INTELLIGENCE GATHERING ON KIDNAPPING INCIDENCE USING GEOSPATIAL TECHNOLOGIES ALONG ABUJA – KADUNA HIGHWAY OF NIGERIA

BY

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ABSTRACT

Of late, Nigeria has been posed to all forms of insecurities which threatens the existence of the entire nation. Of the several crimes being perpetrated, is the act of kidnapping. The crime of kidnapping for ransom has become so rampant in various parts of the country particularly on the highways. This has seen the abduction of several travelers on the highways. Most particularly, is the Abuja- Kaduna highway, which has witnessed incessant kidnappings that has claimed several lives. The security agencies saddled with the responsibility of ensuring safety of lives and property of individuals on the highway have come short in their duties due to poor information gathering and management skills to harness proper allocation and distribution of personnel, resources and logistics to aid security personnel to effectively combat the crime along the highway. Fortunately, kidnapping being a spatial crime enables the application of GIS and remote sensing to effectively collect, manage and analyze kidnapping information with respect to the geographical features around the highway to determine geographical features that attract or detract kidnapping. However, an adequate GIS and remote sensing training skill in our armed forces, shall aid security agencies in strategic mission planning and positioning of personnel to prone areas. On the basis of the aforementioned, the research was framed to involve mapping the major land use and land cover (LULC), the divisional police stations, the potential kidnapping hotspots and outlining the spatial relationship among LULC information and kidnapping activities in the study area. Road network data, satellite imagery of the study area (landsat8 of 30m resolution) and the base map for the study area were obtained from the United States Geological Surveys (USGS). Coordinates of the kidnapping hotspots and divisional police stations were obtained from the field survey using Global Positioning System (GPS). The base map was overlaid on the satellite imagery and a 10km buffer was carried out on both sides of the highway. The areas of reference along the highway were areas with divisional police stations, namely Kaduna toll-gate, Rijana, Kateri, Jere, Tafa and Sabon Wuse. The image was classified into tree cover areas, grassland, croplands, built-up areas, and water body and a 10 km buffer was done on both sides of the road. Kidnapping hotspots, divisional police stations and kernel density maps were produced. Of the LULC obtained for the study area, tree cover dominates 43.97%, croplands 34.15%, grassland 15.46%, built-up 6.17% while 0.25% of the area is covered with water. The study revealed that the Kateri area which was the highest in vegetative cover (tree cover and grassland), but less in built up, had the highest case of kidnappings along the highway. Whereas, the Kaduna City Toll-gate, Jere, Tafa and Sabon Wuse areas which had more of their area covered with crop lands and built-up, reported less cases of kidnappings. The research concluded that areas along the highway with very thick and large vegetation cover, sharp bends and bridges are attractors of kidnapping activities while areas along the highway with more built-up distracts kidnapping. However the presence of the divisional police stations in the areas could not be justified to be a hindrance to kidnapping along the highway. The study recommended a joint collaboration in the operations of security agencies and outfits. It also recommended adequate and routine training on GIS and remote sensing for security personnel, provision of necessary equipments and gadgets, proper allocation and distribution of security personnel and logistic along the highway, with more priority on the target and vulnerable areas.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Kidnapping is an unfortunate event whereby a human being is forcefully abducted by a fellow human or group of persons (abductors) who maybe armed, to an unknown location against the will of their victims for selfish reasons (Abdulkabir, 2017). Kidnapping is the act of taking a person or group of persons into captivity in order to achieve a defined aim (Ani & Ndubuisi, 2014). It is the seizing or use of force to take away human being against his/her will for alternate wants or achievements (Sam, 2009). The act places a victim on hostage for the purpose of using the abducted to attain a goal. Therefore, to kidnap, there must be two parties which include the living-prey on one hand and the heartless-criminal predator who is there to manipulate terror in order to attain an outlined objective or societal cause. Kidnapping and abduction are quite synonymous. At times it may involve hijacking of vehicles conveying people or goods for terrorism or gain. To cap it all, kidnapping in criminal law is an offence that involves taking away a person against his or her will by force or by fraud or intimidation and it is a grievous offence in many parts of the world ranging from life imprisonment to death penalty (Odoemelam & Omage, 2013).

Though, kidnapping is dated back to human history and could be said to be as old as human existence itself, it has been pointed out as one of the dangerous crime that is fast spreading around the globe today (Abdulkabir, 2017). The method of operation in Kidnapping has made it a key interest in most states because of the nature of its execution which in most occurrences is accompanied with violence and the use of arms and weapons resulting to victims losing their lives (Alexander and Klein, 2009). This trend is now on the increase all over the world as the

Global Slavery Index (2014) reported that throughout 2014; men, women and children continue to be kidnapped in village raids and held as slaves by militias in eastern Democratic Republic of Congo (DRC).

Globally, kidnapping increased rapidly in the 1990s in some part of the world leading to some cities being branded "kidnapping capital of the world". In 2001, Colombia recorded the highest absolute number of kidnappings and the highest kidnapping rate in the world and it was branded "Kidnapping Capital of the World". In the same light, Mexico was branded in 2004. Iraq had an estimated 1,500 foreigners kidnapped in 2007. As at 2003, Colombia had roughly 4,000 kidnappings per year and Argentina had 2,000 per year. In 2013, Mexico's National Institute of Statistics reported 1,695 kidnappings, a 20 percent increase over 2012. But experts estimated more than 90 percent of kidnappings in Mexico go unreported. Parts of the twentieth century saw the unlawful global trend becoming more rampart in various parts of the world like in Latin America and Pacific countries such as Mexico, Brazil, Venezuela and Peru (Roberts, 2017).

Figure 1.1: Top 10 Countries affected by kidnap for ransom risk in 2017.

Source: Ayuba, 2017.

In 1999, kidnapping in the USA took the form of family and non family abduction with an estimated 115 kidnappings. According to the Federal Bureau of Investigation (FBI) and The U.S Department of Justice, about 400,000 kids are reported missing annually due to family kidnappings (Hammer *et al.,* 2002). Arizona was reported to be America's kidnapping capital after hundreds of ransom for kidnapping occurred in 2009. Chicago, New Orleans, Houston, Atlanta and Detroit are other major U.S cities that have been described as hotbeds for kidnappings (Castillo, 2014; Williams, 2009).

In Europe and Asia, quite a number of countries are equally battling with the problem of kidnapping. These includes: Venezuela, Bangladesh, Peru, the Philippines, Saudi Arabia, Pakistan, Lebanon, Afghanistan, India, Iraq (U.S Department of State, 2010), Taiwan (Yang, 2007), Malaysia, Syria, Pakistan, Yemen and the Indian Ocean especially near the Somali coast (Banlaoi, 2010) and North Korea (Yamamoto, 2011).

Approaching into the African Continent, kidnapping is relatively new and has been experienced in some counties (Essien & Ben 2013). Countries like Nigeria, Sudan, Southern Sudan, South Africa, Horn of Africa countries such as Somalia, Eritrea, Djibouti and Ethiopia, Algeria, Burkina Faso, Cameroon, Chad, Democratic Republic of the Congo, Egypt, Libya, Mali, Mauritania, Morocco, Niger, Senegal, Tunisia and Uganda have experienced incidence of kidnappings and abductions (Onuoha, 2010). A number of factors appear to facilitate kidnappings in Africa. Reports indicate that the instability that led to the international intervention in Mali has increased the risk of kidnapping throughout North and West Africa. Malian-based militants and others located in Nigeria and Niger have carried out a number of

kidnappings including in neighboring countries such as Cameroon. Further kidnappings resulting from conflicts have been experienced in the North and West Africa region (Onuoha, 2014). In some other African countries, political rivalries have also contributed to kidnapping. For example, Libyan Prime Minister Ali Zeidan once accused a "political party" of organizing his brief abduction by gunmen (Le and Cervantes 2013).

In Nigeria, the first act of kidnapping was in 2006 when the militants of the Niger Delta took total hostage to protest the inequality in the region (Anuoha *et al*., 2014). It started with the kidnapping of government expatriates, religion clerics, politicians and common men. The kidnapping business in Nigeria has been mostly perpetrated by criminal gangs and violent groups pursuing political agendas. Basically, they take hostage for two primary reasons political bargaining and economic gains. Taking a step further, kidnapping in Nigeria can be further categorized as: domestic kidnapping, political kidnapping, predatory kidnapping and staged kidnappings. Some groups in the Niger Delta have used the kidnapping of international oil workers to raise international attention regarding the plight of those living in the Delta, the environmental damage caused by oil spills and the oil industry, and the demand for more local ownership of the extraction of natural resources (Oluwaniyi, 2014). Hence, the Kidnap tactics normally might not be entirely politically motivated as the community might be looking for ways to have their voice being heard; nevertheless, there are reports of significant ransom payments in other instances which have then been used to fund the activities of other groups. The tactic now being seen as a very lucrative business makes a number of other criminal groups, militia, bandits and movements resolve into kidnapping to make money. Similarly, Boko Haram insurgents have used the proceeds of kidnapping to keep their insurgency afloat (Okoli, 2019). The insurgents engage in single or group kidnapping as a means of generating money to fund their activities.

Huge sums are often paid as ransom by the victim's families and associates to secure their release.

In addition to militants and insurgents, organized local and transnational criminal syndicates have been involved in kidnapping. This is happening to apocalyptic proportions in North West Nigeria where rural bandits engage regularly in kidnapping in the states of Zamfara, Katsina, Kebbi, Sokoto and Kaduna (Okoli, 2019).

Kidnapping as a variant of armed robbery is infinitely more disturbing as it now occurs in the open not only among persons going about their normal business but also targeted at the executive, legislative, and the judicial branch of the government (Anucha, 2018). The widening scale of it occurring to travelers on the remote parts of some highways where security is more difficult to manage is the new trend. One of the highways that have recorded a large number of incidences is the Kaduna-Abuja highways. As a result, several dreadful attacks have been carried on innocent commuters along the Abuja-Kaduna road, which includes attack on government dignitaries, politicians and more. The most recent along the Abuja-Kaduna road is the abduction of the board chairman of Universal Basic Education Commission (UBEC) alongside his daughter. Another Abduction of about 30 travelers in early April 2019 instigated a public outcry which saw many Nigerians charge security operatives to put an end to the menace (Ayuba, 2020). The unrelenting efforts by security agents to root-out criminal elements terrorizing commuters along Abuja–Kaduna expressway have seen security operatives engaging these criminals in gun battles **(**Egbegi *et al.,* 2019).

However, kidnapping like other major crime such as armed robbery, banditry, and theft have a spatial phenomenon, that is, the incident locations are geographically defined. Hence it could be

managed with the aid of Geographical Information System (GIS) and Remote Sensing (Satellite technology) to reduce its intensity. An example of studies done using GIS and Remote Sensing to aid crime management and control includes, mapping crime risk distribution using GIS (Eman *et al.,* 2013). Spatio-temporal analysis of reported kidnapping activities in Nigeria using 'MORANS I' by (Aubrey, 2014). Similarly, (Chhachhiya, 2017) carried out a study to reveal the "Spatio-Temporal Analysis of Kidnapping and Abduction of Women in Chandigarh".

