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Geospatial Intelligence for Crime Analysis and Kidnapping Reduction: Evidence from Ondo State, South Western Nigeria

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Abstract **Original Research Article**

This paper examines the application of Geographic Information System (GIS) techniques to analyse crime distribution and support kidnapping reduction efforts in Ondo State, Nigeria. Conventional law enforcement approaches in Nigeria remain largely reliant on manual record systems and non-digital crime tracking, which constrain timely intervention and evidence-based decision-making. Against this backdrop, the study pursues three specific aims: first, to delineate crime concentration zones, spatial trends, and recurring patterns within the state; second, to appraise the performance limitations of prevailing policing strategies; and third, to assess how GIS can enable a more anticipatory and intelligence-driven approach to public security management. To accomplish these aims, a mixed-method research design was adopted, incorporating structured questionnaire surveys administered to police officers and civilian residents alongside field-collected GPS coordinates and remotely sensed satellite imagery. Spatial analyses, including hotspot delineation and buffer zone modelling, were carried out within ArcMap. Findings reveal that robbery and burglary constitute the most frequently occurring offences, while significant operational deficiencies persist within the policing system. The study demonstrates that geospatial technology offers substantive improvements over conventional methods by enabling targeted resource deployment, strategic patrol planning, and proactive mitigation of criminal incidents including kidnapping. These results affirm the urgency of mainstreaming digital geospatial tools into Nigeria's law enforcement infrastructure.

Keywords: Geospatial Technology, Crime Mapping, Global Positioning System (GPS), Satellite Imagery, Kidnapping, Ondo State.

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1. INTRODUCTION

Crime, broadly defined as conduct that contravenes established law and renders the perpetrator liable to legal sanctionwhether monetary, custodial, or otherwiseconstitutes a persistent challenge to social cohesion and economic productivity across all segments of Nigerian society (Crown Prosecution Service, 2024). The consequences of criminal activity extend across socioeconomic strata, affecting both affluent and vulnerable populations and eroding the social fabric at community and national levels (Balogun et al., 2014). Compounding these challenges is the persistent technological deficit within Nigerian law enforcement institutions,

which continue to operate without adequate digital infrastructure for evidence management, incident documentation, and strategic crime analysis. This deficit undermines the capacity of security agencies to develop proactive, intelligence-led approaches to crime prevention.

Crime exhibits inherent spatial and temporal qualitiesevery offence occurs at a specific location and at a particular point in time. Agboola (1997) observed that urban crime, by virtue of its definable geographic and chronological distribution, requires swift engagement from the agencies of government mandated to maintain public order, principally the police and the judiciary. GIS is uniquely positioned to address this need, given its capacity to answer fundamental spatial questions about where events occur, when they happen, and how they relate to surrounding features. As a spatial phenomenon, criminal activity can be disaggregated by location and mapped across urban terrain, yielding actionable intelligence that far surpasses the utility of conventional paper-based incident logs (Balogun et al., 2014). The spatial non-randomness of crime means that analytical tools capable of detecting clustering, adjacency, and proximity relationships hold considerable value for law enforcement planning (Sahu and Srivastava, 2004). GIS further enables the layering of multiple thematic datasetssuch as police station locations, road networks, land use patterns, and socioeconomic facilitiesinto integrated visual outputs that support operational decision-making (Balogun et al., 2014).

Whereas GIS-based crime mapping has become standard practice across most developed nations, displacing earlier pin-board mapping methods, the majority of law enforcement agencies in low- and middle-income countries, including Nigeria, retain antiquated analogue filing systems. The absence of digital crime management infrastructure in Nigeria creates several compounding problems: it denies security forces a technological parity advantage over increasingly sophisticated criminal networks; it prevents cumulative learning from historical crime data; it limits the analytical flexibility that digital formats provide; and it results in unwieldy physical maps that become increasingly difficult to interpret as offence categories multiply. These structural limitations provide the central impetus for the present investigation. The overarching aim of this study is therefore to evaluate the potential of GIS as an instrument for enhanced crime mapping and kidnapping mitigation within Ondo State, Nigeria. This is pursued through three guiding research questions: (i) What are the prevailing spatial trends and distributional patterns of kidnapping in Ondo State? (ii) How effective are current policing strategies in addressing kidnapping and related crimes in the study area? (iii) In what ways can GIS-based methodologies deliver a more systematic and data-informed approach to crime management in the state? These questions collectively orient the inquiry toward a critical assessment of existing security practices and the transformative capacity of geospatial technologies for crime reduction.

