

Lewis-Beck, Bryman and Futing define sampling as to the process of selecting a representative group from a population under study[37]. Both probability and non-probability sampling techniques were used to select survey participants for this study (See table.1.1). With regard to probability sampling, simple random was specifically employed to collect data from the NPS officers, the KDF officers, the administrative chiefs and the general public. Non-probability sampling on the other hand, specifically purposive sampling, was employed when collecting data from respondents drawn from the office of the governor, NIS, the office of the county commissioner, and the deputy county commissioners.

Yamane provides a simplified formula to calculate sample size and the same was used to calculate the sample size as shown below[38];

$$n = {N}/{1 + N(e)^2}$$

Where;

n is the sample size

N is the population size

e is the level of precision or margin of error at 5% (standard value of 0.05).

Using the formula, 370 individuals were engaged in the research survey as calculated below. This number was distributed across the five categories of target population as shown in Table 1.1

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[37] Lewis-Beck, M. S., Bryman, A., & Futing Liao, T. (2004). *The SAGE encyclopedia of social science research methods* (Vols. 1-0). Thousand Oaks, CA: Sage Publications.
[38] Yamane, T. (1967). Statistics, an Introductory Analysis, 2nd Ed., New York: Harper and Row.

$$n = {5,067}/{1 + 5,067(0.05)^2} = 370$$

Table 1.1: Target group, Sampling Procedure and Sample Size

Categories	Frequency	Sampling Procedure	Sample Size
Office of the Governor of Nairobi	1	Purposive sampling	1
Office of the Nairobi County Commissioner	1	Purposive sampling	1
Offices of the Nairobi Deputy County Commissioners	7	Purposive sampling	3
Offices of the Administrative Chiefs	18	Simple random sampling	5
Officers of the National Police Service	2,150	Simple random sampling	60
Officers of the National Intelligence Service	1,280	Simple random sampling	5
Officers from the Kenya Defence Forces	1,610	Simple random sampling	55
Total	**5,067**		**370**

Source: Researcher, (2021)

1.18 Data Collection Methods
1.18.1 Survey Questionnaire

A questionnaire (Appendix I) is one of the main tools that were mainly used to collect data for this research study. To gather information from respondents, the researcher developed a self-administered questionnaire consisting of a series of questions based on the three specific objectives of the study. For clarity purposes, each objective was put in a section and the section had questions related to the objective.

1.18.2 Key Informant Interviews

Interview schedules with adequate significant questions (Appendix II) were also prepared based on the specific objectives of the study. These were conducted with purposely selected informants: Governor, NIS, the office of the county commissioner, and the deputy county commissioners.

1.19 Data Processing and Analysis

The quantitative data was cross-checked in Microsoft Excel for missing data and cleaned for analysis. Analysis through the use of descriptive statistics were then follow and frequency tables and bar graphs were used to present the findings. The coding technique was used to code and analyse the qualitative data. Using this technique, the researcher demarcated the data into segments. Each segment was labelled with a code that suggests how the associated data segments inform the research objectives. After coding, reports were generated accordingly by summarizing the prevalence of codes, discussing similarities and differences in related codes across distinct original contexts, and comparing the relationship between one or more codes. In comparing the relationships between the independent variables and the dependent variable, cross tabulations and regression analyses were used to analyse the data. The verbatim quotes were used alongside the presentation and discussions to vocalize the informants' opinions in the findings.

1.20 Ethical and Ethical Considerations

Ethical considerations guide the norms that govern human conduct to behave in appropriate and accepted ways. The researcher's responsibility is to ensure these norms are not violated, especially regarding respondents' dignity taking part in the study. In this regard, the identities of the respondents were not revealed to persons outside the research. The ethical considerations that will guide the research include voluntary or willingness to participate in the study, informed consent, confidentiality, and

guaranteed protection of information and privacy. The researcher and the research assistants explained the study's objectives and provide room for the respondents to willingly participate in the study.

The researcher also obtained a letter from the university to confirm his association with the university and to also facilitate his application for the research permit from the National Commission for Science, Technology and Innovation (NACOSTI).

2.0 APPROACHES TO APPLICATION OF THE GIS TECHNOLOGY IN CRIME CONTROL

2.1 Introduction

This chapter presents the analysis followed by discussion on the various way the security and law enforcement agencies apply the GIS technology to control drug trafficking in Nairobi County. It begins with analysis of the background information relevant to the study.

2.2 Gender of the Study Respondents

The study considered gender to be an important demographic aspect since different gender groups not only perceive the different socio-economic perspectives differently, but are as well affected by them differently.

Figure 2.1 indicates that from the sample engaged in this study, 63% of the respondents were of the male gender while the remaining 37% were female. This is indication that individuals from both genders gave their views on the issues under survey thus fair representation.
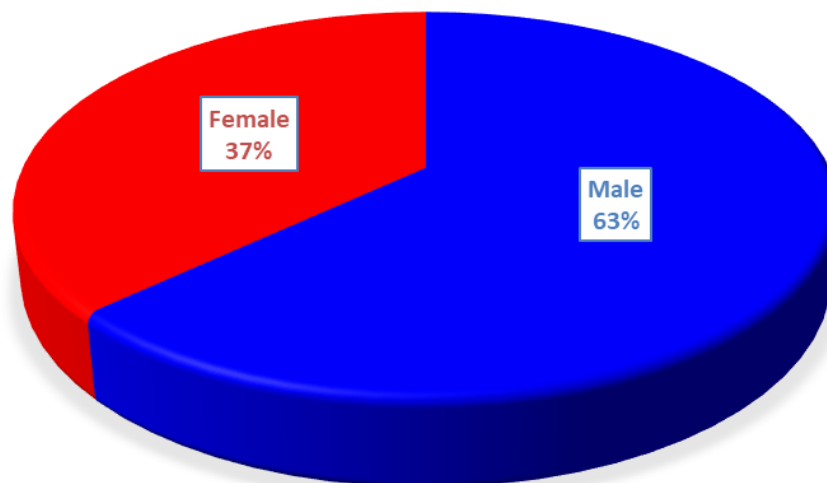
Figure 2.1: Gender of Respondents
Source: Field Data, 2021

2.3 Duration Lived in the Study Area

This was considered important for this study mainly because it could be used to measure the respondents` experiences and encounters on the key issues under investigation.

According to the results presented in Figure 2.2 approximately 31% of the respondents had lived in Nairobi County for between 21 to 25 years, about 22% of the survey participants had lived in the county for between 16 to 20 years, another 16% had lived in the county for between 11 to 15 years, 12% had lived in Nairobi County for 6 to 10 years, 9% had lived in the county for 5 years or less, 5% had lived in the county for between 26 to 30 years while an equal proportion, 5% had also lived in the county for 31 years or more. This distribution shows that the respondents had sufficient experience of life in the city and were thus able to reliably comment and give views on the issues being researched.
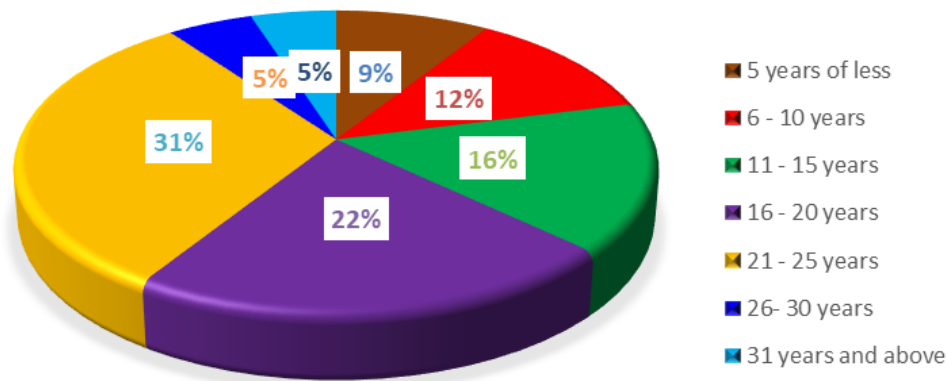
Figure 2.2: Duration of Residence in Nairobi County
Source: Field Data, 2021

2.4 Affiliated Security Agencies

As depicted in Figure 2.3 approximately 45% of the respondents were from the National Police Service, about 41% were from the Kenya Defence Force and the rest 14% belonged to the Administrative Chiefs. This indicates a fair representation from

each of the security agencies hence balanced feedback with regard to influence of GIS on drug trafficking crime control.
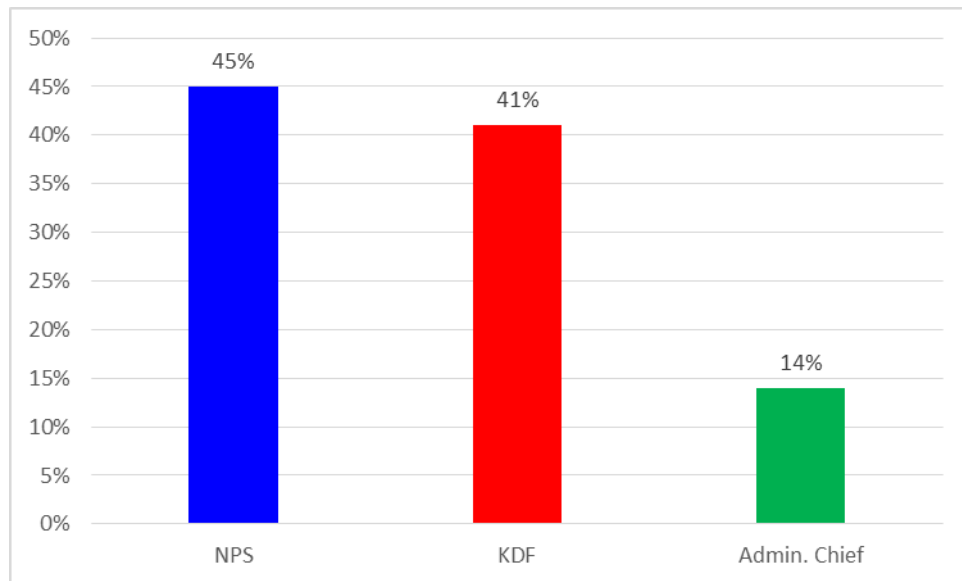
Figure 2.3: Security Agencies in Which the Respondents Serve
Source: Field Data, 2021