1.2 Statement of the Research Problem

The Abuja- Kaduna expressway has in recent years been branded "kidnappers den for innocent citizens" as it has witnessed and recorded several kidnapping activities (Onucha and Okolie, 2019). Just recently, "ASIS International" raised the alarm over the payment of over N1billion to kidnappers as ransom on the Kaduna-Abuja highway which in turn is suspected to be deployed to purchase more arms by the kidnappers in an unending vicious cycle (Nwezeh, 2019). The scenario of this crime in Nigeria particularly Abuja-Kaduna highway disregards class distinction in the society, as both high (haves), and low (have not), experience similar and equal attack of the criminals from time to time. The resultant tragedy, suffering, colossal loss and distress, occasioned by these inimical attacks, have been pervasive and had left an indelible mark on our national psyche and societal tranquility. Worse still, is the fact that the law enforcement agencies are yet to be fully computerized for effective record keeping to enable easy reference, retrieval and storage of information to help the analysis of cases, particularly spatial analysis, strategize and adequately plan the combating and eradication of crimes in general (Balogun *et al.,* 2014) . However, several studies on crime have been embarked on using spatial analysis. Most of these studies focused on a set of crime in a location over a period of time. Balogun *et al*. (2014) developed crime hotspots, areas deficient of security outfit, areas of overlap and areas requiring

constant police patrol in Benin City using buffering analysis. Olajuyigbe *et al*. (2016) revealed a transport route cutting through Akure metropolis is prone to crime activity using neighborhood and statistical analyses with GIS.

Unfortunately, very little spatial analysis has been documented on specific crime type such as kidnapping.

1.3 Aim and Objectives of the Study

The aim of this study was to carry out intelligence gathering of kidnapping hotspots in the study area.

To achieve this aim, the secondary objectives are to:

i. Derive Land use and land cover map of the study area.

ii. Identify and map Divisional Police Stations in the study area.

iii. Identify locations of kidnapping hotspots in the study area.

iv. Examine the spatial relationship among land use and land cover information, security posts and kidnapping activities in the study area.

1.4 Research Questions

The following are the research questions that can be deduced from the study.

i. What are the major land use and land (LULC) types of the study area?

ii. How is the spatial distribution of the divisional police stations along the expressway?

iii. Where are the potential kidnapping hotspots within the study area?

iv. What is the spatial relationship among land use and land cover, distribution of security posts and kidnapping activities in the study area?

1.5 Scope and Limitation of the Study

The study area was defined as the length of the road Dikko junction and Kaduna city gate with the width of 20 kilometers on both sides along the Abuja-Kaduna expressway. Coordinates of kidnapping hotspots within the study area was taken on the field with the aid of the Nigeria Police Force. Similarly, the divisional police station within the area of study was identified and their coordinates taken. Specifically, the research produced maps of hotspot locations of within the study area, divisional police stations and the land use and cover map of the study area.

1.6 Justification for the Study

Abuja being the capital city of Nigeria obviously houses more of the prominent people in the country. Various dignitaries; top government officials, international ambassadors, socialites, business men and women. Relatively, Kaduna being one of the border states to Abuja and the successor of the old Northern Region of Nigeria, which had its capital at Kaduna and now the state capital to an estimated 8,252,366 million people (Nigerian Population Commission, 2016) is also home to influential and prominent dignitaries, thereby making the only major road (Abuja – Kaduna) that links it to the federal city, busy and fluxed with highly prominent persons who are mostly the targets of the kidnappers. Despite the much gap yet to be filled by the Government, particularly the police force. The force have received so much commendation in it its effort in battling kidnapping. Of the bold measures put in place by the government over the years, includes The Nigerian police anti-kidnapping squad introduced in the 2000s to stem the menace in spite of which kidnapping has still prevailed even with the series of engagement by other security forces on kidnappers along the highway. The effort so far has been to no avail mainly due to lack of sufficient information management.

As an entity, kidnapping like other spatial crimes has spatial attributes, that is, location, time and process. In essence, availability and quick access to timely and up-to-date spatial information about crime prone areas, to the law enforcement agencies, will in no small way contribute to effective policing of the entire area. Generally speaking, policing methods in Nigeria are still manual and un-automated. The old filing system of record-keeping is still in use. This limits the force from having the technological edge over the ever increasing technology sophistication of the criminals (Balogun *et al.,* 2014).

Also, the nature of forests, which comprises of land, trees and other forms of vegetation pose it a security threat as bandits, criminals, armed groups, rebels, insurgents and terrorists can use them

in carrying out their activities (Ladan, 2014). However, recent operations by the Nigeria police against kidnappers have seen an exchange of gunfire between the police and kidnappers in forests off Kaduna – Abuja highway. In relations to this, intelligence report suggests that some of the heavily armed notorious criminal gang situate their base and hideouts in the thick forest off Abuja- Kaduna highway. However, routine surveillance and raid by the police have unveiled kidnapper's hideouts to within and outskirt of villages along Abuja-Kaduna expressway (Onuoha and Okolie, 2019). They identified portions of the highway bordered by Kakau, Rijanah and Jere communities as the deadliest portion on the highway.

In generality, it is vital to note that criminals take cognizance of both manmade (settlements: villages) and natural features: land cover (thick forest), weather and season to situate, plan their hideouts and perpetrate crime (Michael *et al.,* 2001). Fortunately, these features are geographically defined by their locations in coordinates. Nonetheless, not much has been documented with regards geo-database creation and map production which can be used to know areas highly risked to kidnapping, the spatial distribution of security posts, their operational distance to the locations where we have recorded kidnapping activities and kidnapping hideouts for proper spatial analysis to develop models and maps to help security operatives monitor and manage kidnapping activities and in essence take informed decisions along Abuja-Kaduna highway to counter kidnapping.

Conclusively, with the unending incidence of kidnapping in the country, particularly along Kaduna – Abuja highway, where kidnappers mostly target citizens on transit, to and from the federal capital city. The essence of this research is to come up with solutions through spatial analysis of spatial data and data on reported kidnap cases along Abuja – Kaduna road to help stake holders, security agents and personnel for proper planning and allocation of resources,

security post facilities and deployment of security personnel to ensure the safety of lives and property around the area

1.7 Study Area

1.7.1 Geographical location

This study was carried out for Abuja – Kaduna expressway which lies between the boundaries of the Abuja, Niger and Kaduna states (Figure 1.1) and falls within longitude 6˚00ˈ to 8˚00ˈ east of the Greenwich Meridian and latitude 9˚00ˈ to 11˚00ˈ north of the Equator with a total length of 123km, from Diko Junction to Kaduna. (See figure 1.2).