2. LITERATURE REVIEW

A substantial body of scholarly work documents the growing role of GIS and artificial intelligence (AI) in crime analysis across diverse geographic contexts. Within Europe, Eman et al. (2013) undertook a study of property crime in Slovenia, combining GIS-based hotspot analysis with a Google Maps interface to create a publicly accessible web application for crime monitoring. Ferreira et al. (2012) adopted an integrated approach in Lisbon that merged cluster analysis with spatial modelling to pinpoint high-crime zones and construct predictive maps. More recently, Bedirogiu and Colak (2023) conducted spatial crime analysis for Trabzon in Türkiye, applying Kernel Density Estimation (KDE) to classify and visualise crime data from 2011 and 2015. Beconyte et al. (2024) advanced this line of research in Lithuania by combining spatial clustering, zoning, and statistical inference to map criminal concentrations at the urban scale. Across Asia, He et al. (2022) traced the evolution of Police Geographic Information Systems (PGIS) in China, documenting four developmental phases and illustrating how GIS has been operationalised within local police departments for public safety protection. Liu et al. (2014) investigated the spatial configuration of violent offences in Changchun, employing spatial statistics to identify clusters and explore the relationship between neighbourhood-

level characteristics and crime distribution. In India, Thangavelu et al. (2013) applied GIS to assess the geographic spread of criminal activity across urban centres, contributing to the growing literature on spatially informed policing in developing-country contexts. Within the Nigerian context, scholarship on GIS-based crime analysis has grown steadily. Balogun et al. (2014) demonstrated the utility of GIS for crime mapping in Benin City, establishing a foundational framework for the Nigerian literature. Fajemirokun et al. (2006) focused on the management of criminal incidents on Victoria Island, Lagos, while Bako et al. (2020) advanced participatory GIS (PGIS) approaches, engaging local communities in co-producing two-dimensional crime maps that captured indigenous spatial knowledge. Ahmed and Salihu (2013) employed spatial database analysis to delineate crime hotspots in Dala, Kano State. Apene et al. (2024) more recently reviewed the evolution of crime prevention from conventional methods toward AI-augmented solutions, using a triangulated approach combining literature review, local observation, and global case analysis. The present study builds on this body of work by focusing specifically on kidnapping dynamics in Akure, Ondo State, and explicitly incorporating AI-assisted spatial analysis to address a documented gap in the existing literature.

3. MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Akure, the administrative capital of Ondo State in southwestern Nigeria. Geographically, Akure lies between latitudes 7°5'0" and 7°20'0" N and longitudes 5°5'0" and 5°20'0" E, covering a total area of approximately 318.0 km². The city is situated at an elevation of roughly 370 m above mean sea level and is bounded by Idanre Local Government Area to the south, Owo to the east, and Ifedore to the north. Its central position relative to these surrounding settlements has historically made Akure an attractive destination for in-migrants seeking employment and social amenities (Okoko, 2002, cited in Oyinloye et al., 2017). The presence of the state government headquarters, expanding infrastructure, and access to institutions such as healthcare facilities, markets, and educational establishments has drawn sustained population inflows, particularly among young people from rural communities in the region. Akure's population stood at 360,268 in the 2006 national census and was projected to reach approximately 744,000 by 2023reflecting an annual growth rate of 3.76%with a further estimate of 773,000 based on a 3.90% growth rate (Macrotrends, 2024). This rapid urbanisation has been driven by industrial expansion, the city's status as an oil-producing state capital, and its designation as a Millennium Development City. Together, these factors have intensified socioeconomic pressures that contribute to elevated crime rates. Climatically, Akure falls within Nigeria's tropical rainforest belt, receiving mean annual rainfall of approximately 250 cm, with temperatures ranging between 28°C and 31°C and a relative humidity averaging around 80%. Figure 1 shows the study area map.