2.5 Involvement in Drugs and Drug Trafficking Assignments

With regard to the question on direct involvement in drugs and drug trafficking assignments, 86% of the survey participants indicated that they had been involved in such assignments in the line of duty while the rest 21% had never been involved in such operations as depicted in Figure 2.4. This implies that majority of the respondents had first-hand experience in issues related to drug trafficking such as investigations and arrests and were therefore better placed to comment on the questions of the survey. Those who had not been directly involved had probably had remote experience thus still being essential to the survey.
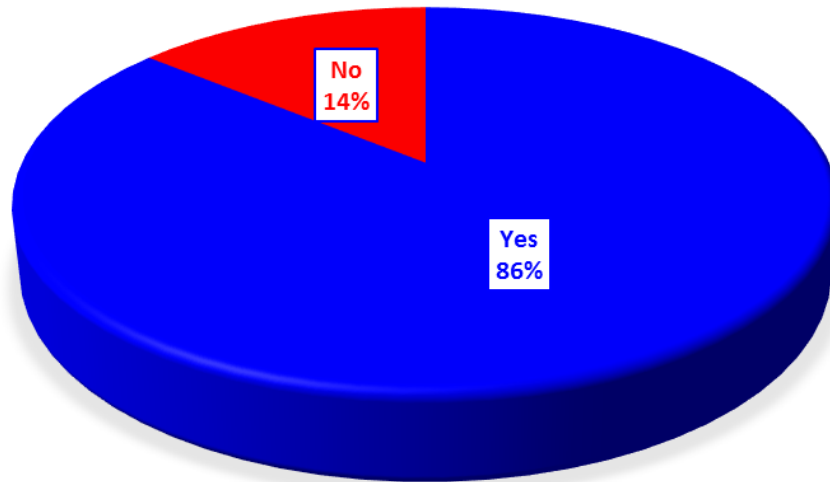
Figure 2.4: Involvement in Drug Trafficking Cases in Nairobi County
Source: Field Data, 2021

2.6 Frequency of Application of the GIS Technology in Crime Mapping

With regard to the question on application of application of the GIS technology in crime mapping, 46% of the survey respondents were of the view that the system is fluently applied in crime control in Nairobi County, approximately 41% opined that the technology is frequently applied and 9% held the view that the GIS is occasionally applied in crime mapping in the county. The rest 4% of the respondents were of the view that the GIS technology is was rarely applied in crime mapping in Nairobi County as presented in Figure 2.5. The general indication from these findings is that the various security apparatus does use the GIS technology to map crime in Nairobi County.
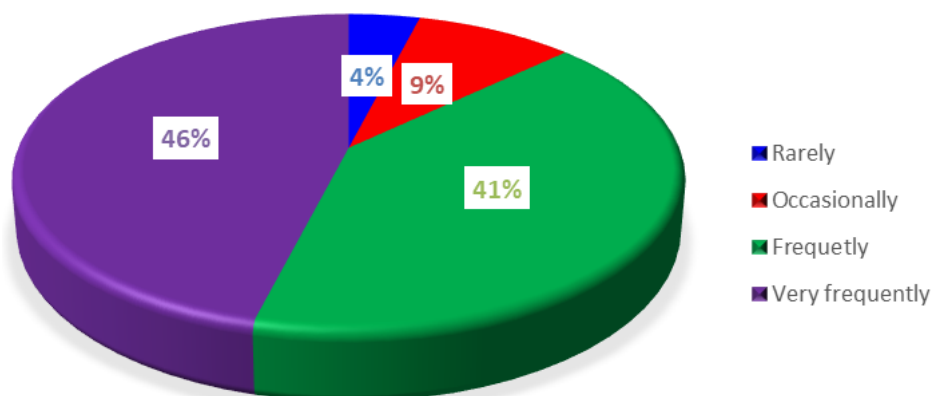
Figure 2.5: Frequency of Application of GIS in Drug Trafficking in Crime Mapping
Source: Field Data, 2021

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The findings indicate that the GIS technology is applied in crime mapping where it helps the law enforcement officers identify the geographic location of potential crime committers in the given region. Contrary to what many believe, the technology does not replace the process of collection and storage of information carried out by law enforcement[39]. The technology only enhances the ability to utilize the data collected. Through the technology, it is possible to determine the location of a suspect at the time a crime was committed and consequently either issue an arrest for questioning or move on to interview other suspects. After data is collected about a crime in a given location, the law enforcement officers have the obligation to carry out as much research about it as possible.

A common crime mapping tool used by law enforcement officers is the Community Policing Bet Book. The book enables police officers to review the performance of parolees in a given area and determine whether they are engaging in appropriate actions[40]. Police officers often use the book to match repeat offenders to various crimes carried out in a neighbourhood. For example, if a location has seen a surge in the number of rape victims and there was a recently released convict that had initially been arrested for rape, it is possible for the police to use this book to determine the location of the parolee at the time of the crime and consequently, the person can either be treated as a suspect or exonerated of the said crime.

2.7 Frequency of Application of GIS in Drug Trafficking in Crime Investigation

The outcomes of analysis presented in Figure 2.6 indicate that approximately 38% of the respondents were of the opinion that the GIS is frequently applied in crime

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[39] Yang, B. (2019). GIS crime mapping to support evidence-based solutions provided by community-based organizations. *Sustainability*, *11*(18), 4889.

[40] Bako, A. I., Aduloju, O. T. B., Osewa, D. J., Anofi, A. O. & Abubakar-Karma, A. T., (2021). Application of Participatory GIS in Crime Mapping of Ibadan North, Nigeria. Papers in Applied Geography, 7(2), pp. 183-198.

investigation in the county, about 21% held the view that the system is occasionally applied in crime investigation in the city, 11% were of the opinion that the system is rarely applied by the security agencies when investigating crime in the county and while 29% held that the GIS technology is very frequently applied. The rest 1% of the survey participants felt that the technology is never applied when investigating crime in the county. The overall inference according to these findings is that the security agencies have been keen to use the GIS technology to investigate cases of drug trafficking in Nairobi County.
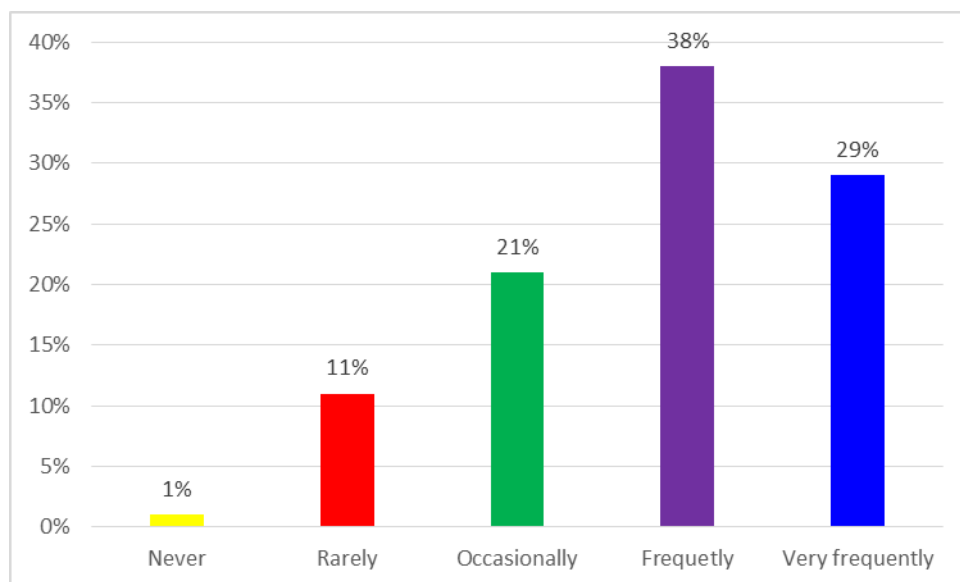
Figure 2.6: Frequency of Application of GIS in Drug Trafficking in Crime Investigation
Source: Field Data, 2021

It is evident from the findings that GIS is used by law enforcement officers to investigate drug trafficking crimes in the county. Whether the law enforcement officers are uniformed or undercover, they can use the technology to investigate crime. In many cases, when a crime is committed, the perpetrator escapes as opposed to some scenes where the perpetrator panics and is found at the scene. Through the use of GPS, it is possible to identify all the routes that the perpetrator might have covered[41]. Using the

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[41] Butorac, K., & Marinović, J. (2017). Geography of crime and geographic information systems. *Journal of Forensic Sciences & Criminal Investigation*, *2*(4 s 002).

technology, the investigators can digitally analyse an area and figure out which buildings in the vicinity might be probable for the criminal to have either hidden or dumped the crime weapon.

The technology works effectively to assist the investigators with this matter where in case a criminal is sloppy enough to remain hidden in one area for a long time, they can be found easily and arrested. It is also essential to note that GIS can also be linked to various other technologies to enhance investigations. For example, linking it to satellites is a professional way through which law enforcement officers can track moving criminals. After the law enforcement officers identify the location of the criminal, they can make the decision of either moving in and arresting the criminal or using the criminal as bait to capture more criminals that they associate with[42]. Generally, GIS comes in very integral in crime investigation and given the fast-moving technology environment, there are hopes that further improvements will be made in the field of crime investigation.