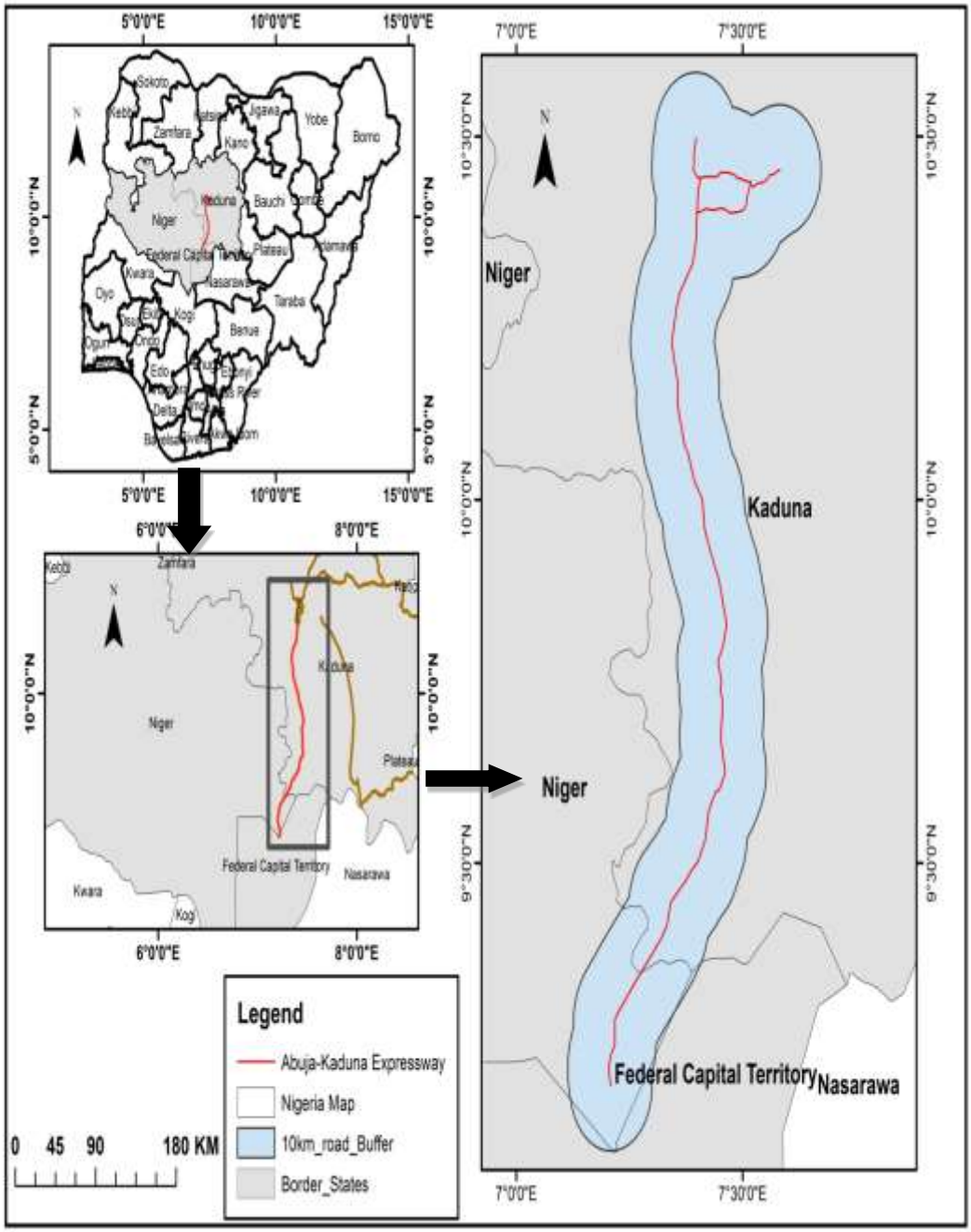

Figure 1.2: The Abuja-Kaduna Highway, Nigeria

Source: Dangana, 2021

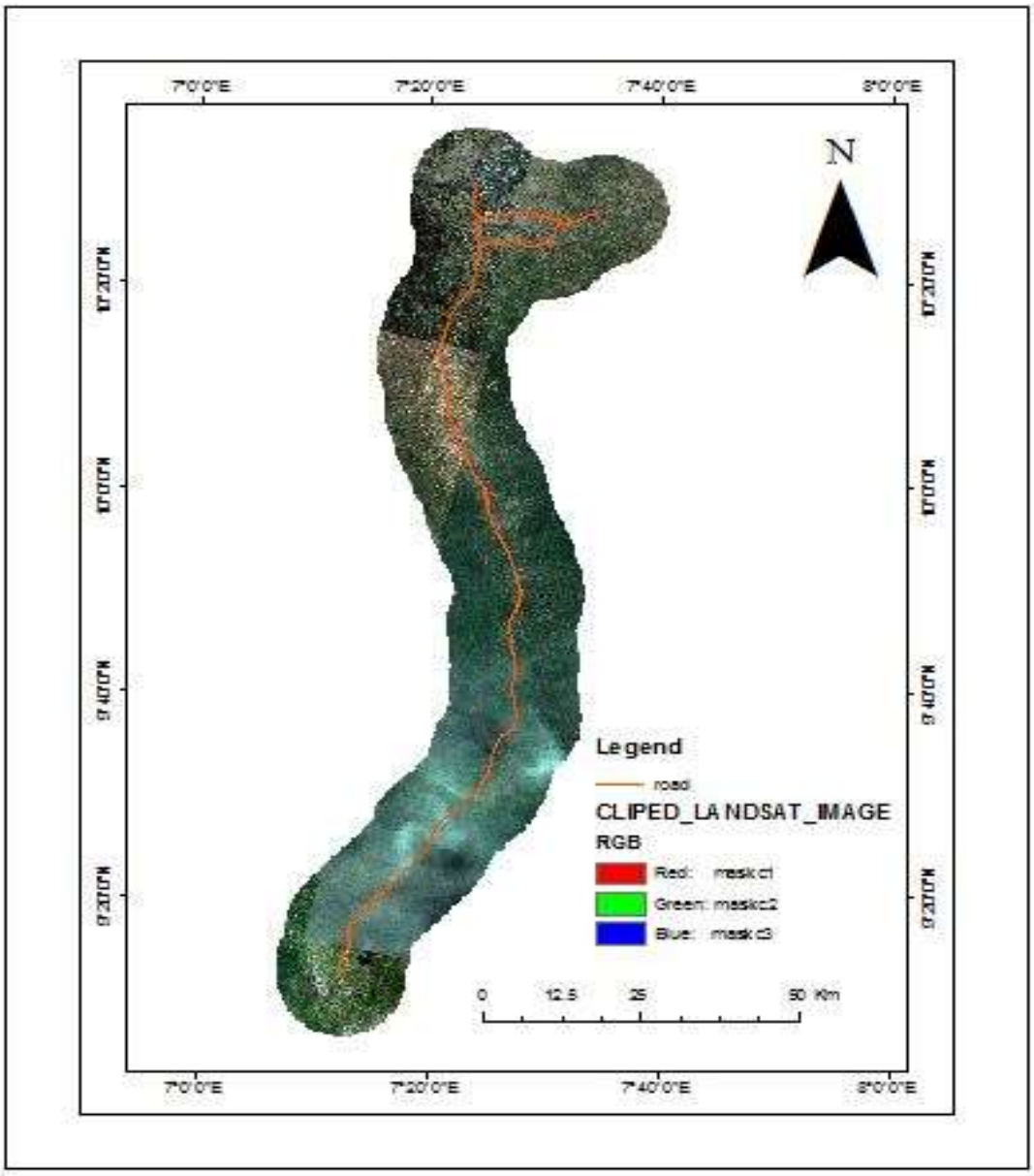

Figure 1.3: Satellite Image of the study area showing the Abuja-Kaduna Highway

Source: Dangana, 2021

The Abuja-Kaduna expressway lies between the borders of the Federal Capital Territory, Niger state and Kaduna state with major part of the road in Kaduna State. Therefore, the weather, climate, soil, vegetation, relief and drainage and socio-economic activities of FCT, Kaduna and Niger state shall be adopted for the study area for the purpose of this research.

1.7.2 Weather and climate

The Abuja – Kaduna expressway experiences the tropical savanna climate or tropical wet and dry climate beginning from the tropical rainforest climate boundary in southern Nigeria to the central part of Nigeria, where it exerts enormous influence on the region. The tropical savanna climate exhibits a well marked rainy season and a dry season with a single peak known as the summer maximum due to its distance from the equator. Temperatures are above 18 °C (64 °F) throughout the year. Abuja, Nigeria's capital city found in central Nigeria, has a temperature range of 18.45 °C (65.21 °F) to 36.9 °C (98.4 °F), and an annual rainfall of about 1,500 mm (59.1 in) with a single rainfall maxima in September. The single dry season experienced in the tropical savanna climate in the central Nigeria beginning from December to March, is hot and dry with the Harmattan wind, a continental tropical (CT) air mass laden with dust from the Sahara desert prevailing throughout this period.

With the Inter Tropical Convergence Zone (ITCZ) swinging northward over West Africa from the Southern Hemisphere in April, heavy showers coming from pre-monsoonal convective clouds mainly in the form of squall lines also known as the north easterlies formed mainly as a result of the interactions of the two dominant air masses in Nigeria known as the Maritime tropical(south westerlies) and the Continental tropical(north easterlies), begins in central Nigeria while the Monsoons from the south atlantic ocean arrives in central Nigeria in July bringing with it high humidity, heavy cloud cover and heavy rainfall which can be daily occurrence lasting till September when the monsoons gradually begin retreating southward to the southern part of Nigeria. Rainfall totals in central Nigeria varies from 1,100 mm (43.3 in) in the lowlands of the river Niger Benue trough to over 2,000 mm (78.7 in) along the south western escarpment of the Jos Plateau (Olayemi *et al.*, 2014).

1.7.3 Soil and vegetation

Basically the vegetation of the study area could be termed to be partly Sudan Savannah type, characterized by scattered short trees, shrubs and grasses and partly Guinean forest-savanna mosaic, made up of plains of tall grasses which are interrupted by trees, the most common across the country. The soil type is mostly loamy to sandy type. A substantial amount of clay is found also. (Ako *et al.*, 2014).

1.7.4 Relief and drainage

The study area is part of the extension plains of northern Nigeria. The general relief of the area is fairly plain, with isolated rock outcrops of inselbergs found in the area, thus creating undulations. The inselbergs are granitic in origin, formed from underlaid basement complex rocks. Depressions are found along the water courses where streams occur. The Niger River Basin Drainage System is the major drainage system of the study area (Clement, 2013).

1.7.5 Socio-economic activities

The economy of the settlements along Abuja – Kaduna express way is agrarian based, with agriculture as their major economic activity, which serves as the bedrock of other activities. These activities include food and cash crop production, livestock rearing, poultry trading and crafts making.

The major system of farming practiced is the subsistence farming by peasant farmers, with few people investing in commercial farming which produces large quantity of agricultural products. A little dry season farming is practiced in the area by people living close to the rivers. Tomatoes, pepper, vegetables, onions, okra and sugar-cane are grown in the Fadama areas. These additional products attract traders from surrounding urban centers and towns, thereby constituting a major source of income.

Animal rearing is also an important occupation which is carried out in a form of subsistence mixed farming, apart from the Fulani in the area who depend largely on cattle rearing. These animals supply organic manure to farm lands, provide income and also are used for consumption. Animals such as cattle, goats, pigs, sheep and poultry are the predominant animals reared in the area. Trading activities also form another vital occupation that combines both agricultural and non-agricultural commodities made from crafts (Adewuyi *et al.*, 2019).

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter reflects generally on the scientific methods and related literatures which can be used to set the pathway for the research on intelligence mapping of potential kidnapping hotspots.

2.1 Review of Concepts

This section discusses the relevant concepts to the research under the following headings: kidnapping as a crime, reasons for kidnapping, factors influencing kidnapping, general implication of kidnapping, kidnapping as a spatial crime and the role of remote sensing and GIS in crime management.

2.1.1 Kidnapping as a crime

Kidnapping is the forcible seizure, taking away and unlawful detention of a person against his/her will. It is a common law offence and the key part is that it is an unwanted act on the part of the victim (Inyang and Abraham, 2013). Another definition by (Salihn *et al.,* 2019) conceived kidnapping as the forceful or fraudulent abduction of an individual or a group of individuals for reasons ranging from economic, political, and religious to struggle for self-determination. Uzorma and Nwanegbo-Ben (2014) also defined kidnapping as the "act of seizing and detaining or carrying away a person by unlawful force or by fraud, and often with a demand for ransom". It involves taking a person from their family forcefully without their consent with the motive of holding the person as a hostage and earning a profit from their family". From the foregoing, the definition of kidnapping has no one best way to describe it, but it is clear that for an act to be deemed kidnapping, it shall involve conceive movement of a victim from one place to another, detention or seizure of that person, be it a child or an adult. Inyang and Abraham (2013) added that, it is legally regarded as a restriction of someone else's liberty which violates the provision of freedom of movement as enshrined in the constitution of Federal Republic of Nigeria, where every other law takes its cue from.

2.1.2 Reasons for kidnapping

Even though there is no justification to kidnap and abduct another individual, criminals carry out the act of kidnapping for various reasons and intentions, such as for ransom, adoption, begging,

illicit intercourse, marriage, prostitution, political interest, rituals, slavery, unlawful activity, murder and for other purposes (National Crime Records Bureau, 2014).

2.1.3 Factors influencing kidnapping

The act of kidnapping can be tied to certain factors that attract people into it. Below are some of the leading factors that encourage kidnapping:

Poor security system

Unemployment

Leadership failure

Loss of societal value

2.1.4 General implication of kidnapping

Over the years, kidnapping has led to the loss of lives and huge sum of innocent victims; it affects the psychology of the direct victims and their families and spreads fear in the minds of citizens. In the short term, it hinders direct economic investment in the area where this evil act is being perpetrated and in the long term it leads to decline in economic productivity and unemployment and a threat to the government in convincing investors to do business in the country (Noble *et al.,* 2015).

2.1.5 Kidnapping as a spatial crime

Kidnapping as crime is a human tendency. Therefore, for someone to commit a crime, one must come from a place (such as their home, work or school). This place could be the same location where the crime is committed or is often close to the place where crime occurred. Therefore, place plays a vital role in understanding crime. To reduce crime, geography of crime needs to be

understood as crime has an inherent geographical quality. When a crime occurs, it happens at a place with a geographical location (Chainey and Ratcliffe, 2013).

Crime are usually not randomly distributed in space or not distributed in a definite pattern across space (Cozen, 2005;Wilson and Bocij, 2003) as cited by (Oyinloye and Olamiju, 2018). For instance, some areas have records of more crime incidence than others, and the kinds of crimes differ from one area to another. Identifying high crime areas or hot spots plays a key role in how law enforcement agencies operate and address crime in problem areas for strategic and problem-solving purposes. Identifying high crime areas can be useful for the development and evaluation of police responses, and testing for spatial displacement or diffusion of benefits (Braga and David, 2010), this clearly define the concepts of hot and cool spots. When analyzing crimes or a particular crime such as kidnapping, areas of concentrated crimes or where certain crime occur the most are often regarded as "Hotspot" (Eck *et al.*, 2005). Even though different people have defined hot spot of crime in different ways based on their understanding, the common understanding is that a hot spot is an area which has recorded a greater number of criminal events relative to other locations or area within the scope of the investigation or study (Eck *et al.*, 2013). It could also be seen as an area where people are faced with a higher risk than average of being victimized. Hence, this leaves the question of what should be termed places or areas with less than average amount of risk of being victimized by kidnappers thus the suggestion for the existence of cool spots. Cool spots are simply areas or places with little or no risk of being victimized (Eck *et al.*, 2005).

2.1.6 The role of remote sensing and GIS in crime management

Geographical Information System (GIS) and Remote Sensing (RS) is a tool for analyzing criminal events. A geographic information system integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information (Rudow and Sounny, 2014).

Thangavelu *et al*. (2013) discussed about the importance of GIS, as it can be used as a tool to identify factors contributing to crime and thus allow police department to proactively respond to the situations before they become problematic. However, satellite imageries are used in every part of the world by security agents and detectives both large and small, to provide spatial solutions for crime analysis, tracking crimes, traffic safety, community policing, Intranet/Internet mapping, and numerous other tasks (Oyinloye and Olamiju, 2018). Also, as cited by (Oyinloye and Olamiju, 2018), that; (Ajide *et al.,* 2004) opined that the use of Satellite image to obtain land cover information at more frequent intervals are more economical than those obtained by traditional methods". For instance, (Balogun *et al.,* 2014) examined crime situation in Benin metropolis using questionnaire to elicit information from the public and the police. Result shows that crime is on the rise and that the police are handicapped in managing it because of the obsolete methods and resources at their disposal. It also reveals that members of the public have no confidence in the police force as 80% do not report cases for fear of exposure to the informant to the criminal. In the light of these situations, this research looks at the possibility of utilizing GIS and remote sensing in tackling the problem in this area.