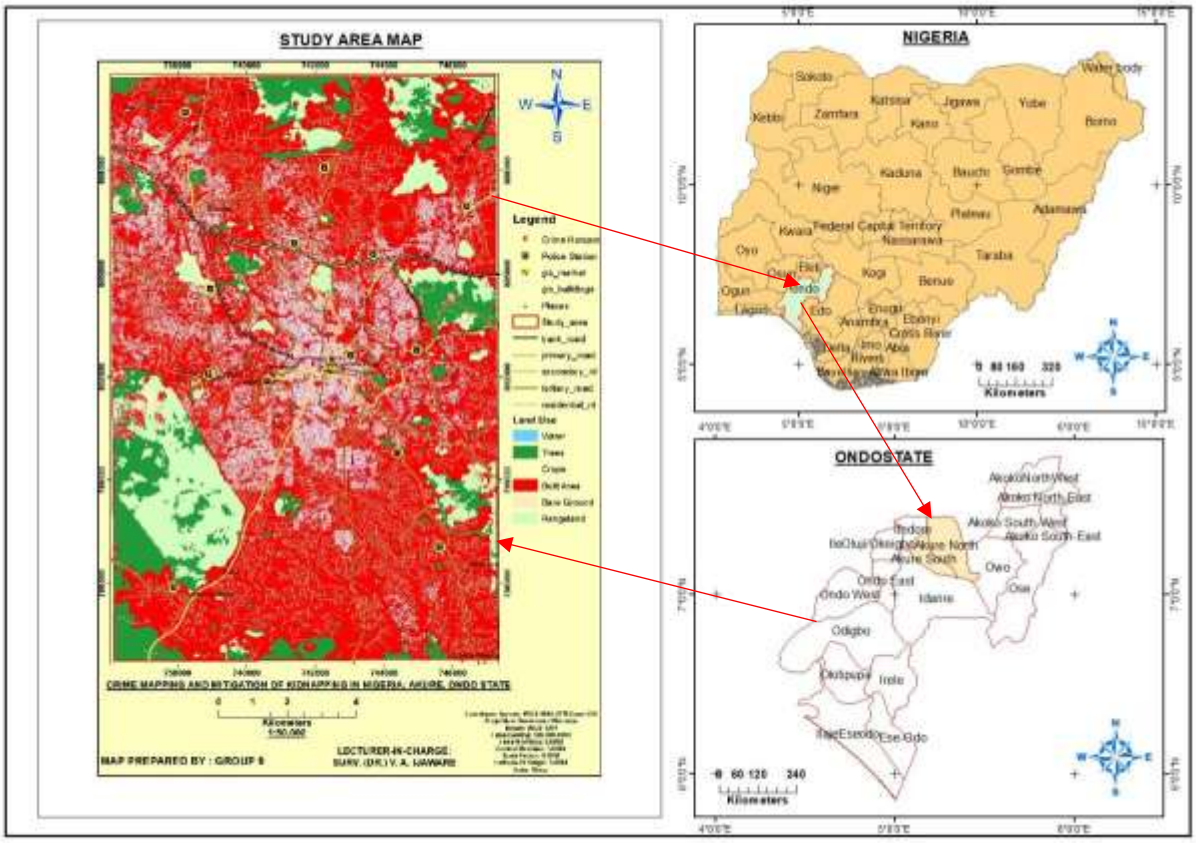

Figure 1: Study Area Map

3.2 Data Collection and Processing

The research adopted a mixed-method design integrating both primary and secondary data sources to construct a comprehensive picture of crime dynamics in Ondo State. Primary data collection commenced with a reconnaissance survey of the study area, enabling the research team to develop familiarity with key spatial features, land use characteristics, and the general settlement pattern. This preparatory phase informed all subsequent data collection activities. Structured questionnaires were then administered to two distinct groups: police officers stationed within Akure and members of the general public residing across the study area. The instruments were designed to elicit firsthand accounts of criminal incidents, assess community perceptions of safety, and evaluate the operational effectiveness of current policing arrangements. In addition, field surveys using GPS receivers were conducted to obtain precise geographic coordinates of identified crime concentration points, police station locations, and other infrastructure relevant to crime and security analysis.

Secondary data were obtained from multiple institutional sources. Satellite imagery, road maps, and land use classifications were sourced from the Ondo State Ministry of Lands and Survey, while demographic data including census figures and housing statistics were obtained from the National Population Commission. Drug-related crime statistics were drawn from relevant secondary databases. The combination of spatially referenced field data and institutionally sourced datasets provided the multi-layered input required for comprehensive GIS analysis.

Data processing followed a structured sequence. Existing thematic road maps were scanned and converted to digital format, subsequently geo-referenced using UTM coordinates obtained from GPS field observations and resampled to ensure alignment with real-world ground conditions. Digitisation was carried out within the ArcMap-ArcInfo environment, with meticulous editing to eliminate topological errors such as overlapping features and disconnected nodes. GPS-derived point data for crime hotspots and police facilities were overlaid onto the digitised base map. Satellite imagery was enhanced, geo-referenced, and digitised to update the representation of built structures, arterial roads, and places of interest, with a consistent uniform coordinate system maintained throughout. A relational database was constructed and populated using Microsoft Access, with referential integrity enforced through primary and foreign key constraints.

AI methods were incorporated at several stages of the analytical workflow. Convolutional Neural Networks (CNNs) were employed for image classification and feature extraction from satellite data, enabling accurate identification of buildings and road networks. K-means clustering algorithms were applied to examine the distributional patterns of crime incidents and isolate probable hotspot clusters. Spatial analytical operationsincluding buffer zone generation, network analysis, and crime distribution mappingwere executed to interrogate the geographic configuration of offences relative to socioeconomic infrastructure. Outputs were visualised using AI-enabled tools such as Tableau and ArcGIS Insights, which enhanced the interpretability of spatial relationships for both analytical and communication purposes. Figure 2 presents the research methodology flowchart.