2.8 Application of GIS in Drug Trafficking Crime Analysis

As depicted in Figure 2.7, approximately 51% of the survey respondents opined that the GIS technology was very frequently applied in Nairobi County to analyse drug trafficking crime pattern, 40% of the respondents were of the view that the technology is very frequently applied when analysing drug trafficking in the county and 7% were of the view that the technology is occasionally applied by the security agencies when analysing drug trafficking crime pattern in Nairobi County. The rest 2% of the respondents held the view that the security agencies rarely applied the GIS technology when analysing crime patterns in the county. These findings therefore indicate that the security agencies, in order to address the problem of drug trafficking in the county, do

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[42] Wang, F., (2012). Why police and policing need GIS: an overview. Annals of GIS, 18(3), 159-171.

use the GIS technology to analyse crime patterns, in this case drug trafficking, in the county.
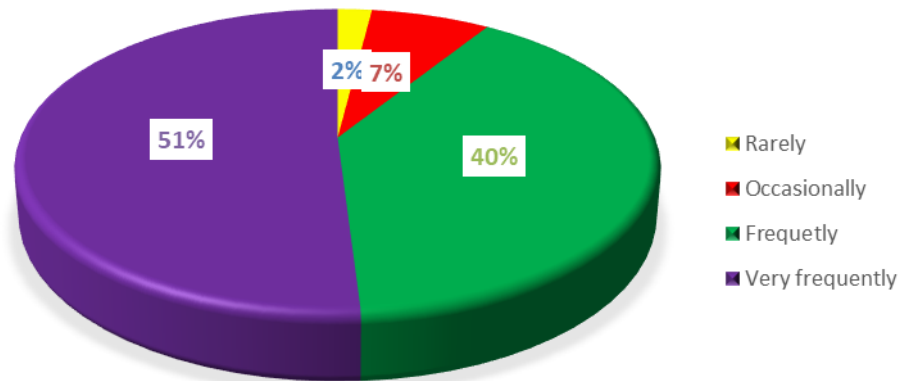
Figure 2.7: Application of GIS in Drug Trafficking Crime Analysis
Source: Field Data, 2021

Different locations have various patterns related to crime. For example, a location might have a high rate of home invasion during the summer and this is because many people are not in their homes and have gone for vacation. Another region might see an increase in assault cases during a rainy season. These patterns are better analysed through the use of GIS. After law enforcement officers get information relating to the criminal activities, they can incorporate GIS where they can use digital satellites to note the specific locations where these numbers of crimes are taking place[43]. Through the use of GIS, the law enforcement officers can also note their own trend. For example, the officers can note that a specific geographic region has seen an increase in the number of criminals during the month of August but later on during the month of December, the area has few criminal acts and these activities move to another region during the month of December.

Using GIS, it is possible for the officers to note the trend by looking at the reasons why this might be happening. The technology can help the officers note the

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[43] Setiawan, I., Dede, M., Sugandi, D., & Widiawaty, M. A. (2019). Investigating urban crime pattern and accessibility using geographic information system in Bandung City. *KnE Social Sciences*, 535-548.

changes in geographical features such as the weather conditions in an area that might be causing the changes[44] [45]. Considering this is important for it enables law enforcement to determine the number of officers to deploy in a certain area and consequently see positive changes.

2.9 Application of GIS in Drug Trafficking Crime Prediction

Results in Figure 2.8 indicate that 41% of the survey participants were of the view that the GIS technology is frequently applied by the security agencies to predict drug trafficking crime in Nairobi County, 28% were of the view that the technology is very frequently applied in predicting drug trafficking in Nairobi County, 19% were of the view that the technology is occasionally applied drug trafficking crime prediction and 9% were of the view that the technology is rarely applied. The rest 3% of the respondents held the view that the GIS technology is never applied by the security agencies in drug trafficking crime prediction in the county. This indicates that largely, the technology is applied by the security agencies to fight the scourge in the city.
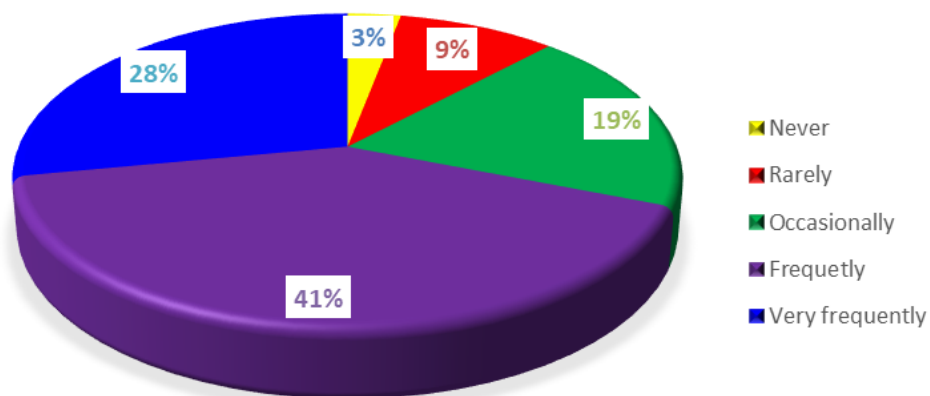
Figure 2.8: Application of GIS in Drug Trafficking Crime Prediction
Source: Field Data, 2021

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[44] Mohammed, A. F., & Baiee, W. R., (2020). Analysis of Criminal Spatial Events in GIS for predicting hotspots. IOP Conference Series: Materials Science and Engineering, 928(2).
[45] LeBeau, J. L. (2000). Demonstrating the analytical utility of GIS for police operations: A final report. Southern Illinois University. National Insitute of Justice, NCJ187104.

It is evident from this finding that crime prediction is the consequent process that follows crime pattern analysis. After the law enforcement officers get information relating to a crime or crimes in a location, they can feed the information to GIS. Once the information is fed to GIS, it then goes through a vigorous process of processing and the incorporation of probabilistic statistics. After the information is processed, then GIS software effectively provides information that unmasks the area where the next crime is going to be committed[46]. It is imperative to note that it is very rare for the information provided by the GIS database to be faulty. However, in order to get quality information, it is important that the information fed the data base be comprehensive to ensure better results.

Probability statistics use is an effective way to understand crime and the fact that it is present in GIS and used in crime prediction makes the general crime analysis work even easier[47]. A positive fact to note with regard to the software and crime prediction is the fact that information produced is done so in a speedy manner. The fact that this is a technology means more efficiency which is very important in crime prevention. The number of crimes resolved using the software has increased over the years and many developing nations have come to use it more to predict and prevent crimes in high risk areas.

2.10 Application of GIS in Drug Trafficking Crime Identification

Approximately 36% of the survey respondents held the view that the GIS technology is frequently applied in drug trafficking crime identification in Nairobi County, about 27% of the respondents were of the opinion that the technology is very

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[46] Kim, S., Joshi, P., Kalsi, P. S., & Taheri, P. (2018, November). Crime analysis through machine learning. In *2018 IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)* (pp. 415-420).

[47] Kounadi, O., Ristea, A., Araujo, A. *et al.* (2020). A systematic review on spatial crime forecasting. *Crime Science* 9(7).

frequently applied while 20% were of the view that the GIS technology is rarely applied in drug trafficking crime identification. On the other hand, 10% opined that the technology is rarely applied and the rest 7% were of the opinion that the technology was never applied in drug trafficking crime identification in the county as shown in Figure 2.9.
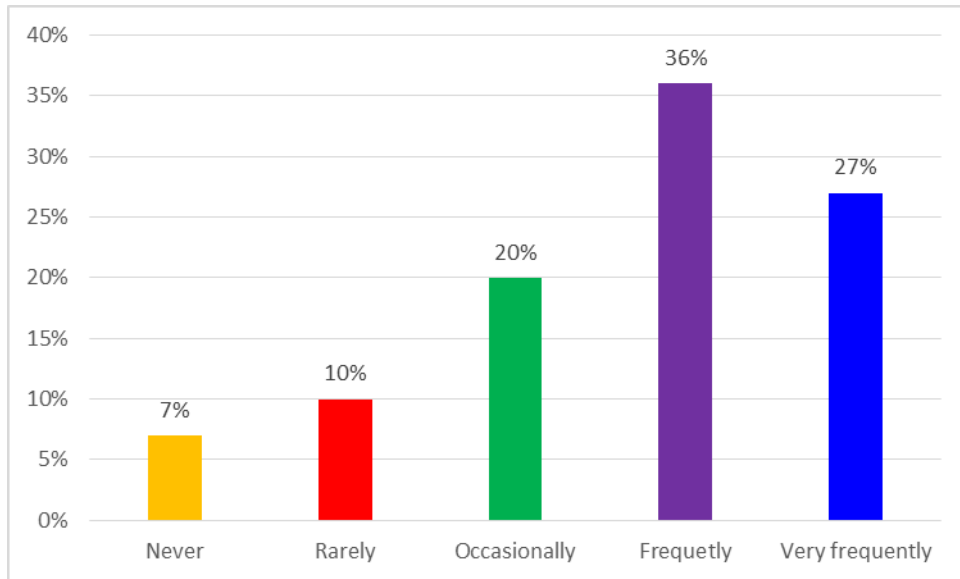
Figure 2.9: Application of GIS in Drug Trafficking Crime Identification
Source: Field Data, 2021

From the interviews, it was clear that majority of the interviewees were of the view that the GIS technology was widely applied by the security agencies to curb the scourge of drug trafficking in the county. One of the interviewees commented as follows:

"In the security force I work for, application of the GIS is taken very seriously. It is widely applied to track criminals, trace the movements of drug consignments and to investigates cases before they are culprits are presented in court."

Other approaches where the GIS technology is applied is in the involvement of informers together intelligence and expose the criminals. Additionally, the system is

used in surveillance and during security patrols. It also came out that GIS technology is applied to search motor vehicles and persons involved in drug trafficking.