GIS and Remote Sensing can be used for visualizing the data, analyzing the facts, and to take firm decision based on the analysis. This can be used to map the Police stations and to identify

the crime zones as hot spots and to statistically analyze the reported crime which will help to take effective measures to control the crime (Sivaranjani andSivakumari, 2015).

2.1.7 Hotspots mapping

A hot spot is an expression indicating the clustering of events in a spatial distribution. Hence Crime locations are as important and crucial as the characteristics of those places and the environment where crime occurs. Hence a crime hotspot is a place where crime occur the most. The hot spots are where the occurrence of a certain crime or a collection of crimes is so frequent such that it is highly predictable, at least over a 1-year period (Sherman, 1995). Generally, the concept of hotspot applies to crimes perpetrated on the street rather than white-collar crime, organized crime, or terrorist crime.

In mapping hotspots, several cluster analysis have been developed into several general categories. Point locations, this is the most intuitive type of cluster involving the number of incidents occurring at different locations. Locations with the most number of incidents are defined as ‘hotspots’.

2.1.8 Heat map

The “heat” refers to the concentration of the geographic entity within any given spot. Heat Maps are graphical representations of data that utilize color-coded systems. The primary purpose of heat maps is to better visualize the volume of locations/events within a dataset and assist in directing viewers towards areas on data visualizations that matter most. Heat maps are extremely versatile and efficient in drawing attention to trends. They are innately self-explanatory, the darker the shade, the greater the quantity (the higher the value, the tighter the dispersion). When existing data visualizations are paired with heat maps, their ability to rapidly communicate key

data insights to the viewer is greatly enhanced (Vasileva *et al.,* 2018). Heat mapping is a geographical way of visualizing, such that patterns higher than average occurrence of events such as crime incidence and activity, traffic accidents in a location can emerge (Hooge and De, 2016). Heat maps are created by interpolating discrete points to create continuous points surface known as density surface. A heat map is a hotspot surface map similar to the temperature map one might sight on the weather report (McLafferty *et al*., 2000). The map actually shows kernel density surface map of the crime intensity. This process involves estimating the density of crime across an entire two dimensional study area, based on the known locations of discrete events (Sha and Xie, 2016).

2.1.9 Crime location quotient (CLQ)

Location quotient has been fondly used in Urban and regional planning to measure the densities of local economic activities of different industry departments (Wuschke *et al.,* 2021). In criminology it is termed "Crime location quotient", used to analyze the collocation patterns of various point sets. The crime location quotient is based on the location quotient. The CLQ measures the overall extent to which category A points (crimes in the within study) are attracted to category B points (land-use features within study). It provides yet another understanding of why particular crimes occur in particular places by capturing those factors that attract criminal activities. Location quotients are able to identify specialization in crime even in the presence of a small crime count (Termurcin and Dziwornu, 2016).

2.1.10 Land use and land cover classification

Land cover is the observed bio physical cover on the earth's surface. When considering land cover in a very pure and strict sense, it should be confined to the description of vegetation and man-made features. Consequently, areas where the surface consists of bare rock or bare soil are

land itself rather than land cover. Also, it is disputable whether water surfaces are real land cover. However, in practice, the scientific community usually includes these features within the term land cover.

Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. In this view, land use establishes a direct link between land cover and the actions of human in their environment. The following examples are a further illustration of the above definitions:

- "Grassland" is a cover term, while "rangeland" or "tennis court" refer to the use of a grass cover; and
- "Recreation area" is a land use term that may be applicable to different land cover types: for instance sandy surfaces, like a beach; a built-up area like a pleasure park; woodlands; etc.

Classification is an abstract representation of the situation in the field using well-defined diagnostic criteria. Sokal (1974) defined classification as: "the ordering or arrangement of objects into groups or sets on the basis of their relationships". A classification describes the systematic framework with the names of the classes and the criteria used to distinguish them, and the relationship between classes. Classification thus requires the definition of class boundaries, which should be clear, precise, possibly quantitative, and based upon objective criteria. A classification should therefore be: scale independent, meaning that the classes should be applicable at any scale or level of detail; and source independent, implying that it is independent of the means used to collect information, whether it is through satellite imagery, aerial photography and field survey or using a combination of sources.

2.2 Theoretical Framework

2.2.1 Crime event places and crime theory

Crime event places and crime theory describes how the study of crime and place have been harmonized and applied to crime prevention. Three theoretical perspectives (rational choice, routine activity and crime pattern) theories have influenced our understanding of the importance of place in crime prevention efforts.

The rational choice perspective describes the basic rationale for studying place in crime management. It suggests that offenders will select targets and derive means to meet their goals as explained by (Cornish and Clarke, 1986).

The routine activity theory explains how crime events occur when there is the presence of certain circumstances (Cohen and Felson, 1979;Felson, 1986, 1994). A motivated offender, a desirable target, the target and the offender must be at the same place at the same time. Finally, three other types of controllers (intimate handlers, guardians and place managers) must be absent or ineffective. Intimate handlers are people who have direct personal influence over an offender (such as parents, teachers, coaches, friends or employers). In the presence of such people, potential offenders do not commit crimes. Most adults are away from intimate handlers for many hours of the day and many offenders, both juvenile and adult, have few or no intimate handlers. Guardians are people or authority who can protect the target.

Crime pattern theory is essential in the understanding of crime and place. It combines rational choice and routine activity theory to aid the explanation of crime distribution across places. Hence, the distribution of offenders, targets, handlers, guardians, and managers over time and place will describe crime patterns. Pattern theory explores the interactions of offenders with their physical and social environments that influence offenders' choices of targets. According to crime

pattern theory, how targets come to the attention of offenders influences the distribution of crime events over time, space, and among targets (Brantingham and Brantingham, 1993). This occurs because offenders engage in routine activities. Just like other, non offending individuals, offenders move around the schools, work places, shopping, and recreational centers. As they conduct their normal legitimate activities, they become aware of criminal opportunities. Thus, criminal opportunities that are not near the areas offenders routinely move through are unlikely to come to their attention. A given offender will be aware of only a subset of the possible targets available. Criminal opportunities found at places that come to the attention of offenders have an increased risk of becoming targets (Brantingham and Brantingham, 1993). While a few offenders may aggressively seek out uncharted areas, most will conduct their searches within the areas they become familiar with through non-criminal activities.

2.2.2 Crime hot spot theories

Some theories help explain point concentrations of crime. Other theories help explain linear concentrations of crime or hot spot crime polygons. Place theories deals with crimes that occur at the lowest level of analysis (specific places). Crime phenomena at this level occur as points, so the appropriate units of analysis are addresses, street corners, and other very small places, which are typically represented on maps as dots. Street theories deal with crimes that occur at a slightly higher level than specific places; that is, over small, stretched areas such as streets or blocks.

2.3 Review of Literature

2.3.1 Land use and land cover classification

Remote Sensing and GIS are efficient tools for land use/land cover classification and mapping over a space and time (Abbas, 2012). Ezeomedo and Igbokwe, (2013) carried out mapping and analysis of LULC using high resolution satellite images and GIS in Onitsha. The authors made

use of multi-temporal data which consists of existing Topographical map, SPOT-5 and IKONOS images. The data were processed using spatial analysis tools of resampling, georeferencing, classification and post-classification overlay, to map the patterns and extent of land use and land cover in the study area as well as determine the magnitude of changes between the years of interest, 1964, 2005 and 2008 respectively. Land cover classes: built-up areas, open/bare land, water bodies and vegetated area were adopted for the study. The study shows the effectiveness of remote sensing as a tool for mapping and analysis of land use and land cover at various levels for planning. This system enables the capability for repetitive coverage of an area which is required for change detection studies to ensure planned development and monitoring of land utilization pattern, preparation of land use and land cover map when necessary. The study demonstrates the effectiveness of satellite data for the preparation of accurate and up-to-date land-use/land-cover maps depicting existing land classes.

Similarly, Lekha and Kumar (2018) carried out a study "Classification and Mapping of Land Use Land Cover change in Kanyakumari district with Remote Sensing and GIS techniques" as published in the International Journal of Applied Engineering Research. The study was primarily undertaken to analyze the LULC of kanyakumari district, where there has been great environmental impact on vegetation, forest, ground water pollution and also deterioration of bare land with more built-up and dumping of garbage as a result of the increase of population and climatic variability. Built-up areas, water bodies, agriculture land, hilly areas, forest and bare land were the categories of LULC classes adopted for the study. Google earth and photo interpretation was used to analyze the accuracy by finding the error matrix. The study shows developed spatial map can serve as an efficient technical vehicle for spatial analysis and spatial modeling functions, to gain insights into developmental problems, e.g. to evaluate development

impacts in the past, and to enhance regional development strategies through facilitating various scenarios. It is expected to be useful for formulating meaningful plans and policies so as to achieve a balanced and sustainable development in a region.

The assessment of land use and land cover changes in a section of Niger Delta, Nigeria for the years 1986 and 2008 using landsat TM imagery of 1986 and Nigeriasat-1of 2008 respectively by (Abbas, 2012), the magnitude, trend and annual rate of change analysis of different classes for the years under study was generated. The analysis was further used to as a yard stick to project the land use and land cover situation for the year 2050. Majumder, (2011) carried out a study to detect changes in land use and land cover of Sukinda valley using remote sensing and GIS. The researcher used ERDAS imagine and Quantum GIS to analyse landsat data of 1975, 1991 and 2005 to detect land use and land cover changes in the study area. The study was aimed to assess the extent of land consumed by quarries as against forest land due to mining activities in the area. Hence quarry, dense forest, non forest area and water body was determined as the classes for the classification scheme. The result unveiled a tremendous growth in mining activities between 1975 and 2005 at the expense of forest areas which experienced decrease.

In addition, a study of land use and land cover detection of Mirzapur Union of Gazipur District by (Yesmin *et al.*, 2014) to monitor and analyze the spatio-temporal land use and land cover change patterns of the study area for a period of 20 years. landsat TM imageries of the years 1989 and 2009 with 30mx30m spatial resolution were considered to detect LULC changes of the study area. Findings from the study indicates that forest cover and water bodies decreased by 20.29% and 6.25% respectively while in the same period, settlement area and bare land increased by 28.64% and 20.91% respectively. The author attributed the change to agricultural and

economic demands as well as urbanization as a result of population growth in the area within the period of study.

2.3.2 Mapping security posts

Ezemeyovwi and Ochuko (2015) cited a research done by Sonoye on Remote Sensing/GIS based evaluation of "the adequacy of police stations in Ikeja LGA, Lagos State" and considered a direct relationship between likelihood to commit crime and distance away from a police station. Thus, the research opined that efforts at mobilizing police facilities and/or establishing new stations, should give precedence to geographical spread, population characteristics and crime incidents. As a veritable tool for site selection, the application of GIS could yield a remarkable benefit in evaluating and integrating these parameters into selecting suitable sites (for additional stations) if and when considered necessary. Furthermore, he stated the merits for enhanced management of crime in wide and diverse and that GIS tools can be used to select optimal locations for police facilities especially police station, to design and formulate crime-based policies, to analyze the variables that enhance crimes (e.g. the social and economic characteristic of offenders and hot spot areas), to store and retrieve crime records, to pick offenders with global positioning systems (GPS), to visualize crime occurrences and patterns with a view of identifying these hot spot areas.