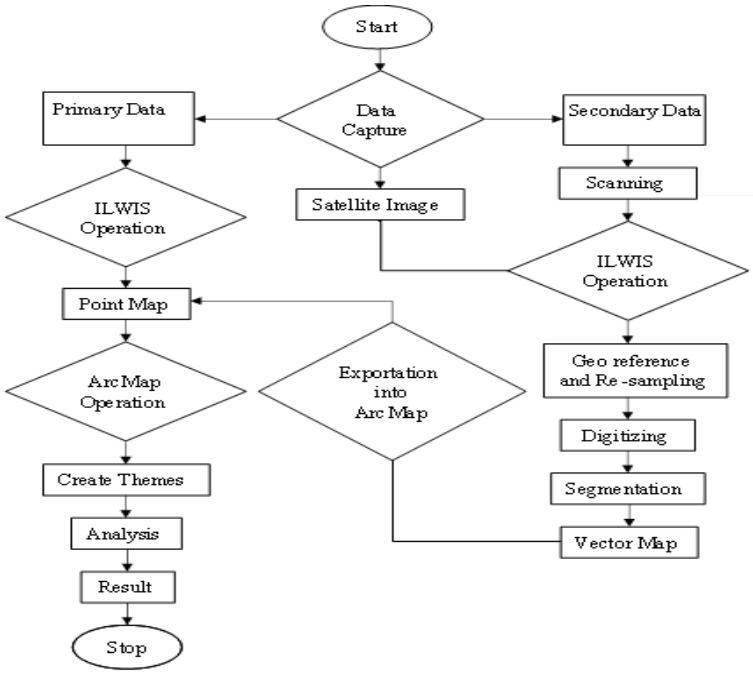

Figure 2: flowchart of research methodology

4. RESULTS AND DISCUSSION

4.1 Respondent Characteristics

Demographic profiling of survey respondents revealed that 67% were aged above 25 years, with a marital status distribution showing 23% married, 61% single, and 16% categorised under other statuses including separated or widowed. All participants had resided within the study area for a minimum of three years, ensuring that their responses were grounded in substantive local experience of the crime environment. Regarding occupation, students from tertiary institutions constituted the largest occupational group at 49%, a demographic considered particularly susceptible to criminal involvement due to a combination of economic need, peer influence, and age-related vulnerabilities. The remaining respondents were distributed across various formal employment categories. Figure 3 illustrates the age distribution of respondents.

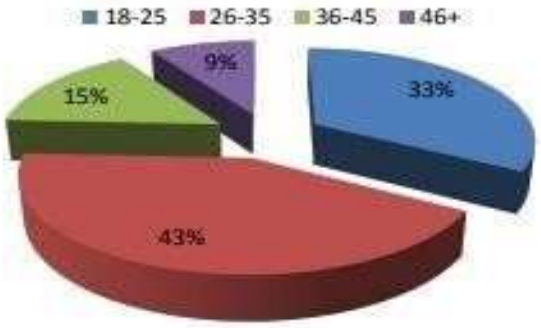

Figure 3: Age Distribution of Respondents Crime Rate and Pattern

4.2 Crime Prevalence and Reporting Behaviour

Survey results indicate near-universal awareness of crime among residents, with 97% of respondents reporting personal knowledge of criminal activity within the study area. Figure 4 presents the typological breakdown of offences recorded in Ondo State. Armed robbery emerged as the single most prevalent category, accounting for 29% of all identified crimes. This was followed by burglary (22%), sexual assault (19%), kidnapping (15%), homicide (4%), and miscellaneous offences including pickpocketing, which collectively constituted 11% of reported incidents. The high incidence across multiple offence categories confirms that criminal activity is a pervasive and systemic challenge in the study area, warranting coordinated and sustained intervention.

Despite this widespread prevalence, 84% of crime victims chose not to report incidents to the police. Figure 6 illustrates the reasons cited, which included: apprehension that police officers might disclose victim identities to criminal networks; a widespread perception of institutional indifference to public safety concerns; and documented shortcomings in police armament, analytical capacity, professional integrity, and logistical readiness. These findings underscore a profound trust deficit between the civilian population and law enforcement, which significantly constrains official crime reporting rates and the accuracy of administrative crime data. Separately, 81% of respondents who had been victimised were able to identify the location of the nearest police station (Figure 5), suggesting that

geographic accessibility of police facilities is not the primary barrier to reporting.

Among the minority who did report crimes, only 19% indicated that police responded consistently, while 78% noted that responses were intermittent, and 3% reported receiving no police response whatsoever to their distress communications (Figure 7). On the matter of proactive enforcement, 42% of respondents confirmed awareness of police raids conducted by the Special Anti-Robbery Squad (SARS), while the remaining 58% held varying views on this practice. Given the inadequacy of formal policing, approximately 96% of residents surveyed indicated that they had turned to informal community security arrangementscommonly referred to as vigilante groupsas their primary recourse against theft and robbery. Despite these parallel security structures, crime rates in the study area continue an upward trajectory, as evidenced by ongoing reports of attacks on financial institutions, private individuals, and even police personnel. Police officers interviewed during the study acknowledged the challenges they face and identified several active countermeasures, including enhanced investigative procedures, the protection of informant identities, periodic publication of crime data, checkpoint operations, routine patrols, and targeted arrests. Notably, none of these strategies incorporate geo-information technology.