Increasingly, the law enforcement authorities recognize the value and benefits of GIS technology to combat crime. The law enforcement agencies rely on computerized mapping for most of their daily operations. The GIS links information to a map; integrate location data with descriptive data. The computerized crime mapping model helps law enforcement authorities to examine and correlate information sources to develop a comprehensive snapshot of crime episode, in this context drug trafficking, and related features within a specific locality[17]. The GIS technology is gaining momentum within the law enforcement authorities in Kenya. Crime-related information obtained from GIS analysis is contrasted and analysed with other relevant external data sources. The findings of the study indicate that the GIS system has been widely applied in prediction and identification of drug trafficking crime activities in Nairobi County. The security apparatus in the country use spatial statistics and prognostic analysis materials to predict where and when drug trafficking activities may take place. By applying GIS to patterns, they have been able to understand community concerns and execute duties with accurate intelligence. The GIS system have made it possible to analyse crime trends; locate hot spots; and link an offence, criminal, vehicles and weapons - all by one location. The GIS platform enable security personnel to make appropriate decisions with scalable desktop and mobile apps that support among others administrative analysis, tactical analysis and intelligence analysis[23].

Crime analysis has been another key approach. It begins by aggregating crime data, pointing patterns and studying the relationship between crime and other set of data, then assessing the impact of crime reduction methods. The GIS platform simplifies data barriers and combine multiple functions to represent scenarios of drug

trafficking as well as the individuals and transportation mechanisms. Analysts derive information from system outputs such pictures in the event of crime. Though security personnel perform much of their core work in the computer room, the GIS platform remains key in delivering authoritative maps, crime data and analytics to the entire organization. In the fight against drug trafficking, the GIS system enhance administrative and strategies analysis capacities of security officers. It provides thousands of ready datasets having data down from the census block level. Through analysis of the GIS data, security agencies are able to easily understand the operations of the drug trafficking syndicates with authority. This means that they are able to access dataset to make better policies, plan intelligently using past data and future projections, relay policy decisions using data pinned to your location, reach the public through published reports and maps on website and identify areas with urgent needs by using customized search criteria.

The power of GIS intelligent mapping extends past identifying and locating crime. The system has been widely and successfully used identify community policing work, share data about current crime patterns, and involves the public in solving a case[20]. The GIS technology brings all together maps, pictures, test and other materials into one interactive document. Additionally, the GIS technology is applied in sequencing stories of drug trafficking crime to organize evidence. Further, it is used to share crime patterns and policing efforts and progress with the public. The GIS technology makes it possible to transform web maps into multiple maps and applications which are shared among different security agencies to fight drug trafficking and other forms of crime. Further, the system has been applied to create incident maps, conduct field interviews, and analyse mobile data and to predict crime.

2.11 Summary of Findings

Based on the findings in this chapter, it is evident that the GIS technology is considerably applied by the various security agencies in tackling the drug trafficking scourge in Nairobi County. The findings have revealed that the security agencies applied the technology to visualize, analyse and detect patterns in this particular criminal activity. The GIS technology was also applied by the responsible security apparatus to investigate cases of drug trafficking and the individuals involved in these activities. Also important is the revelation from the findings that the GIS technology is applied in internal security and anticrime operations such as crime pattern analysis, crime prediction and crime identification.

3.0 EFFECTIVENESS OF THE GIS TECHNOLOGY IN CRIME CONTROL

3.1 Introduction

This chapter covers the analysis of data on the effectiveness of the GIS in controlling drug trafficking crime in Nairobi County. The analysis is done based on the main approaches identified in the preceding chapter.

3.2 Enhanced Identification of Drug Trafficking as a Major Crime in the County

On the question on whether the use of GIS technology has enhanced identification of drug trafficking as a major crime in the county, 24% strongly agreed with the question statement, 35% agreed that the use of GIS technology has enhanced identification of drug trafficking as a major crime in the county, while 7% were neutral. On the other hand, 21% of the respondents disagreed that the use of GIS technology has enhanced identification of drug trafficking as a major crime in the county and 13% strongly disagreed with the question statement as shown in Table 3.1.

According to research carried out by the National Institute of Justice, 62% of police departments that have over 100 officers incorporate the GIS technology[48]. The figure shows how trusted the technology is in the contemporary environment. The interviewed officers stated that the technology has been effective in tracking parolees, ensuring that they are in line and follow the directives offered. Offenders have a high chance of repeating a crime and it is because of this that they are suited with ankle bracelets to track their movements for a stipulated amount of time.

Through GIS, it is possible to track the movement of these people and since these offenders know that they are being tracked, there are fewer chances of them committing a crime again. GIS has proved effective in crime mapping and this is with regard to the number of first-time offenders carrying out a crime. The technology has

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[48] Bowers K., Johnson S.D. (2014) Crime Mapping as a Tool for Security and Crime Prevention. In: Gill M. (eds) The Handbook of Security. Palgrave Macmillan, London.

proved effective in determining the location of a suspect at the time of the act[49].

Through the technology, many people have been exonerated of a crime as compared to earlier times when there was a haul up of numerous suspects while trying to determine the actual criminal. Rather than generalizing the criminal offenders, the GIS technology has managed to slim down the number of people accused of a crime which is quite impressive.

GIS has become a crucial tool for geographical analysis and visualisation of crime in South Africa over the last two decades. Because of the availability of precise socioeconomic and demographic datasets, as well as crime data and computerized information technology, a wide range of quantitative methodologies may be utilized to evaluate probable crime cause and effect linkages.

3.3 Enhanced Mapping of Drug Trafficking Through Application of the GIS Technology

From the results analysis depicted in Table 3.1, among the positive responders, 19% strongly agreed that application of GIS in mapping of drug trafficking routes has led to significant arrests and prosecution of perpetrators of drug trafficking, 41% agreed that applying the GIS technology in mapping drug trafficking routes had led to significant and arrest and prosecution of the involved criminals. Approximately 11% of the respondents were indifferent with regard to this question. Among the negative responders, 18% disagreed with the question statement while the remaining 11% strongly disagreed that application of GIS in mapping of drug trafficking routes has led to significant arrests and prosecution of perpetrators of drug trafficking.

GIS has been credited with quality crime investigation in the past and this is something that has made various neighbourhoods safer. It is also essential to note the

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49 Mohammed E. A. (2018). Mapping the Spatial Distribution of Crimes in Iraq. The Sixth Scientific Conference "Renewable Energy and its Applications"

fact that people have gained more trust in law enforcement for they believe that perpetrators of a crime can be arrested faster before they engage in more heinous acts[50]. The public has been notified about the existence of GIS and the fact that it is applied in criminal investigations. The purpose of notifying the public is increasing their confidence in the system and for instilling fear in criminals that might think of committing a crime.

GIS has worked very well to see to it that criminals are fetched from their hiding places. Through the technology, the law enforcement officers have managed to fetch out these criminals in a safer way. In the past, these criminals would be taken in through serious violence where in some situations, people might get injured. However, through quality investigation with the use of GIS, it is possible to determine all possible areas of exist for a criminal and consequently cover them[51]. The method has proved effective and has seen many criminals taken in without any forms of violence.

Another point that has shown effectiveness of GIS in investigations is the amount of time taken to investigate a crime. With the technology, the law enforcement officers do not spend a lot of time carrying out an investigation. In the past investigation would take a long time and this is because traditional methods of investigation would give the criminals a window to carry out various other activities such as changing clothes thus making it harder for the investigating officers to find them. However, through GIS, such discrepancies are eliminated and the officers can arrest the criminals in time[52]. GIS's utility in illuminating crime is based on its capacity to interact with crime data as well as its ability to analyse crime. A GIS may extract data from crime

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[50] Butorac, K., & Marinović, J. (2017). Geography of crime and geographic information systems. *Journal of Forensic Sciences & Criminal Investigation*, *2*(4 s 002).

[51] Shafique, I., Zahra, S., Farid, T., & Sharif, M., (2017). Role of GIS in Crime Mapping & Analysis. Sukkur IBA Journal of Computing and Mathematical Sciences. 1(39).

[52] Baraka, G. E., & Murimi, S. K., (2021). Why geographic information systems in spatiotemporal crime analysis? Attitude of Kenyan police officers. Police Practice and Research, 22(5), pp. 1453-1468.

dockets, reports, and documented crime sites using time, date, mode of operation, crime type attributes, and geographic queries. GIS can also be used for operational and tactical purposes, such as identifying and mapping crime series, as well as strategic decision-making, such as locating police precincts and patrols, targeting crime in high-risk areas, and developing policing projects.

3.4 Enhanced Interception of the Movement of Drugs into and out of the County

Results presented in Table 3.1 indicate that 21% of the respondents strongly agreed that the law enforcement agencies have been able to considerably intercept the movement of drugs into and out of the county as a result of the application of the GIS technology by the security agencies in the county, slightly more than one half of the respondents, 51%, agreed with the question statement while 6% were neutral. On the other end of the continuum, 12% of the respondents disagreed with the question statement and 21% of the survey participants strongly disagreed that as a result of the use of the GIS technology, the law enforcement agencies have been able to considerably intercept the movement of drugs into and out of the county.

Over the past few years, crime pattern analysis has been made possible and easier through the use of GIS. Traditionally, law enforcement officers could haphazardly try to note patterns through physical review of criminal activities in a given region and this was not effective enough because they could miss out on some vital information. However, though the use of GIS, the activity has been made more effective and has seen officers determining changes in trends in criminal behaviour. The software has managed to pin various activities and align them with activities of the same nature and cluster them together and an example of this is in the case of Bandung[53]. However

[53] Setiawan, I., Dede, M., Sugandi, D., & Widiawaty, M. A. (2019). Investigating urban crime pattern and accessibility using geographic information system in Bandung City. *KnE Social Sciences*, 535-548.

small a crime might be, it is possible for the software to categorize it and place it alongside other activities of the same nature. Through this categorization, it is possible to see various trends that take place in a given region. One can note that this is a very effective way of pattern analysis without losing out any information.