Abbas *et al.* (2012) carried out a healthcare facility and data base creation study using GIS. The study investigated the spatial distribution of healthcare centers in Chikun local government area of Kaduna state Nigeria for management and planning purposes. Administrative map of the study area collected from the local government was used as base map. Information regarding the healthcare facility center number and their addresses was collected from the local government.

Global Positioning System (GPS) was used to obtain the coordinates of the healthcare centers. These data were imported into GIS environment and analyzed using ArcMap 9.2 software. The study shows how GIS can be a veritable tool used to reveal the pattern of distribution of a certain facility within an area for planning and decision making.

2.3.3 Identifying kidnapping hotspots

Safiyyanu (2015) carried out geospatial mapping of crime hotspots in Gundumi forest reserve of Sokoto state in Nigeria. In the study, one of his objectives includes; to identify locations of major crime activities in the study area. The methodology adopted to carry out his objective involved a reconnaissance survey to help gain acquaintance with the study area. In the course, he involved the police divisions in the study area who gave him insight on the crime issues in the area. He adopted the concept of Geospatial intelligence (GEOINT) technique. The data obtained for his study includes; Topographic Map of the study area (1;50,000), crime records (year the crime was committed, type of crime, crime scene location and frequency of the crime) from the Police Divisions and DSS Offices of the study area and the crime scene coordinates were collected with the use of Global Positioning System (GPS) receiver.

The coordinates of the various crime locations were then imported into the ArcGIS 10.1 environment, and point overlay analysis (mapping) was carried out. The study postulates that; mapping crimes which includes kidnapping is a vital and essential aspect of crime monitoring, assessment and management. From the study, success can be attained in managing crime when there is comprehensive baseline information about criminal dwelling units and other criminal hideouts. The information and data gathered can be relied upon as a basis on which security infrastructures can be built. Also, it gives an insight into the nature, types, trend, hotspots and

time at which these notorious activities take place. The information data on the underlining causes, the perpetrators of certain crimes in an area can be deduced. It also allows for the analysis of vulnerable location and effectiveness of security resources allocation.

Ayuba *et al.* (2016), carried out Geo-spatial analysis of crime in Kaduna metropolis, Nigeria. The major objective of the research was aimed at mapping and analyzing crime in Kaduna metropolis, Nigeria using Geo-Spatial Technique. Eleven (11) crime types were slated to be mapped for the study within the study area between 2010 and 2011 based on crime categorization by the Nigerian Police Force. The crimes included Kidnapping, Armed Robbery, Murder/Homicide, Assault, Theft/Stealing, Rape, Forgery, Burglary/Home Breaking, Suicide, Cheating and Hurting/Fight.

To achieve the objective of the research, the researchers sourced administrative maps from the Kaduna State Ministry of lands and survey. The map was used to delineate the districts according to the Divisional police headquarters jurisdiction in Kaduna metropolis. Crime data was obtained from the Police divisional headquarters in Kaduna. The researchers stated that there were a total of Seventeen (17) divisional head quarters within the study area and only fifteen (15) of these divisional headquarters provided consistent records on crime incidence. The Crime data collected from all the fifteen (15) divisional headquarters was used for the Crime mapping analysis.

The technique adopted by the researchers in analyzing the crime data involved a combination of descriptive and overlay analysis of the data. The descriptive statistics such as appropriate maps, line graphs, bar graphs, and tables were employed to illustrate the distribution of the crime types and incidences in the study area. The study advanced further to assess crime hot spots in the study area. To achieve this, they created an attribute table of crime data in ArcGIS 9. The

attribute table was then used to provide crime maps and high crime spots within the study area. The Authors however noted that identifying hotspots, onspot (point) that is, exact spot where this crime were perpetrated within the study area was difficult to ascertain because the crimes were not documented with geographic coordinates. Therefore they adopted a work by (Bala *et al.*, 2015) where the clustering method was used to identify crime hotspot. The hotspots were identified using crime average for the various wards. Hence, wards with crime above the average were marked or identified as hotspots. Therefore, identifying the crime hotpots in this study was achieved using the formula below: Average Crime Incidence = Total number of crime cases ⁄ Total number of areas

Conclusively, the study showed that crime is not evenly distributed but randomly spread across an area and it clumps in some areas and in some areas it is almost absent or entirely absent. The study showed how GIS as a tool can be used effectively to analyze crime and display crime maps for adequate planning in terms of resources and personnel deployment towards combating crime in the study area. From the study, the need to record crime data alongside their geographic coordinates of their incidence spot to permit hot spot analysis at point level was observed.

Kedia (2016) conducted a study on crime mapping and analysis using GIS. The study was carried out in Faribada in India. The primary objective of the work was to map out several crimes such as crime against women, murders, theft, illegal drug and liquor trade and its consumption in public. Crime data of the study area collected had no geographical coordinates identifying the locations where these crime occurred which makes the data unsuitable for any analysis on a GIS environment. Hence, the Author adopted the use of the location sharing feature of WhatsApp, being the medium used by investigation Officers to send in crime data. Hence, the various crime

locations were filed into different spreadsheet according to the respective Police station area providing the data in company of non-spatial attributes.

Haven solved the problem of crime locations; the author adopted the use of maps from open street maps available as plugin of the GIS Software QGIS analysis. Heat maps for the various police station of the study were produced. In the map three different colors were used to show areas of high, medium and low intensity of crime. Ground investigations, which involved the use of handheld high precision GPS and a digital camera for pictorial coverage of hot spot (where possible) was carried out. The pictures helped the researcher in understanding why certain crimes occurred most in those areas. Conclusively, crime data was used to produce heat map which depicts crime hotspots and crime pattern which in turn would help the police with support in decision making and help in effective use of the available force and scarce resources.

Ahmad *et al.* (2018) carried a study on the role of Geospatial technology in crime mapping, a case study of Jharkhand state of India. District wise crime data (murder, rape, kidnapping, dacoity, burglary, theft and riots) was collected. The analysis and evaluation was done using ArcGIS Software and Microsoft Excel. Various district wise attribute columns in polygon vector layer for the crimes types murder, rape, kidnapping, dacoit, burglary, theft and riots. Population data was also collected. The Indian census data 2011 (latest) was used to understand crime density for each district. Their result was presented in a graph showing the violence crime density (crime per lakh population) of Jharkhand for the year 2013. The study shows the role of remote sensing data, GIS and GPS to harness variety of applications in crime mapping, prediction and identification. The research showed how recorded crime data and their respective locations when analyzed with other thematic data sets such as location of police station, road

network, shopping malls, buildings, bus stand, recreational centre with urban sprawl, mobile police van location and installed camera location etc manifest several logical clues which can be highly useful for crime identification and prevention.

Kannan (2017), carried out a study on crime mapping analysis of ajmer city using GIS approach. Crime type data (murder, attempt to murder, rape, kidnapping, robbery, home breaking day and night, automobile theft and other theft), Non-spatial attribute data (Census data) and ward map were collected. GPS was used to collect geographic locations of crime incidence. The study involved the creation of the database of spatial and non-spatial attribute of crime and time series analysis to understand crime pattern of the study area, calculation of crime rate and identification of hotspots of different crime occurring in the study area. This study shows that GIS analysis on crime data can be used to provide insight to police with a view to decreasing crime rate.

Jitendra *et al.* (2012), carried out a study using geo-spatial approach to identify hotspots and safe zones of crimes in Uttar Pradesh. The various crimes considered were; murder, culpable homicide not amounting to murder, attempt to cossmmit murder, dowry death, hurt /grievous hurt (HGH), kidnapping and abduction, rape and riots. Hence the study was aimed to know the crime pattern of Uttar Pradesh in India, under consideration of demographic and geographic areas. Crime data of the study area was collected from State Crime Record Bureau. The hot spots within the study area were determined using the cluster analysis by SatScan and it was represented in geographic map by ArcView. From the spatial analysis of Uttar Pradesh crime data, the researchers were able to identify the maximum crime zone as hotspot while less crime area as safe zone.

2.3.4 Examining the spatial relationship of land use and land cover on crime

Ludin *et al.* (2013) analyzed the impacts of urban land use on crime patterns using GIS application. Digital data on land use and crime data and their attributes were obtained. Estimate on crime locations were made where exact locations of crime were not recorded by the police. The hotspot locations of the various crimes were overlaid on the google earth image for the analysis of influencing factors to criminal incidents. Based on the influencing factor analysis, it was found that crimes are related to land use. These findings revealed the spatial correlation between types and patterns of criminal activities and land use namely commercial (banks and shopping malls) and residential areas. The opportune spots for criminals are at roads with heavy traffic, pedestrian bridges and bus stops. The study revealed that the integration of spatial statistics and GIS can assist local authorities and police departments in particular, to identify hotspots for crime incidence and influencing factors to crime incidents.

Adebayo and Oriola (2016) reviewed a work similar to the one done Nwagwu to analyze the relationship between land use and crime in Sub-saharan Africa. Spatial data of the locations within the study area and the police security posts were collected using GPS, Aerial photo, topo maps and satellite imageries of the area. Non spatial data such as population was collected. Satellite imageries were used to identify and classify land use types. Data on the land-use were collected from relevant authority. Structured questionnaires were used to collect the land-use types affecting crime. Spearman rank correlation coefficient was used to determine the association between crime and population, crime and land-use. The result of the correlation analysis between population of wards and crime revealed a positive significant relationship.

However the correlation analysis between land use types and crime showed that not all land use types have significant correlation with crime. Land use types such as residential and commercial revealed high significant positive correlation. However, the result was consistent with the findings of previous researches which reported that the combination of commercial centers with residential areas can increase the risk of crimes (Wolfe and Pyrooz, 2014; Sohn *et al*, 2016). In summary, the research revealed that a combination of residential and commercial land uses in an area can increase the risk of crime occurrence in that area. It also revealed that the higher the population in an area the higher the crime rate. Finally the study have proven that with GIS, good maps can be produced to enhance proper monitoring of crime to enhance crime reduction. Security maps can also be used to recommend for the establishment of more security posts and gadgets to locations where necessary.

Sypion-Dutkowska and Michael (2017) carried out a research on the land use influencing the spatial distribution of urban crime. Multiple ring buffer and the crime location quotient (LQC) were used to analyze the influence of various land use on different crime types. The major deduction from this research indicated that land use types have a strong influence on crime types within a distance of 50m (0-50m zone). The research revealed that land use types are strongly attracting crime.

Yue *et al*. (2017) carried out a study on the patterns of crime and land use features. The collocation quotient was used to measure the extent to which crime locations are attracted by land use types within an area. There were limitations associated with the methods used in this study. First, each land use feature was represented as a point feature. However, some of these features covered large areas (e.g., industrial plants, markets, and universities). Simplifying polygons as points might produce a certain amount of deviation.

Sayafzadeh and Hassani (2014) carried out a study on the effects of land use in urban crime. The authors noted that the world has been greatly urbanized in the 21st century and based on this fact, the study seek to analyze the impact of land use on the spatial patterns of crimes in the unofficial settlement of Islam Abad and Zanjan. The softwares used for the research includes Arc GIS for spatial analysis of crimes and land uses while office excel was used for data formation. The findings indicated that the unofficial settlement of Islam Abad as a result of rural urban migration recorded the highest crime committed in residential area and mixed residential area than Zanjan. The study attributed the high crime rate in of Islam Abad as compared to Zanjan to; the amount of space converted to residential use as it was 3 times as much as Zanja, the population which was 6 times denser than the population of Zanjan, the absence of police uses in Islam Abad and the lack or short of required residential uses such as sanitary, urban installations, cultural recreational and leisure uses. The authors were particular on the recreational and leisure uses. That it helps to engage the residents and reduce or prevent crimes.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Reconnaissance Survey

In preparation for the study, a reconnaissance survey was carriedout for the purpose of acquaintance with the study area. The essence was to obtain vital information on the kidnapping activities in the area, to ascertain areas that would be asseesible with less security risk and to enquire and examine the distribution of the divisional police stations within the study area.