Figure. 4: Prevalent Types of Crime in Ondo State

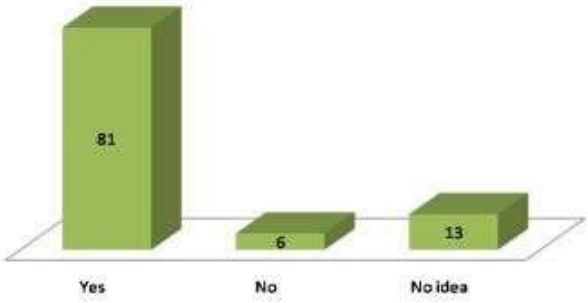

Figure 5: Knowledge of the Location of Police Station

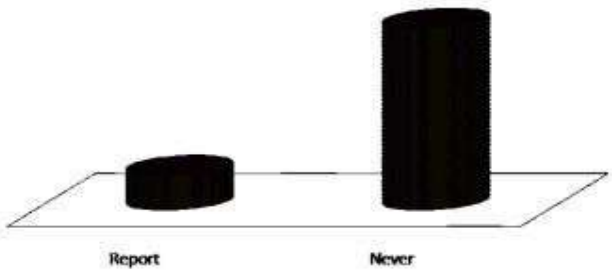

Figure 6: Crimes Report to Police

Figure 7: Police Response to Crime

4.3 Crime Hotspot Analysis

Spatial buffer analysis (Figure 8) identified several zones of elevated vulnerability across Akure. High-risk locations include major commercial nodes such as Jilalu Market, Akure Market, Bagbe Akure Market, and Isikan Market, as well as their immediate environs along key transport corridors including Oba Adesida Road, Oke-Ijebu Road, Ondo Road, and the Akure–Owo Expressway. Residential and peri-urban zones including Gaga, Ipinsa, Ita Oniyan, Ilere, Adofure, and Araromi-Adofure areas, together with communities adjacent to the Federal University of Technology Akure and other tertiary institutions, were also identified as high-risk zones. Figure 8 presents the single buffer of crime hotspots.

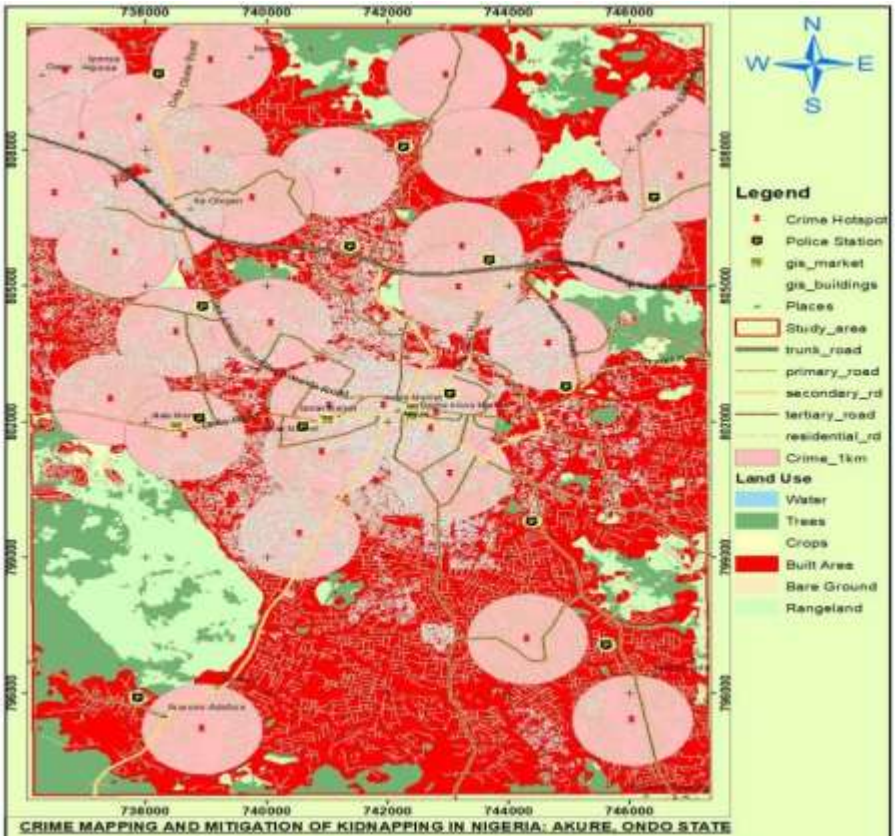

Figure 8: Single Buffer of Crime Hotspot

Multiple buffer analysis (Figure 9) demonstrated a distance-decay pattern in crime vulnerability: as distance from identified hotspots increases, particularly toward the northeastern part of the study area, risk levels decline markedly. The spatial coincidence of police station locations with zones of overlapping buffer coverage is analytically significantit reveals that these stations are embedded within the highest-risk areas yet are demonstrably unable to suppress criminal activity within their immediate operational radius. This suggests that the presence of police infrastructure alone, in the absence of data-driven patrol planning, is insufficient for effective crime deterrence. The analysis further

indicates that the spatial configuration of hotspot clusters provides a rational basis for reforming police deployment and operational protocols. Figure 9 presents the multiple buffer analysis of crime hotspots.