The human eye can see particular crime and assume it is negligible and fail to categorize it. However, the technology has the ability to decipher even the smallest piece of information relating to crime and consequently determine whether the criminal activity is connected to another. After the connection is made, then the law enforcement officers can use this information to note how frequent the criminal activities take place in a given region. The form of pattern analysis has made officers more informed on changes taking place in a given location. For police interdiction operations and criminal prevention, GIS has shown to be a very valuable tool. Combating drug trafficking is one area where GIS has proven to be beneficial. Drug traffickers perceive of their activities as a cost or benefit, and this form of crime often follows established or historical patterns. They aim to convey their goods to a location with the least amount of expense and the least chance of the cargo being seized. The converse is true for police and other law enforcement authorities involved in drug interdiction.

Kenya's Blue Economy for a long time remained idle and unexploited. This was among other factors due to insecurity in the country's territorial waters where criminals were thriving in their activities including drug trafficking. A classic case in point is an instance in March 2011 when a ship loaded with more than three tons of heroin was anchored close to shore in Kenya's territorial waters for more than ten days. During that period local and international traffickers made use of speedboats to reach the ship to purchase the heroin before police intercepted a consignment worth more. This possibility of this happening was attributed to absence of a dedicated coast guard to

protect the country's coastline. However, in order to enhance security at the coast and to exploit the Blue Economy which is a key job creator and a powerful economic driver, the government of Kenya established the Kenya Coast Guard Service (KCGS), an agency tasked with the responsibility of law enforcement in the territorial waters of Kenya[54]. The agency incorporates personnel from different agencies, being the Navy, Customs, Kenya Fisheries and Kenya Wildlife Service, and protects the country's waters from all crimes including drug trafficking. Since its inception and commission, this agency has been instrumental in strengthening Kenya's maritime territories and mitigating risks of transnational organized crime such as drug trafficking thus contributing significantly to improving internal security of the ocean ecosystems of Kenyan waters.

3.5 Enhanced Identification of Points of Illicit Drugs Origins and Destination

With regard to the question on whether the law enforcement agencies have effectively used the GIS system to identify the points of origin of drugs insides and outside the country and collaborating with other parties to deter production of the drugs, results in Table 3.1 indicate that 9% of the respondents strongly agreed with the question statement, 27% agreed with the question statement, 14% were neutral, 29% disagreed and the remaining 21% strongly disagreed that the law enforcement agencies have effectively used the GIS system to identify the points of origin of drugs insides and outside the country and collaborating with other parties to deter production of the drugs as depicted in Table 3.1.

The GIS technology as proved very important in the prediction of criminal activities. Many police officers have been trained to carry out investigations and arrest

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[54] Gastrow, P., (2011). Termites at Work: A Report on Transnational Organized Crime and State Erosion in Kenya—Comprehensive Research Findings," New York: International Peace Institute, December 2011.

criminals. Some other officers have been trained on prediction tactics. However, the traditional method of crime prediction by simply looking at information is not effective enough. The software is effective for it uses a scientific approach that is not contested. The fact that it is software and used different algorithms to analyse data fed to it makes it even more resourceful as compared to a human being (Kim et al., 2018). As identified, the traditional means of crime pattern analysis was imperfect and thus information presented in this stage of crime prediction might be faulty. However, incorporation of GIS in both the pattern analysis and prediction phases makes the outcome even more believable. It's not so much about always being in the right place at the right time in drug interdiction as it is about making resource allocation decisions for interdiction teams. One may never be sure what routes or methods a drug dealer will use to get their items to market. The decision for law enforcement is how many police officers or agents should be assigned to a certain area.

The software has proved effective in predetermining areas where criminals might hit next and this is by critically using the information it generated during the pattern analysis stage. The GIS has thus been used to make decisions on when and where to deploy agents based on information such as the geography of the region, the time of day, and the means of transporting illicit drugs. Many criminal acts have been prevented after using the information noted above and consequently lives have been saved and property protected all because of the effectiveness of the software. It is imperative to note that another effectiveness of the software in this stage is the fast yielding of results[55]. Criminals tend to move fast so as to avoid capture. The software produces information fast enabling the officers to get to a predetermined scene before

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[55] Bello, I. E., Ikhuoria, I. A., Agbaje, G. I., & Ogedegbe, S. O., (2013). Managing Urban Crimes with Geoinformatics: A Case Study of Benin City, Nigeria. Computer Engineering and Intelligent Systems, 4(13).

the criminals, waiting for them and consequently incarcerating them. Applying Bayesian modelling or statistical processes that employ proxies, such as historical drug arrests, to assess the likelihood of a specific place producing likely drug activity are examples of how police might use GIS. For instance, ships that may transport drugs could take less used or unlikely paths to drop off their cargo.

3.6 Contribution of GIS in Formulation of Laws and Policies Aimed at Curtailing Drug Trafficking

Analysis of the question on the usefulness of the formulation of laws and policies aimed at curtailing drug trafficking in the county and country at large based on analysis of the GIS data as presented in Table 3.1 indicate that 34% of the respondents strongly agreed with the question statement, 45% agreed that findings based on the analysis of the GIS data have been useful in formulation of laws and policies aimed at curtailing drug trafficking in the county and country at large while 3% expressed neutrality. Among the negative responders, 11% disagreed with the question statement while the rest 7% strongly disagreed that findings based on the analysis of the GIS data have been useful in formulation of laws and policies aimed at curtailing drug trafficking in the county and country at large.

Hot spots are geographical areas which exceed average levels crime activities. The higher the number of crimes in a given locality, the 'hotter' it becomes. Hotspots are determined by available historical data and can be represented on maps obtained from GIS software tools[56]. Security agents have created hot spot maps for various categories of crime and employ a number of techniques to display and analyse the information. These methods and techniques involve setting individual cameras as

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[56] Reid, S. E., Tita, G., & Valasik, M., (2011). The Mapping and Spatial Analysis of Crime. *obo* in Criminology

points on maps and analyse their distribution, observing crime trends and levels in

administrative areas such as census zones.

Table 3.1: Effectiveness of the GIS Technology in Drug Trafficking Crime Control

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The use of GIS technology has enhanced identification of drug trafficking as a major crime in the county.	24%	35%	7%	21%	13%
Application of GIS in mapping of drug trafficking routes has led to significant arrests and prosecution of perpetrators of drug trafficking.	19%	41%	11%	18%	11%
As a result of the use of the GIS technology, the law enforcement agencies have been able to considerably intercept the movement of drugs into and out of the county.	21%	51%	6%	12%	10%
The law enforcement agencies have effectively used the GIS system to identify the points of origin of drugs insides and outside the country and collaborating with other parties to deter production of the drugs.	9%	27%	14%	29%	21%
Findings based on the analysis of the GIS data have been useful in formulation of laws and policies aimed at curtailing drug trafficking in the county and country at large.	34%	45%	3%	11%	7%

Source: Field Data, 2021

The interviewees indicated that the GIS technology is also being applied widely

by the security agencies to track movement of drugs from outside the county and

country into Nairobi County. One of the interviewees made the following observation:

"The anti-narcotics, working together with other arms of the security
agencies have continuously applied vigorously the GIS technology to
curtail movement of drugs from suspected prone areas in and out of the
country and Nairobi County to other parts of Nairobi County."

The GIS has also been useful in guiding formation of laws and policies aimed

towards institution of legislation to enhance the fight against drug trafficking in the

country.

The GIS tools exhibit, keep, manage and examine geospatial information and related data. The GIS tools are main components in the developing science of predictive policing, that brings together crime mapping, data analysis and law exestuation experts to give predictions of locations where crimes are likely to take place. Predictive policing technology solutions serve to enhance police effectiveness and generally reduce crime by assisting to guide the designed deployment officers in the areas of work. Major function of GIS technology in reducing crime is to provide law enforcement agencies with data on the component and prognostic policing materials to assist in exercising systematic procurement and deployment[28].

The application of GIS materials has greatly promoted and enhanced the development of crime maps that virtually pinpoint reported crime activities and help security officers to detect special and frequent crime trends. Security officers have used GIS tools to map crime data such as location of sites were illicit drugs are produced and sold. These detailed map views assist security personnel to gain better understanding of underlying factors which give increase to crime rise and come up with advanced effective response measures. Using the predictive policing solutions, GIS technology has been effectively used in assigning coordinates, which are expressed in latitude and longitude digits to data inputs, to display data on a map[57]. Upon geocoding, GIS platform is used to visualize fresh data, lay a basis for subsequent analysis forecasting, and develop maps which display results of analysis and estimations[58].

According to their analysis, security agencies develop resource allocations methods (for instance, when to release officers to a specific location and how many

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[57] Phiri, J., Lubobya, C. S., & Phiri, J., (2020). Crime Mapping Model based on Cloud and Spatial Data: A Case Study of Zambia Police Service. International Journal of Advanced Computer Science and Applications, 11(1).

[58] Balogun, T. , Okeke, H. and Chukwukere, C. (2014) Crime Mapping in Nigeria Using GIS. *Journal of Geographic Information System*, **6**, pp. 453-466.

officers to send) or assist in developing initiatives aimed at determining unlawful acts (for example putting under control vulnerable physical facilities like abandoned structures). Additionally, crime examination bound the processes of evaluating Impacts of subjected response tactics and methods, the success of services provided by security agents, like safety education and victim assistance, and administrative plans such as staffing level budgetary allocations[30].

3.2 Summary of Findings

This chapter reviewed the effectiveness of the GIS technology in influence of the GIS technology on drug trafficking crime control with the focus on the different aspects namely crime mapping, crime investigation, crime pattern analysis, crime prediction and crime identification. The results on the analysis indicated that on the whole, the GIS system has been effective in addressing trafficking of illicit drugs in the county and by extension in the country. The instrumentality of the technology is evidenced by the effectiveness and efficiency with which the law enforcement agencies have been able to locate and track down the criminals engaged in selling and consumption of the drug. Through the use of the technology the law enforcement authorities have also been able to map the various hotspots within the city where the drugs are stored and the routes through which it is moved until it reaches the intended destination thereby intercepting the criminals transiting the drugs.