3.2 Data sources and data collection

The data to be used for this research work consists of primary and secondary data sources.

Primary data source: coordinates was obtained from field survey using Global Positioning System (GPS) for the kidnapping hotspots and divisional police stations.

Secondary source of data:

Satellite imagery (landsat8) of 30m resolution of the study area downloaded from the United States Geological Survey (USGS). Data of reported kidnap cases from the Nigerian police force, base map of the study area was obtained from USGS and relevant Journals, textbooks, thesis and the internet materials were utilized.

3.3 Method of data analysis

3.3.1 Land use and land cover mapping of the study area

To classify the Land use and land cover of the study area, landsat 8 satellite image of the study area for the year 2020 was downloaded from USGS. The landsat 8 image is raster image of 30m resolution. Prior to classification, the image was pre-processed and post- processed after classification.

3.3.1.1 Geo-referencing

To geo-reference the images, a sufficient number of Ground Control Points (GCPs) was identifiable on the image. Preferred GCPs were taken from recognizable, permanent features such as road intersection, large building and the points were well dispersed for accurate rectification. The image was projected on to the Universal Traverse Mercator (UTM) zone 32, WGS84 Minna datum for further analysis.

3.3.1.2 Digitizing

On screen digitization was carried out for the water bodies, road networks, settlements and other relevant features.

3.3.1.3 Image pre-processing

This was done to enhance the spectral properties of the multispectral image by using different filtering algorithms to enhance the image and obtain accurate attributes from the image. This involved image enhancement and reconstruction.

3.3.1.4 Image enhancement

The process of Image enhancement was undertaken on the satellite image to give it a better visual quality to aid its interpretation. This was done by manipulating the apparent contrast among various features in the scene.

3.3.1.5 Image reconstruction

Image reconstruction was carried out to subset the area of interest (AOI). This was done by using the boundary file of the area of interest to extract the study area from the entire satellite image scene.

3.3.1.6 Classification

The classification system used was based on Anderson, Hardy, Roach and Witmer (1976) land use/land cover classification scheme. Considering the study area, the Anderson *et al* (1976) level 1 classification was adopted and modified into five classes of trees cover areas, grassland, crop

land, built-up, and water bodies. Per-pixel image classification method for ground cover analysis was used through a supervised classification algorithm which is the process of using samples of known identity to classify unknown identity. The maximum likelihood was used being a classification method which assigns pixels to the class with the largest probability to determine ownership of a particular pixel.

3.3.1.7 Accuracy assessment

Subsequent to the processes performed above, the accuracy assessment is an important part of any classification project. It compares the classified result to another data source that is considered accurate or ground truth data. Hence, classification result shall be subjected to accuracy assessment as recommended by Food, (2002). For the individual classification, it was vital to carry out assessment accuracy to affirm the LULC analysis is efficient and done to precision (Butt *et al.*, 2015).

To assess the accuracy of a classified image a set of random points from the ground truth data was compared to the classified data in a confusion matrix.

-Open the "Create Accuracy Points" tool on ArcMap 10.7 and set the target field to ground truth. The ground truth layer determines the number and placement of the random points according to the sampling strategy.

-Select a random sampling strategy; this generates random accuracy assessment points across the entire input dataset. A table is created listing each random point as a record along with a field for ground truth and a field for the classified image. The "Ground Truth" field is populated with its value while the "Classified" field is filled with a null value (-1).

-Open the "Update Accuracy Assessment Points" tool.

-Set the "Input Raster or Feature Class data" as the classified dataset.

-Use the output from "Create Accuracy Assessment Points" tool as the "Input Accuracy Assessment Points".

-Set the “Target Field” to “Classified”.

The table is updated to include the value of each point based on the classified data. It now has both fields populated and is ready to be used to compute the confusion matrix.

-Open the “Compute Confusion Matrix geoprocessing” tool and use the table generated in the previous step as the input.

After seeing the results of the accuracy assessment, adjust training samples or classification parameters, or choose a different classifier to get a better result. If this is the case, use the new classified data as the input to the “Update Accuracy Assessment Points” tool and set the “Target Field” to “Classified” and run Compute Confusion Matrix using this output. After updating the ground truth data, there is and need to rerun the assessment again, there are two options. One is to use the new ground truth data as the input to the “Update Accuracy Assessment Points” tool and set the “Target Field” to Ground Truth. This will keep the same set of points that was created the first time you performed the analysis. Alternatively, is to start from the beginning and use the “Create Accuracy Assessment Points” tool to generate a new set of points. Another option is to create the points from the classified dataset and manually identify each point to populate the ground truth field. In this scenario, you would use the “Create Accuracy Assessment Points” tool, edit the Ground Truth Field, and run the Compute Confusion Matrix tool.

3.3.2 Mapping of divisional police stations

The handheld GPS (Garmin 84) was used to acquire the coordinates of the divisional police stations in the study area. A geo-data base for the divisional police stations was created. It contains the following informations: Name of the divisional police station and location of the divisional police stations (coordinates). This was entered in Microsoft excel, converted to text file and subsequently imported into the ArcGIS environment and point overlay analysis (mapping) was carried out on the base map of the study area to show the spatial distribution of security posts within the area of study and for further analysis.

3.3.3 Identifying and mapping kidnapping hotspots

Data of reported kidnapping hotspots obtained on the field with the aid of the Intelligence Response Team (IRT) of the Nigeria Police Force shall be used to create a geo-database which shall contain the following attribute: Name of kidnap scene, Location (Coordinates) of kidnap locations and their respective remarks. These data shall be entered in Microsoft excel, converted to text file and imported into ArcGIS environment. The database would be used for hotspot analysis and queries. The coordinates of the kidnap location shall be obtained using GPS receiver. The coordinates of the various crime locations shall be imported into the ArcGIS environment, and point overlay analysis (mapping) would be carried out on a base map of the study area and subsequently a map of the kidnap locations shall be produced. The data of the kidnap hotspots and their respective crime scene locations shall be used to produce the crime hotspot map of the study area in the form of a heat map which employs the Kernel Density Estimation (KDE) method using ArcGIS software.

3.3.4 Examine the spatial relationship of the study area among land use land cover information, divisional police stations and kidnapping activities.

The analysis for the spatial relationship between the influencing factors (land use and land cover) and kidnapping activities shall be executed based on the results from the hotspot analysis for the kidnapping activities. The LQC is the main tool to be used to evaluate the direction (attraction or detraction), range (distance zone), and the strength of the influence of specific land use or land cover class. The first step of the analysis shall be the geocoding of the reported kidnap cases and the LULC data. This step, like previous and subsequent steps of the analysis shall be performed in the ArcGIS environment. The shape file of the kidnapping hotspots shall be over laid on the land use and land cover map of the study area. Subsequently, the heat map of the kidnapping hotspots and the map of the divisional police station shall also be overlaid on the LULC map to give a unified map consisting the the land use and cover map, kidnapping hotspot map and the map of the divisional police stations. Hence with the ring buffer analysis, LULC class that are attractors to kidnapping in an area would be captured with shorter distance zone to the kidnapping incidence location while LULC class detractors to kidnapping in an area would be at longer distance zone to the kidnapping incidence location. Proximity analysis of the divisional police stations to kidnapping hotspots shall also be identified. Also, the hotspots locations shall be overlaid on the Google Earth image of the study area to facilitate the analysis of influencing factors to kidnapping incidents within the settlements.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents the result of the analysis and the discussion of the findings.

4.1 Land use and land cover mapping of the study area

With the 10 kilometer buffer on both sides of the highway, the land use and land cover is majorly dominated by tree cover which covers 43.97% of the entire area. The area covered by crop-land was ascertained to be 34.15%, grassland covered 15.46% of the area, built-up covered 6.17% while 0.25% of the entire study area is covered by water body. The built ups encompassed to form the various settlements which are sparsely distributed across the study area, though it is clustered and more concentrated in Kaduna city gate area as shown in figure 4.1. However, the dominant feature in the study area is the tree cover. Though the trees cover are not evenly distributed across the study area, it is found to be more concentrated in Kateri area than any area within the study area.

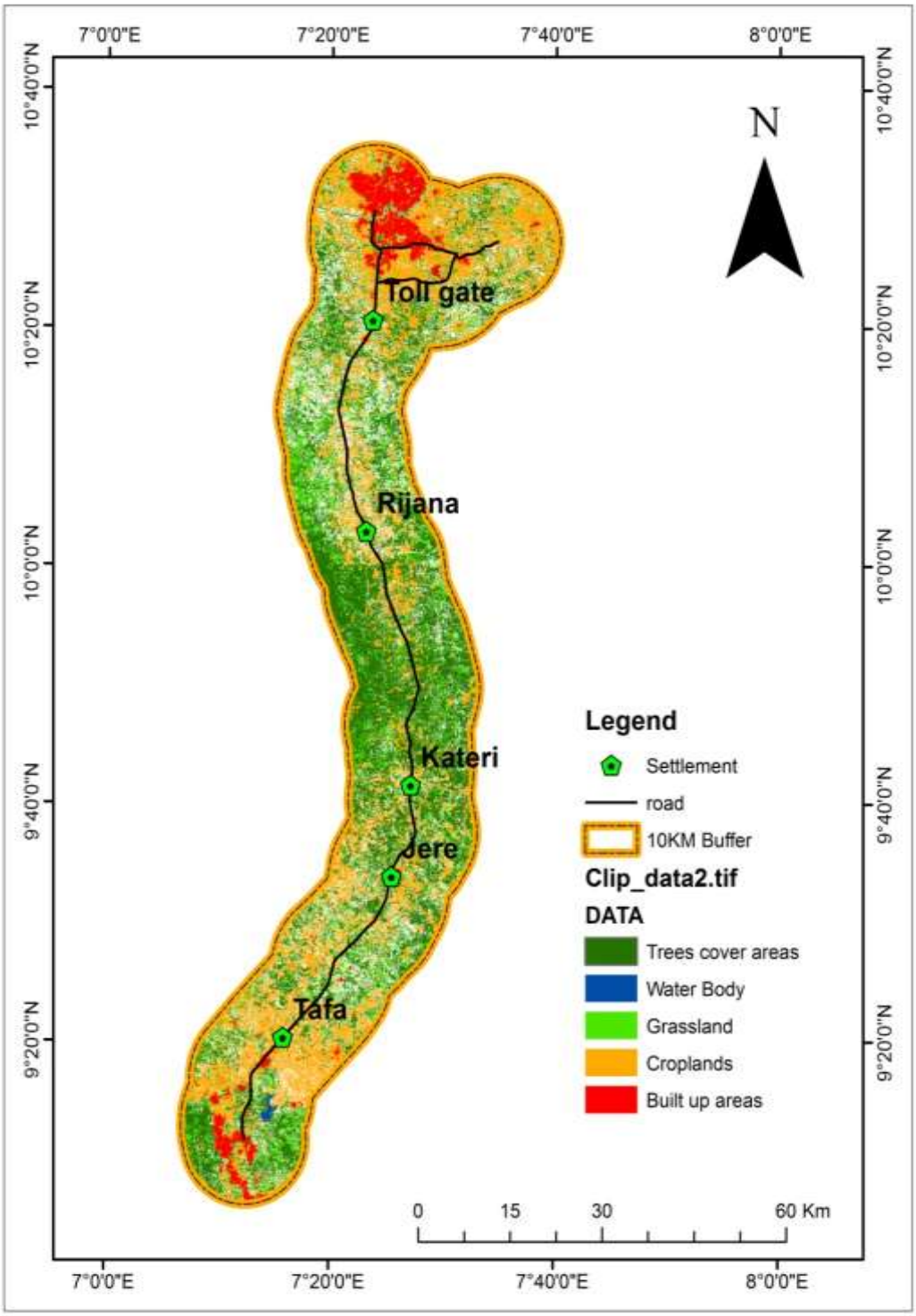

Figure 4.1: Land use and land cover of the study area

Source: Authors Analysis, 2021

4.2 Identifying and mapping divisional police stations within the study area

Figure 4.2, shows the distribution of the divisional police stations in the study area. The police stations which are few meters away from the road in their actual positions on the ground are revealed on the map as points on the road. This is due to the factor of the large scale used for the production of the map. The pattern of the divisional police stations is linear along the highway rather than being sparsely distributed, situated in the nucleus or within the settlements. The positions of the police stations could be seen to be a compromise, which undermines the police and community interactions which enables; vigilance of security agents over the activities of individuals within the settlements. Suspicious criminal activities and planning by kidnappers such as criminal gatherings, initiations and movements prior to kidnapping attacks and operations may go unnoticed.