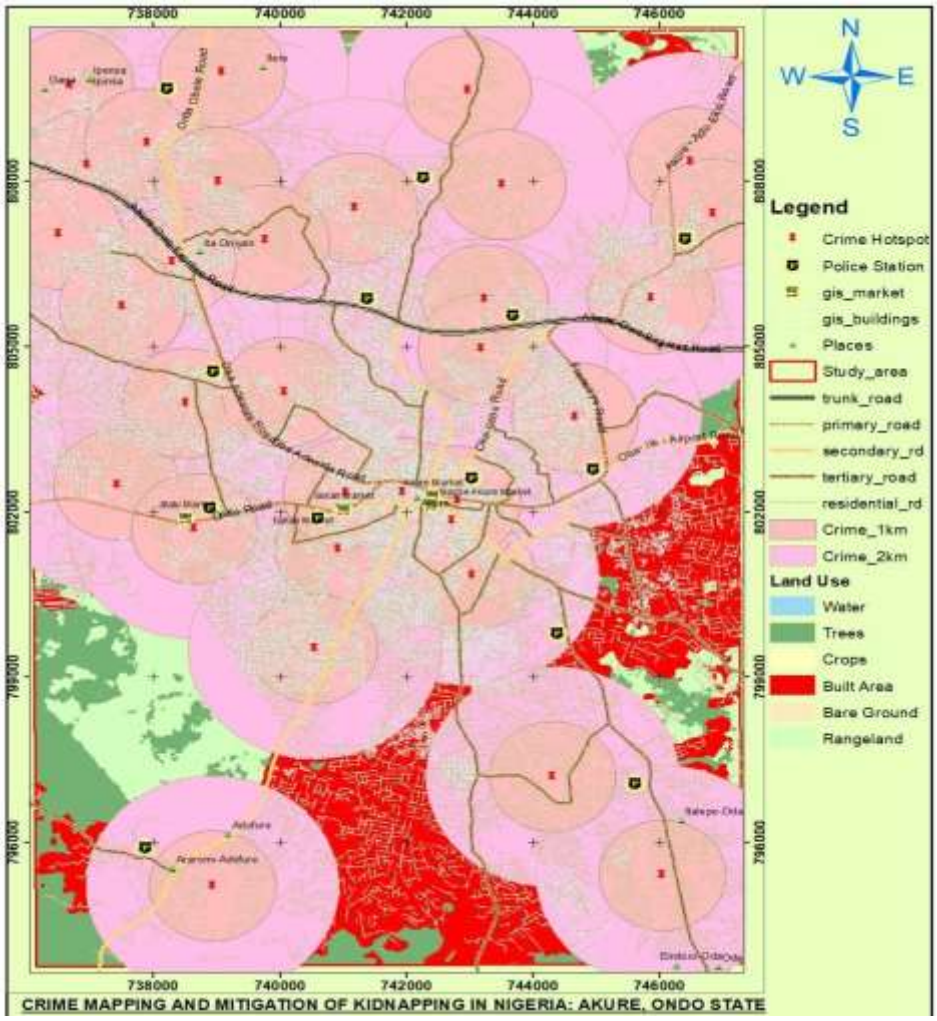

Figure 9: Multiple Buffers of Crime Hotspot

As illustrated in Figure 10, most high-activity socioeconomic facilitiesincluding banks, markets, and commercial clustersare spatially coincident with or proximate to identified crime hotspots. Oyinloye et al. (2017) noted that such locations attract criminal attention by virtue of their high footfall, economic significance, and functional visibility. A one-kilometre buffer around burglary hotspots specifically reveals that this crime type is most concentrated along the Akure–Owo Expressway, Oba Adesida Road, Alagbaka Road, the Akure Market corridor, and zones near tertiary educational institutions. Field investigations suggest that the physical characteristics of housing stock and proximity to police stations are important determinants of burglary prevalence in these zones.

Spatial analysis further identifies cultism, armed robbery, and sexual assault as dominant crime forms across broader Ondo State, with particular intensity in areas hosting university populationsnotably Gaga, Ipinsa, Ita Oniyan, Ilere, and central Akureas well as along Alagbaka Road, Ondo Road, Oba Adesida Road, and rural communities near FUTA.

The GIS analytical outputs cumulatively yield three key operational insights. First, buffer zones delineated around police stations reveal spatial gaps in security coverage and quantify response time implications across the city. Second, zones of overlapping buffers signal areas requiring sustained, proactive patrol deployment rather than reactive, incident-driven responses. Third, the route network layer provides police with real-time chase and apprehension capabilities during active pursuit, transforming GIS from a planning tool into an operational decision-support system. These findings affirm that GIS can fundamentally elevate the analytical quality and strategic coherence of crime management in Akure. Figure 10 presents the buffer analysis of police stations and crime hotspots relative to socioeconomic infrastructure.