4.0 CHALLENGES ENCOUNTERED IN THE USE OF THE GIS TECHNOLOGY IN CRIME CONTROL

4.1 Introduction

Presented in this chapter is the analysis of the various challenges that law enforcement officers encounter when applying the GIS technology in controlling drug trafficking in the county. A detailed discussion of the findings of the study is also covered in this chapter to shed more light on the study's findings.

4.2 Inadequacy of technically trained staff Impeding Application of the GIS in Mapping Drug Trafficking Hotspots

Analysis outcomes presented in Table 4.2 show that 19% of the respondents strongly agreed that inadequacy of technically trained staff in the use of the GIS system makes it difficult to map drug trafficking hotspots, 31% of the survey participants agreed with the question statement while 10% of the respondents were neutral. On the other end of the continuum, 21% of the survey participants disagreed with the question statement while the rest 19% strongly disagreed that Inadequacy of technically trained staff in the use of the GIS system makes it difficult to map drug trafficking hotspots.

One of the challenges associated with GIS and crime control is the lack of qualified staff. GIS is a new technology that requires skilled people with computer proficiency. Some police departments are adamant to change and do not appreciate the new technology[59]. As of such, some police officers fail to engage in classes that can assist them learn more about the technology. Despite the fact that some officers enrol in these classes, it becomes challenging to coordinate with other law enforcement officers that are adamant and do not appreciate the technology.

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[59] La Vigne, N. G., Paddock, E., Irvin-Erickson, Y., Kim, K., Peterson, B. E., & Bieler, S. (2017). *A blueprint for interagency and cross-jurisdictional data sharing*. Washington, DC: Urban Institute.

4.3 Poor Staff Training and Poor Management of the GIS Technology as Obstacles in Drug Trafficking Crime Control

Table 4.2 also shows that 21% of the survey participants strongly agreed that predict routes used by drug traffickers in the county has been made difficult by poor training of staff in the use of the GIS system, approximately one third of the respondents, 33%, agreed with the question statement while 15% while neutral with regard to the question. Among the negative responders, 24% disagreed that poor training of staff in the use of the GIS system makes it difficult to predict routes used by drug traffickers in the county while the remaining 7% of the respondents strongly disagreed with the question statement.

Among the positive responders, approximately 14% of the survey participants strongly agreed that poor management of the GIS system contributes to poor investigation of the drug trafficking crimes while 22% agreed with the question statement. On the other end, 30% of the negative responders disagreed that poor management of the GIS system contributes to poor investigation of the drug trafficking crimes while the rest 21% strongly disagreed with the question statement. The remaining 13% of the survey participants were not certain whether or not poor management of the GIS system contributes to poor investigation of the drug trafficking crimes as shown in Table 4.2.

Data limitation is another problem facing police officers. Having the data set in digital form is a big challenge for many offices in the contemporary law enforcement and this is because some of this raw data is impossible to convert. Even when converted, the data might lose the original meaning and consequently distort the information[60]. Even when the data is available in digital form, it is imperative to note that there are

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[60] Kuta, A. A., & Ibrahim, S., (2015). Challenges in using Geographic Information Systems (GIS) to Understand and Control Crime in Nigeria. IOSR Journal of Humanities And Social Science, 20, pp. 43-48.

various risks involved such as omission of entry which can lead to provision of incomplete information. The consequence of such activities is failure to resolve a criminal activity effectively.

4.4 Resistance Among Law Enforcement Officers and Civilian Population Impeding Drug Trafficking Crime Control

Table 4.2 shows that 23% of the respondents strongly agreed that there are cases of resistance with regard to the use of GIS in fighting drug trafficking among the law enforcement officers thus derailing crime control, 29% agreed with this question statement while 11% were neutral. On the other end, 20% of the survey participants disagreed with the question statement while the rest 17% strongly disagreed that there are cases of resistance with regard to the use of GIS in fighting drug trafficking among the law enforcement officers thus derailing crime control.

As depicted in Table 4.2, approximately 27% of the survey respondents strongly agreed that resistance from the civilian population on the use of the GIS system in the fight against drug trafficking thus compromising control of this scourge, 35% agreed with the question statement while 7% were not sure whether or not resistance from the civilian population on the use of the GIS system in the fight against drug trafficking thus compromising control of this crime. On the other end 16% of the respondents disagreed with the question statement and the remaining 15% of the respondents strongly disagreed that resistance from the civilian population on the use of the GIS system in the fight against drug trafficking thus compromising control of this crime.

Financial implication in the purchase of software and hardware is another major challenge facing the use of GIS in crime control. The cost of acquiring and training in the use of GIS is very high. Given the fact that contemporary changes in law enforcement have seen the state governments cutting their budget, it becomes very hard

for the police institutions to direct financial resources to the technology[61]. Despite the fact that various police precincts might have the motivation and eagerness to incorporate the technology, their financial conditions make it hard for them to acquire it.

Table 4.2: Challenges Encountered in the use of the GIS Technology in Crime Control

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Inadequacy of technically trained staff in the use of the GIS system makes it difficult to map drug trafficking hotspots.	19%	31%	10%	21%	19%
Poor training of staff in the use of the GIS system makes it difficult to predict routes used by drug traffickers in the county.	21%	33%	15%	24%	7%
Poor management of the GIS system contributes to poor investigation of the drug trafficking crimes.	14%	22%	13%	30%	21%
There are cases of resistance with regard to the use of GIS in fighting drug trafficking among the law enforcement officers thus derailing crime control.	23%	29%	11%	20%	17%
Resistance from the civilian population on the use of the GIS system in the fight against drug trafficking thus compromising control of this crime.	27%	35%	7%	16%	15%

Source: Field Data, 2021

With regard to the question on the extent to which inadequate trained technical staff is a challenge to the application of the GIS technology in the fight against drug trafficking in Nairobi County, 29% were of the opinion that this aspect is a challenge to a great extent, 24% indicated that it was a challenge to a very great extent, 17% found it to be a challenge to a moderate extent while 19% found it to be a challenge to a little extent. The rest 11% were of the view that inadequate trained technical staff was a challenge to a very little extent as depicted in Figure 4.1.

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[61] Strom, K., (2016). Research on the Impact of Technology on Policing Strategy in the 21st Century, Final Report.
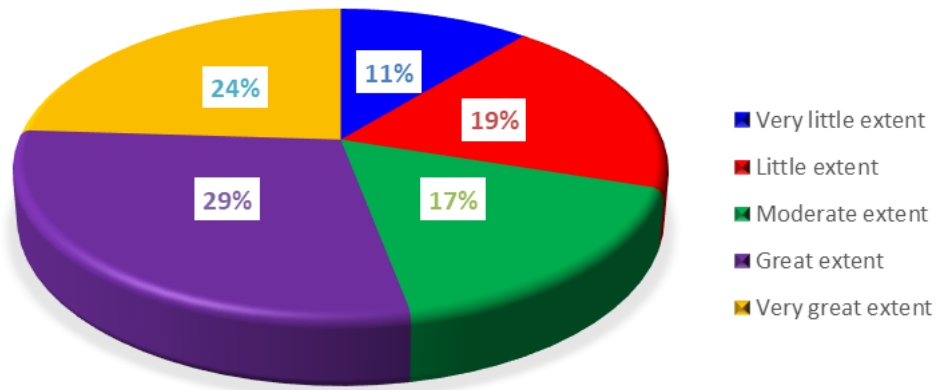
Figure 4.1: Extent to Which Inadequate Trained Technical Staff is a Challenge
Source: Field Data, 2021

About one third, 33% of the respondents were of the view that staff who were not properly trained on the use of the GIS technology affected application of the system to a great extent, 17% found this to be a challenge to a very great extent while 11% felt that it was a challenge only to moderate extent. About 24% found it to be a challenge to a little extent while 15% were of the opinion that poorly trained staff on the use of the GIS system were a challenge to the application of the system in the fight against drug trafficking to a very little extent as shown in Figure 4.2.
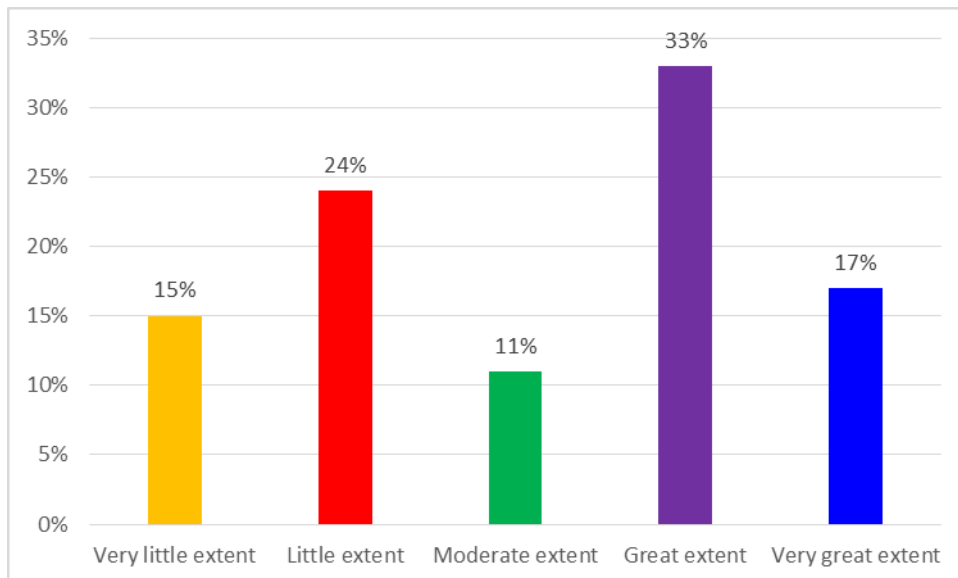

Figure 4.2: Extent to Which Poorly Trained is a Challenge
Source: Field Data, 2021

Hacking is very prominent in the contemporary environment. Basically, anybody with information technology skills has the ability to enter a server and manipulate information according to their wishes[62]. A criminal mastermind has the ability to hire some high-end hackers to ensure that their information is deleted from various databases. Initially, it was hard for criminals to manipulate information given the fact that it was stored in hard copies. However, a lot of credible information is lost through GIS because of various tactics that are incorporated by criminals and their affiliates.