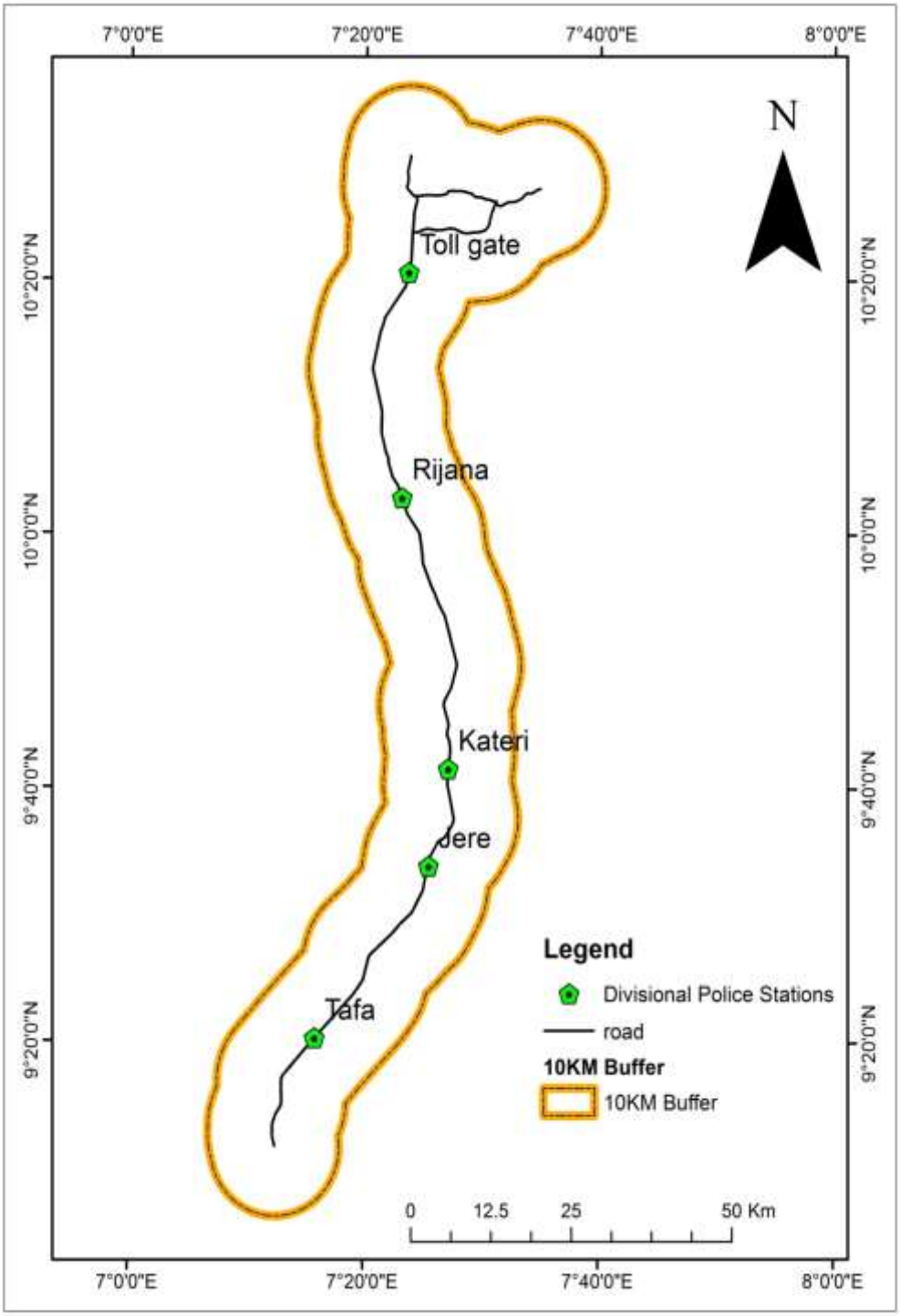

Figure 4.2: Distribution of divisional police stations in the study area

Source: Authors analysis, 2021

4.3 Identification and Mapping of Kidnapping Hotspots in the Study Area

Figure 4.3, shows the kidnapping hotspot in the study area. As revealed on the map, the Kateri area recorded the most kidnapping cases with more concentrated and clustered points while the Rijana area reported moderate cases of kidnapping with medium concentrated points. The Kaduna City Toll-gate, Jere, Tafa and Sabon Wuse reported fewer cases of kidnappings with less concentrated points.

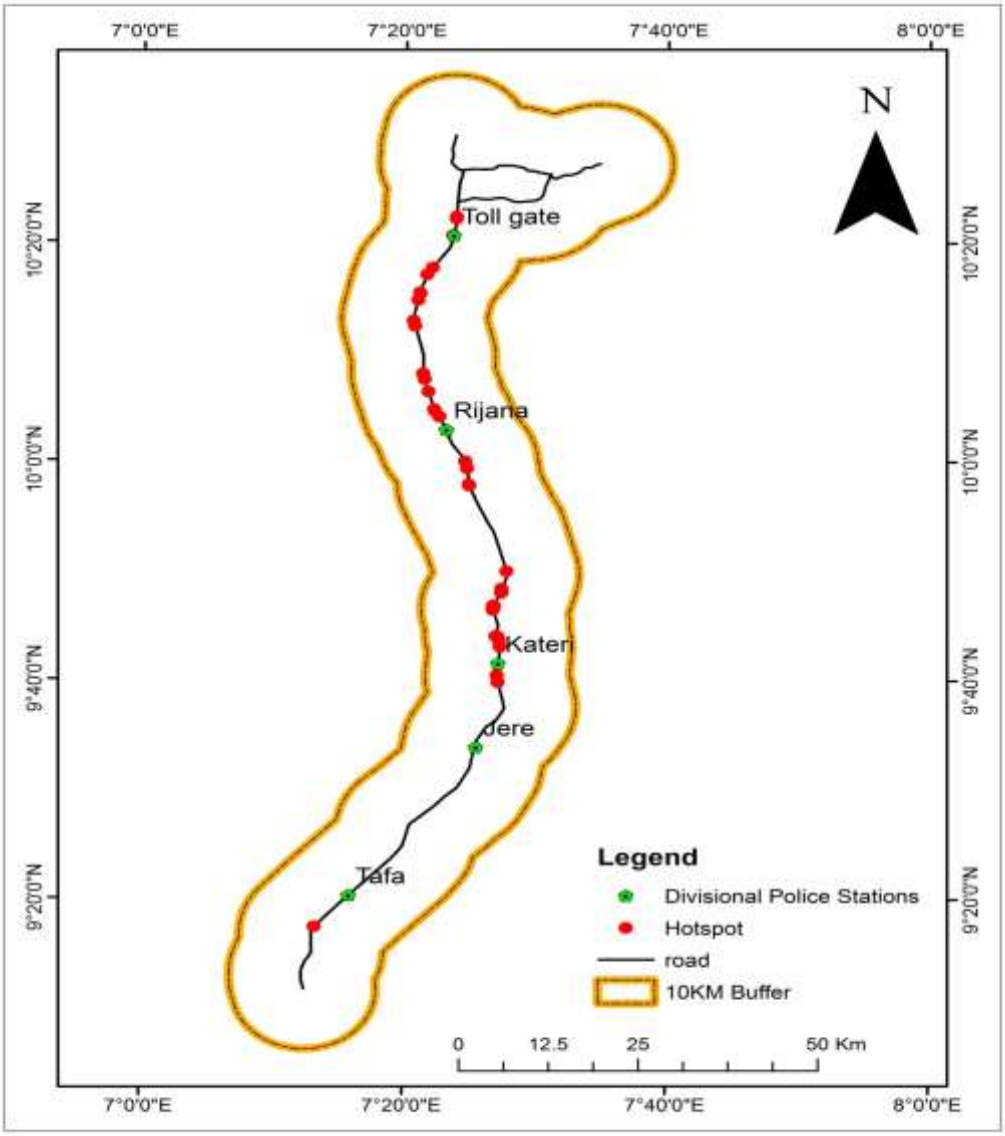

Figure 4.3: Kidnapping hotspots in the Study Area
Source: Authors analysis, 2021

4.4 Examining the Relationship between Land Use and Land Cover Information, Divisional Police Stations and Kidnapping Activities in the study area.

Figure 4.4 reveals that less cases of kidnapping was reported in the Kaduna City gate, Jere Tafa and Sabon-Wuse areas. This was as a result of the dominance of the area by built up and crop lands. The built-ups comprises residential and commercial structures while the crop lands which indicates farming activities, signifies that the area is busy with much human presence which as a result distract kidnapping activities on the highway along these settlements. The Rijana area as reported in figure 4.4 reported medium cases of kidnapping which is attributed to the moderate concentration in green cover (tree cover and grass land) and crop land. However the Rijana area as captured shows less built-up, indicating that, the area has less human presence and activities. The Kateri settlement as revealed in figure 4.4, reported relatively the highest cases of kidnapping attributed to the relatively high green cover (tree cover and grass land). A very small portion of the settlement which is not traceable on the map due the factor of the large scale used is covered by croplands indicating a relatively less human presence.