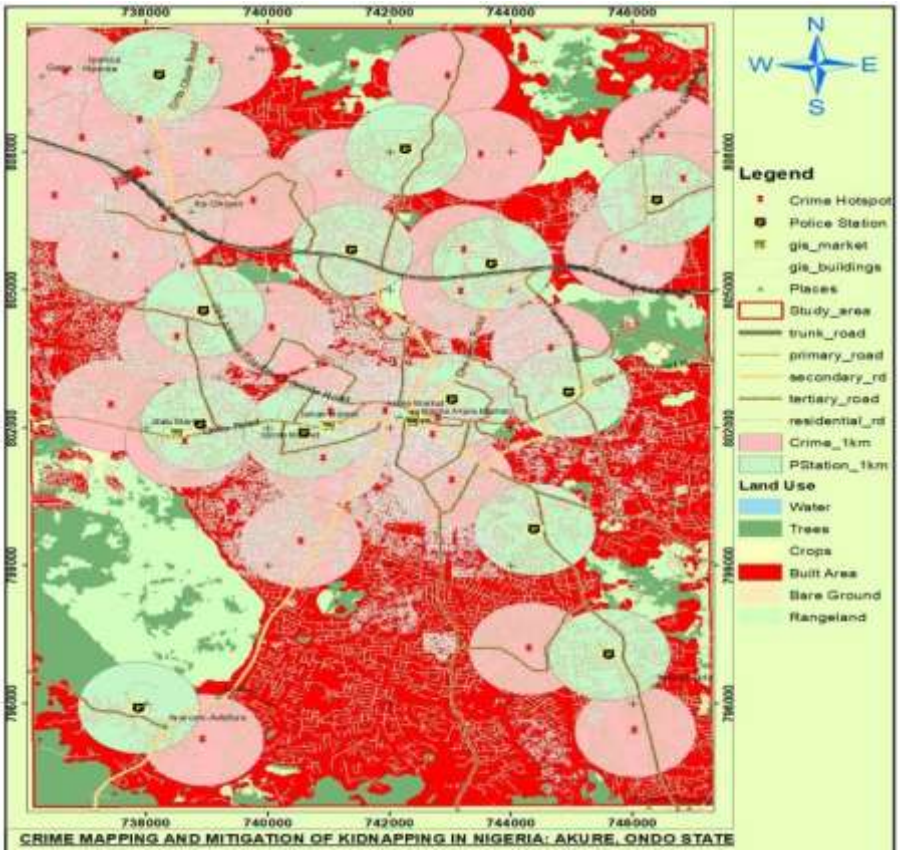

Figure 10: Buffer Police Station/Crime Hotspot concerning Other Socio-Economic Activity

4.4 Kidnapping Spatial Analysis

Figure 11 presents an integrated cartographic output depicting land use, infrastructure distribution, and kidnapping incident mapping across the study area. The map enables cross-referencing between kidnapping occurrences and spatial variables including water bodies, agricultural land, built-up zones, and open terrain. This multi-layered

representation reveals that certain land use configurations create conditions conducive to kidnapping: areas with minimal law enforcement visibility, low population density, and restricted road access are particularly vulnerable. Police station locations serve as proxies for law enforcement coverage, with distance from these facilities correlating positively with kidnapping risk. High-density commercial and transport nodesparticularly fuel stations and marketsemerge as recurrent kidnapping sites due to the volume and predictability of human movement in these spaces.

The road hierarchy is a further critical variable. Major arterial routes offer rapid escape paths for perpetrators, while peripheral roads with limited connectivity to the core network may serve as concealment sites for abducted individuals. The analytical value of mapping these network properties was underscored by recent security incidents in Ondo State, including the recovery of kidnapping victims along the Akure–Benin (A122) highway and the abduction of National Youth Service Corps (NYSC) membersevents that highlight the urgency of evidence-based security planning (Daily Post Nigeria, 2024; PM News Nigeria, 2024). These incidents reinforce the argument for enhanced surveillance infrastructure, expanded law enforcement presence at identified risk nodes, and structured community awareness programmes.

Collectively, the crime map presented in Figure 11 functions as a strategic planning instrument, enabling practitioners to identify where intervention resources should be prioritised and what form those interventions should take. The cross-referencing of criminal incident data with land use and infrastructure layers moves security planning beyond anecdotal or reactive approaches, toward an evidence-grounded, spatial reasoning framework. This methodology holds relevance not only for Akure but for comparable secondary cities across Nigeria and the broader West African subregion that face analogous patterns of urbanisation-induced crime escalation. Figure 11 presents the final crime mapping and kidnapping mitigation output for Ondo State Zone.