As depicted in Figure 4.G, 27% of the survey participants opined that poor management of the GIS technology by the security agencies affected its application in the fight against drug trafficking crime in Nairobi County to a great extent, 23% were of the opinion that the poor application affected implementation to moderate extent while 22% felt that poor management of the GIS technology affected application of the system to a little extent as presented in Figure 4.3. On the extreme ends, 15% were of the view that poor management of the systems affected implementation and application of the systems to a very little extent while the rest 13% were of the view that this aspect affected application of the system to a very great extent.

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[62] Bowers, K., & Johnson, S. (2003). Measuring the Geographical Displacement and Diffusion of Benefit Effects of Crime Prevention Activity. *Journal of Quantitative Criminology, 19*(3), 275-301.
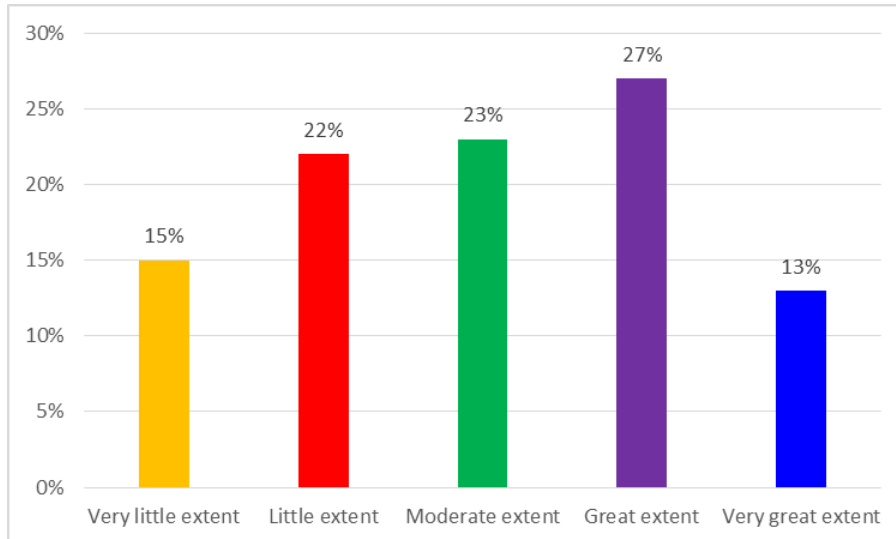
Figure 4.3: Extent to Which Poor Management is a Challenge
Source: Field Data, 2021

With regard to the question on resistance from the service officers, 27% were of the opinion that this aspect of challenge affected application of the GIS technology to a great extent, 19% felt that it affected the application of the GIS in the fight against drug trafficking to a very great extent whole 14% were of the opinion that its effect was only to a moderate extent as shown in Figure 4.4. Among the negative responders, the 23% were of the opinion that resistance from within the security agencies affected the application of the GIS technology in the fight against drug trafficking to a little extent while the remaining 17% of the survey respondents were of the view that this aspect was a challenge to a very great extent.
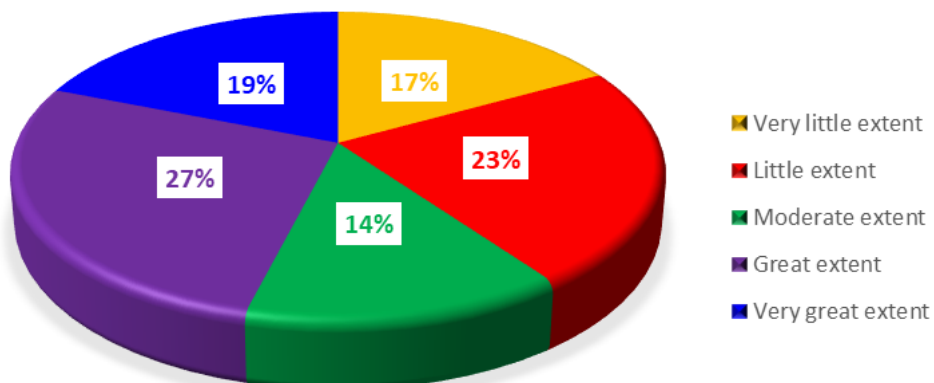

Figure 4.4: Extent to Which Resistance from Within the Security Agencies is a Challenge
Source: Field Data, 2021

One other challenge that is associated with GIS technology in crime is incompetence amongst the police officers that are assigned to use the identified digital technology. Many of the developed countries in the contemporary environment have incorporated digital technology to enable them mitigate crime issues[63]. However, some police officers are incompetent to a point that they ignore the data produced by the software. A point to note is that most of the ignorant officers are those that served in the older departments when this technology had not been invented.

Analysis outcomes presented in Figure 4.5 show that 23% of the respondents were of the opinion that resistance from civilian population is a challenge to the application of the GIS technology in the fight against drug trafficking crime in Nairobi County to a great extent, 14% felt that this aspect challenged application of the system to a very great extent while 12% found it to affect application of the GIS technology in the fight against drug trafficking to a moderate extent. Approximately 27% of the survey respondents held the view that resistance from the general public affected application of the system to little extent while the rest 24% found it to affect application of the system to a very little extent.
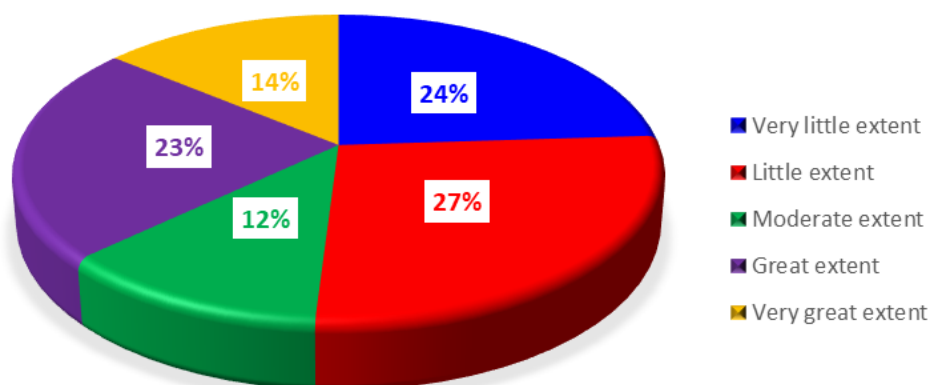

Figure 4.5: Extent to Which Resistance from Civilian Population is a Challenge
Source: Field Data, 2021

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[63] Tennent, J. (2019). Review of GIS Tutorial for Crime Analysis. *Cartographic Perspectives*, (92), 93-94.

The GIS technology faces a number of challenges in combating crime. The challenges vary from one region to another. Among the challenges include; data limitation, inadequate skilled personnel, financial limitations to purchase the software and hardware. Lack of qualified staff is a major challenge in the GIS application. GIS is considerably a modern technology within high concentration of security agents across the globe. GIS software and hardware are normally developed and produced in USA and Europe. Contrary to this fact, just a few individuals can effectively utilize GIS applications in other parts of the world. It translates that GIS coaching and skills are necessary in many parts globally[64].

Data availability is a major problem facing GIS users in both developed and developing countries. Obtaining the necessary data composition in digital form remains a challenge. Surprisingly, even in places it is available; privacy concerns continue to hold the process of data acquisition. This lowers the speed of crime analysis. Data is major component of GIS application and it is seriously unavailable in most countries. Even the human population census data is outdated and unreliable in some countries. Census data of most countries lacks geo-referenced economic data of households. Police officers in most developing countries do not record spatial locations of crime scenes that can help in analysing and marking of hot sports. Additionally, they lack reliable biometric data base for criminals[31].

Availability of computer software and hardware is not appealing in most developing countries. In spite of steady growth in the use of computers in the present world, most staff members are still computer illiterate. Most police departments lack modern computers to install the GIS software to control crime. Additionally, GIS

[64] Breetzke, G., (2006). Geographical information systems (GIS) and policing in South Africa: a review. Policing an International Journal of Police Strategies and Management, 29, pp. 723-740.

software is very expensive, and most staff in the security authority is very unaware on the potential of the software. Therefore, GIS is not often used in crime examination. This complicates the process of understanding criminal behaviour. Low level of awareness is also affecting GIS technology in combating crime. The level of knowledge in the use of GIS technology is low in most developing countries. Many government officials, politicians, academic researchers have no idea of what GIS is capable of doing. It means that there is very minimal degree of adoption and utilization of the technology in many parts of the world.

4.2 Summary of Findings

Despite the effectiveness of the GIS technology in the fight against drug trafficking in the county, the realization of objectives has not been without challenges that continue to impede the use of this important invention. Some of the challenges, as established in the findings herein, are internal to the law enforcement agencies while others are external. This implies that some of the challenges are created by the agencies themselves while other are beyond their control. Law levels of training among the officers and inadequate number of properly trained officers continue to impact negatively on the use of the system. It has also been established that resistance by the general public in some instances because of suspicion that the instruments are being used to infringe on their private lives also continue to pose challenges to the application of the GIS system.

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents a summary of the research findings in light of the study's three research objectives. It also presents conclusions drawn from the study's results. At the end of the chapter, there are recommendations made based on the gaps identified and the challenges faced in the application of GIS technology in battling drug trafficking crime in the country.

5.1 Summary of Findings

This study sought to identify and discuss the influence of GIS on drug trafficking crime control in Kenya, with a focus on Nairobi County since it is the capital city of the country hence one of the regions in the country where drug trafficking and consumption is rampant and widespread. The first objective of the study was to establish the approaches to application of the GIS technology in drug trafficking crime control in the county. The key indicators for the approaches in this study were crime mapping, crime investigation, crime pattern analysis, crime prediction and crime identification.