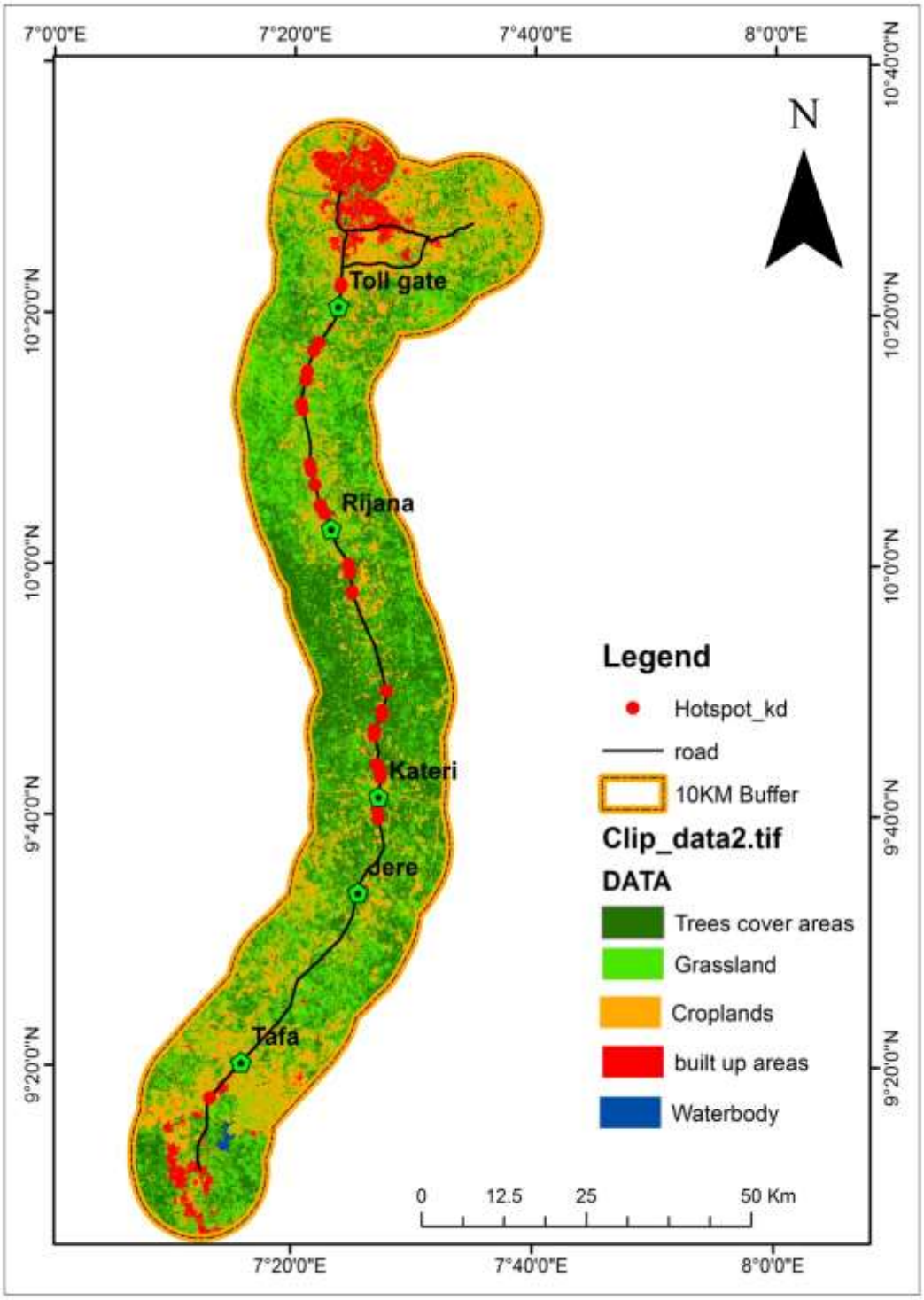

Figure 4.4: Land use and land cover map and kidnapping hotspots.

Source: Authors analysis, 2021

Figure 4.5 reveals the intensity and degree of kidnapping activities along the highway, by classifying the degree of their intensity into high, moderate and low rates. However, kidnapping activities can be interpreted to be high at Kateri which obviously recorded the peak of kidnapping activities. Moving ahead to Rijana, the kidnapping rate is moderate while the Kaduna Toll gate, Jere, Tafa and Sabon-wuse as could be seen on the map, are interpreted to have recorded low kidnapping activities.

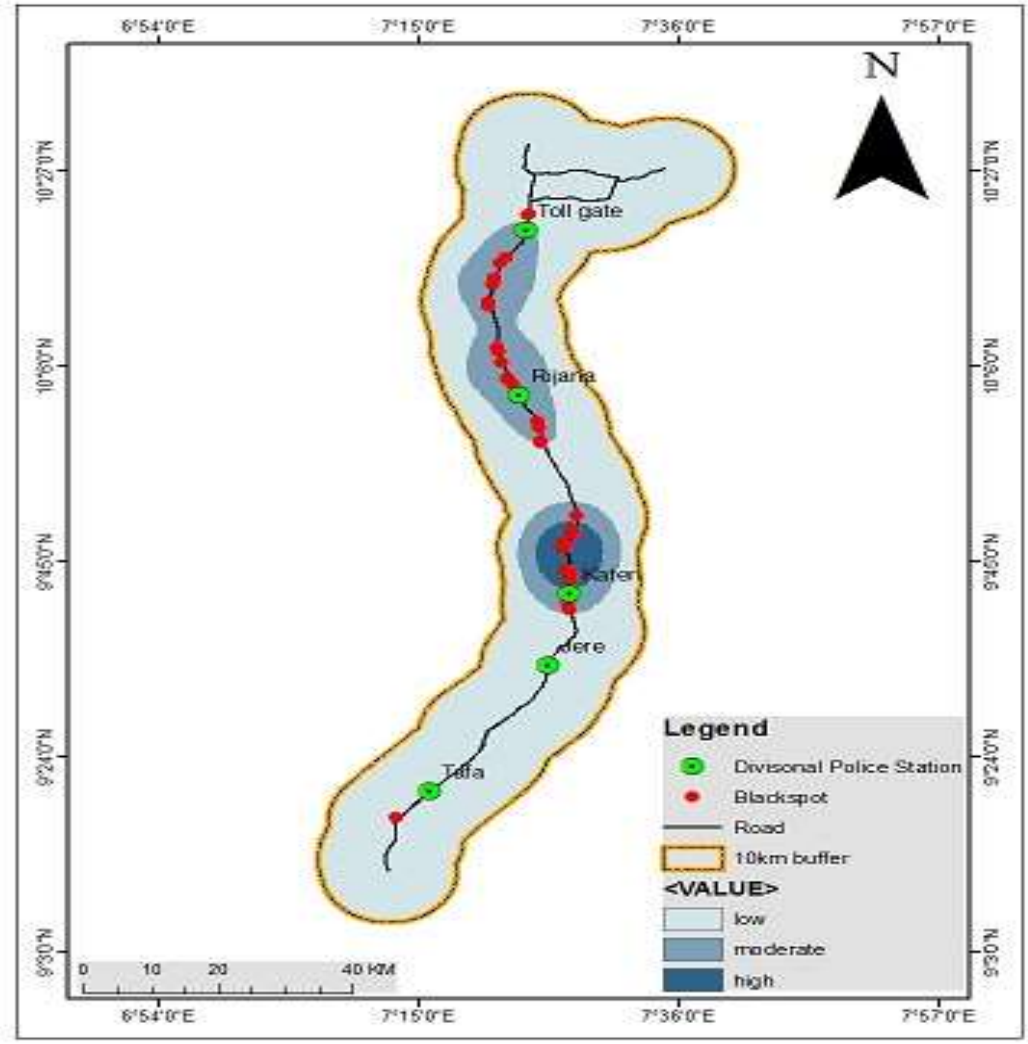

Figure 4.5: Kernel density vector of the divisional police station, hotspots in the study area
Source: Authors analysis, 2021

4.5 Summary of the findings

The finding of this study identifies the major land use and land cover as tree cover, grassland, croplands, built-up and water body. It revealed the order in terms of area occupied by the classes. The percentage cover of the features in the study area is obtained as thus; tree cover 43.97%, grassland 15.46, cropland 34.17%, built up 6.17% and water bodies 0.25%. From the findings, there are six divisional police stations in the study area namely: Toll gate, Rijana, Kateri, Jere, Tafa and Sabon Wuse divisional police stations. The police stations are in a linear pattern, situated few meters on both sides along the highway. The description and remarks on certain kidnap locations revealed that sharp bends and curves on the highway, railway and bridges are vulnerable points of abduction along the highway. The study revealed that there is a high reported case of kidnapping along the highway, in areas with high vegetation cover but low built up. This explains why Kateri is reported to have the highest cases of kidnapping along the highway. Settlements along the highway with moderate vegetative- (tree cover and grass land), less built-up and crop land along the highway as is the case of Rijana reported moderate cases of kidnappings. Whereas, areas along the highway with more crop lands and larger built ups as is the cases of Kaduna City Toll-gate, Jere, Tafa and Sabon Wuse reported less case of kidnappings.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Kidnapping, like other crimes is not evenly spread across the highway. Rather, it is randomly spread in different degrees which are dependent on certain factors which can be categorized as attractors to kidnapping (Vegetative-cover; tree cover and grassland) and detractors of kidnapping (built up areas and croplands) along the highway. However, built-ups and crop lands along the highway signifies human presence and activities which hinders the abduction of travelers along the highway. Whereas, large vegetative-cover; tree cover and grassland with no or less built ups along the highway signifies less human presence and activities and by essence, makes such areas prone to kidnapping.

As a result of the afforementioned, kidnapping is rampant in certain locations (Kateri), scarce (Tafa and Jere) or completely absent in certain locations (Sabon Wuse) on the highway. This however, has led to travelers plying or avoiding certain areas on the highway particularly at certain times or period of the day. Other times, travelers completely avoid the Kaduna-Abuja highway for alternative routes or alternative means of transportation.

However, from this study, GIS and Remote sensing has proven to be an effective and efficient tool to identify kidnapping spots, analyze and display, in the form of maps to enable effective and proper planning by security agencies in resource and personnel allocation, mission and rescue planning for kidnap victims, quick and emergency responses for reported kidnap cases. Furthermore, the maps produced from GIS and remote sensing applications are of great benefit to the populace in creating awareness of areas that are targeted by kidnappers, and as such have recorded high cases of kidnapping in order that they may avoid or take preventive measures.

This study has also shown that kidnapping along the Kaduna-Abuja highway is highly reported in the Katari area, moderately reported in the Rijana area, and, less reported in the Kaduna Toll Gate, Tafa and Jere areas along the highway.

5.2 Recommendations

In line with the summary of the findings and conclusion of this study, the following recommendations were deduced to mitigate kidnapping activities along the Abuja-Kaduna highway.

1. A joint collaboration of security agencies and outfits against kidnapping on the highway should be established into a department or unit. The department/unit should constitute personnel from the Nigeria police, state security services and the Nigeria military. It should as well involve the Man 'O' war, vigilante groups and other local security outfits.
2. The department should be enhanced with necessary and adequate trainings, techniques and equipments to ensure that they are timely in response against kidnapping, to repel and counter kidnapping attacks, effectively launch and carryout successful rescue missions of victims of kidnappings along the highway. Physical, computer aided trainings and also geographical information system and remote sensing skills should be made a handy knowledge for personnel to enable effective spatial analysis. This shall help to guide and lead ground troops to several successful missions.
3. Onward, proper documentations, which should include details acquired on kidnapping events. Such information as the location of abduction (coordinates), time of abduction, number of victims, distress call/report time, response time, arrival time of security agents, rescue locations (coordinates), discovered hideout (coordinates), location of arrest (coordinate), information of arrested kidnappers and other necessary information that can

be obtained from first hand witnesses should be digitally recorded and stored. The information from such documentations when harnessed with GIS and remote sensing shall give the needed spatial intelligence to commence and serve as a point of reference to any investigation, operation or mission.

4. Personnel, welfare and resource allocation should be given topmost priority. Personnel and resources should be properly distributed and assigned to areas on the highway that have been highlighted as the high risk zones of kidnapping. Security personnel should always outnumber the number of kidnappers. It is only by this, that kidnapping attacks can be foiled and more arrests can be made. Resource allocations and purchase of logistic items such as helicopters, patrol vans, motor cycles which should include adequate provision for fuel, sophisticated arms, communication gadgets, protective gadgets and more should be made readily available to security personnel on the highway.
5. Security agencies should build more confidence with the communities along the highway. This can be done by tactically closing the communication gap that exist between the security personnel and the masses through dialogue and engaging community heads and their subjects who can serve as informants who sometimes may have breakthrough information about kidnappers but are afraid of disclosing such information for the sake of their own safety.

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