Crime mapping has emerged as one of the greatest essential and popular innovations in law enforcement. The GIS technology was found to be applied considerably and widespread in mapping of drug trafficking in the county. The responsible law enforcement agencies use the GIS technology to generate location information about drug trafficking events in order to detect patterns in crime activities in the county. Besides crime mapping, the GIS technology has also been widely applied in investigation of drug trafficking activities. Incorporation of the GIS technology in crime investigation and tracking has made law enforcement agencies more agile and efficient in their work. The geospatial had made it possible for the anti-narcotics unit

as well as other security agencies to track and trace persons and vehicles transporting drugs within the county and across the country.

The GIS technology is also being applied in drug trafficking identification of suspects and perpetrators drug trafficking. Additionally, in the fight against drug trafficking, the system has been critical in the collection of sufficient evidence to indict drug trafficking suspects before courts of law. The GIS technology has also been at the centre of crime scene investigation and evidence collection to help the law enforcement agencies and their judiciary to be more accurate and effective in delivery of services. The system has also been widely applied in drug trafficking crime prediction and crime identification in the county to stay ahead of the criminals.

This study also assessed the effectiveness of the GIS technology in the fight against drug trafficking in the Nairobi County. The outcomes of this study indicated that the application of the technology has been successful in achieving the intended objectives. One of the key areas that the technology has been successful is in the mapping of drug trafficking routes. Bringing together the GIS technology with other technology, the law enforcement agencies in Nairobi have been able to track down individuals and gangs involved in the sale and movement of drugs within the county and beyond. Using the data obtained from the GIS system has been an effective way of analyse where drug trafficking crimes occur and acting appositely. The effectiveness of the technology has also been witnessed in interception of drug traffickers into and out of the county. Further, the findings based on the analysis of the GIS data have been useful in formulation of laws and policies aimed at curtailing drug trafficking in the country and county. Therefore, it can be reliably argued that the GIS system has been effective in drug trafficking crime control in Nairobi County and in Kenya at large.

Application of the GIS system has not been without challenges. It came out from the study that due to a number of factors the responsible institutions in the government have not been able to train adequate number of law enforcement officers in the use and application of the GIS technology. Consequently, the use of the GIS technology has not been as wide and intense as one would expect thereby creating some gaps in the fight against drug trafficking crime in the county. Besides inadequate staff, some of the available staff it came out from the study that poorly trained staff is also another challenge facing the application of the GIS technology in the fight against drug trafficking in the county. Like any other technologies, the GIS technology used by law enforcement officers keep advancing and, in such instances, it is important to retrain the officers in order make them up-to-date with the various developments. However, since the responsible institutions have not been able to properly train all the law enforcement officers tasked with the responsibility of tackling drug trafficking in the county, much as not been achieved as would have been desired. Other challenges that have continued to impact application of the GIS technology in the fight against drug trafficking include poor management of the GIS system, resistance from within the security agencies and resistance from the civilian population.

5.2 Conclusion

Based on the findings of this study, it is clear that the law enforcement as well as the security agencies in Kenya have embraced and adopted the use of the GIS technology to enhance their efficiency and effectiveness at work. The technology integrates crime mapping, crime investigation, crime identification, crime prediction and crime pattern analysis. The GIS technology, as established in this study, has been considerably effective in the drug trafficking crime control in the country. The security and law enforcement agencies have successfully applied this technology track

movement of drug transporting vehicles and individuals, arresting the criminals as well as consumers of the drug. Further, from the use of the technology, the law enforcement agencies have been able to work closely with the judiciary to influence formulation of laws to enhance the fight against drug trafficking. Challenges have however been encountered in the use of the GIS technology in drug trafficking crime control. Poorly trained staff on the use of the technology, inadequate trained technical staff, resistance from within the security agencies, poor management of the system and resistance from the civilian population have some of the challenges that have been experience albeit to varying levels.

5.3 Recommendations

Following the analyses and study findings of this study, it is recommended that the law enforcement and security agencies intensify the use of the GIS technology in the fight against drug trafficking in Kenya and in Nairobi County. Further, the GIS should be adopted and applied in tackling other times of crime such as car theft and human trafficking. It is also recommended that the law enforcement agencies take seriously the challenges identified in this study and find ways of effectively addressing the challenges. For instance, the agencies should properly and adequately train their staff who are tasked with the responsibility of fighting drug trafficking in the country. Further, adequate number of staffs should be trained in the use of GIS in addressing drug trafficking crime in the country. The general public as well as officers should be informed what the GIS is and its importance in the fight against drug trafficking so that the resistance already being experience is significantly reduced or completely eliminated.

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Appendix I: Research Questionnaire

Dear Respondent,

My name is **Mr DAVID K. MATHIU**, a student at the University of Nairobi, Institute of Diplomacy and International Studies, pursuing Master of International Conflict Management. I am conducting a research survey on to establish the **Influence of Geographic Information Systems Technology on Drug Trafficking Crime Control in Kenya: Case of Nairobi County**. Your contribution in facilitating the success of this study will be highly appreciated. The information collected will be treated with confidentiality and will only be used for the purpose of this research.

SECTION A: Demographic Information

1. What is your gender?

    Male [ ]   Female [ ]

2. For how long have you been a resident of Nairobi County?

    5 years or less [ ] 6– 10 years [ ] 11– 15 years [ ] 16 – 20 years [ ]

    21 – 25 years [ ] 26 – 30 years [ ] 31 years and above [ ]

3. In which of the following categories do you belong?

    National Police Service Officer [ ]

    Kenya Defense Forces Officer [ ]

    Administrative chief [ ]

    Others (Specify) [ ]

4. In your period and line of service, have you ever been directly involved in drugs and drugs trafficking assignments?

    Yes [ ]   No [ ]

SECTION B: Approaches to Application of the GIS Technology in Crime

Control

How widely is each of the following approaches applied in drug trafficking crime control in Nairobi County with regard to the GIS technology.

	Never	Rarely	Occasionally	Frequently	Very Frequently
5. Crime mapping					
6. Crime investigation					
7. Crime pattern analysis					
8. Crime prediction					
9. Crime identification					

10. In your opinion, what are the other approaches to application of the GIS technology in drug trafficking crime control in Nairobi County?

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SECTION C: Effectiveness of the GIS Technology in Crime Control

In your view, to what extent do you agree with the following statements with regard to drug trafficking crime control in Nairobi County?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
11. The use of GIS technology has enhanced identification of drug trafficking as a major crime in the county.					
12. Application of GIS in mapping of drug trafficking routes has led to significant arrests and prosecution of perpetrators of drug trafficking.					
13. As a result of the use of the GIS technology, the law enforcement agencies have been able to considerably intercept the movement of drugs into and out of the county.					
14. The law enforcement agencies have effectively used the GIS system to identify the points of origin of drugs insides and outside the country and collaborating with other parties to deter production of the drugs.					
15. Findings based on the analysis of the GIS data have been useful in formulation of laws and policies aimed at curtailing drug trafficking in the country and county.					

16. How else has the GIS technology been used in the fight against drug trafficking crime control in Nairobi County?

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SECTION D: Challenges Encountered in the use of the GIS Technology in

Crime Control

In your view, to what extent do you agree with the following statements with regard to challenges in drug trafficking crime control in Nairobi County?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
17. Inadequacy of technically trained staff in the use of the GIS makes it difficult to map drug trafficking hotspots using the technology.					
18. Poor training of staff in the use of the GIS makes it difficult to prevent predict routes used by drug traffickers in the county.					
19. Poor management of the GIS contributes to poor investigation of the drug trafficking crimes.					
20. There are cases of resistance with regard to the use of GIS in fighting drug trafficking among the law enforcement officers thus derailing crime control.					

	Very Little Extent	Little Extent	Moderate Extent	Great Extent	Very Great Extent
21. Resistance from the civilian population on the use of the GIS in the fight against drug trafficking thus compromising control of this crime.					

To what extent do the following challenges affect the application of GIS technology in drug trafficking crime control in Nairobi County?

	Very Little Extent	Little Extent	Moderate Extent	Great Extent	Very Great Extent
22. Inadequate trained technical staff					
23. Poorly trained staff on the use of the GIS system					
24. Poor management of the GIS technology					
25. Resistance from within the security agencies					
26. Resistance from the civilian population					

27. With regard to the GIS, which other challenges would you say are negatively affecting control of drug trafficking crime in Nairobi County?

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Thank you for participating in the survey.

Appendix II: Key Informant Interview Guide

1. What are the major approaches to application of the GIS in the fight against drug trafficking crime in Nairobi County? Please describe each approach and how the security agencies apply them.

2. a) Would you say the GIS technology has been effective in control of drug trafficking in Nairobi County? Please explain.

   b) Besides controlling drug trafficking, in which other areas has the GIS technology been applied by Kenya's security forces?

3. Please comment on the following impediments to the application of the GIS technology in the fight against drug trafficking in Nairobi County;

   a) Inadequate trained technical staff

   b) Poorly trained staff on the use of the GIS technology

   c) Poor management of the GIS technology

   d) Resistance from within the security agencies

   e) Resistance from the civilian population

4. What in your view, can be done to overcome these challenges?

Appendix III: NACOSTI Permit

REPUBLIC OF KENYA

**NATIONAL COMMISSION FOR
SCIENCE,TECHNOLOGY & INNOVATION**

Ref No: **448607**

Date of Issue: **11/June/2021**

RESEARCH LICENSE

This is to Certify that Mr.. David Kainga Mathiu of University of Nairobi, has been licensed to conduct research in Nairobi on the topic: INFLUENCE OF GEOGRAPHIC INFORMATION SYSTEMS TECHNOLOGY (GIS) ON DRUG TRAFFICKING CRIME CONTROL IN KENYA: CASE OF NAIROBI COUNTY for the period ending : 11/June/2022.

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