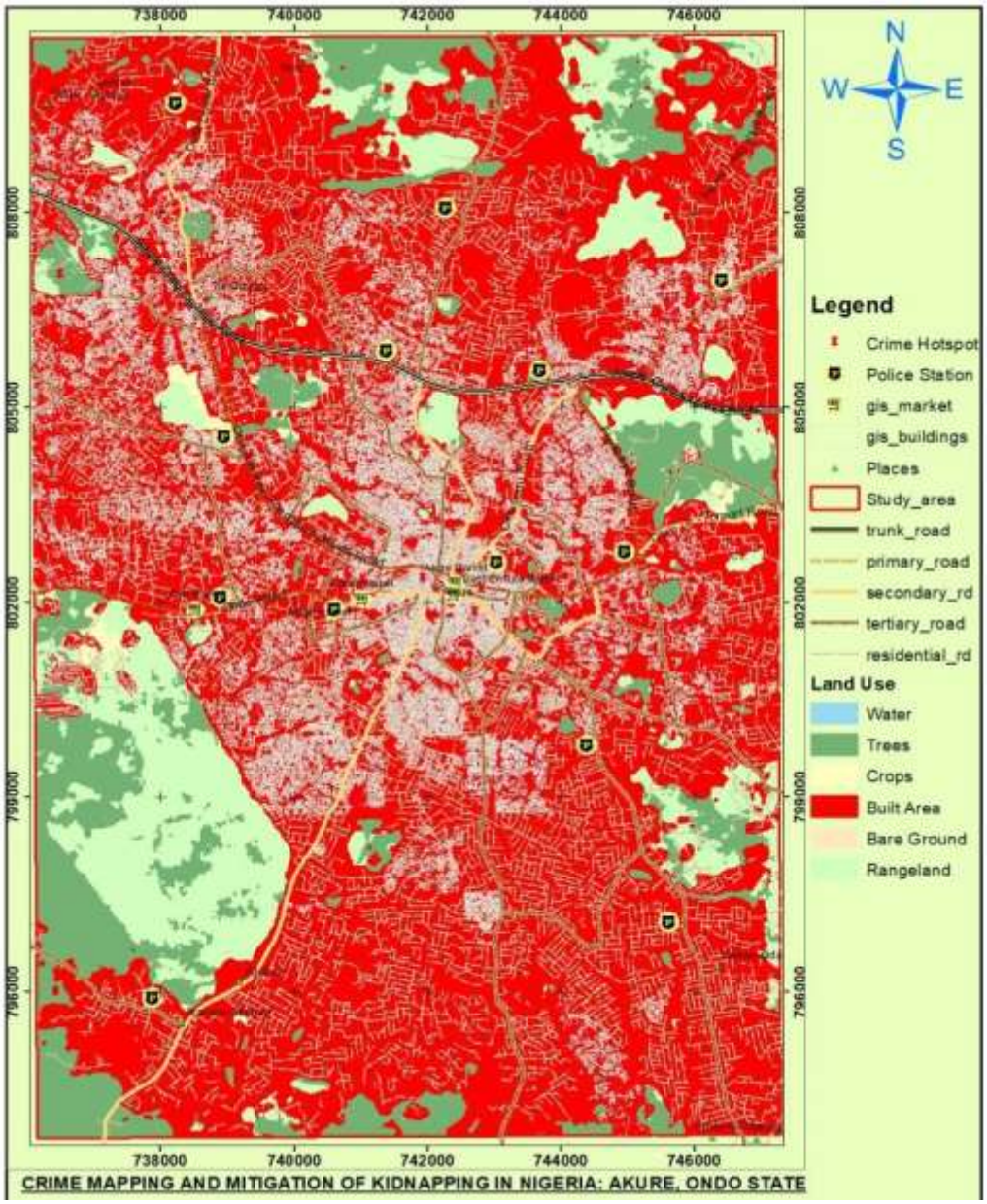

Figure 11: Result of Crime Mapping and Mitigation of Kidnapping in Nigeria, Ondo State Zone

5. CONCLUSION

This study has established that the integration of AI and GIS constitutes a transformative advancement for crime analysis and kidnapping mitigation within Ondo State, Nigeria. Through a systematic application of spatial analytical techniques to multi-source field and secondary data, the research delineated critical crime concentration zones, characterised prevalent offence types, and exposed the operational limitations of existing law enforcement practices. Armed robbery and burglary were identified as the dominant offences, while systemic deficienciesparticularly the continued reliance on manual documentation and the absence of digital analytical toolswere shown to significantly impair police effectiveness.

The deployment of GIS-based hotspot mapping, buffer analysis, and network routing within this study demonstrated how geospatial technologies can shift policing from reactive, trial-and-error responses toward anticipatory, intelligence-driven operational frameworks. By integrating CNNs for satellite image analysis and clustering algorithms for crime pattern detection, the study illustrated the added value that AI-augmented GIS delivers over conventional crime management approaches. The spatial insights generatedincluding the identification of patrol-deficient zones, high-risk corridor routes, and law enforcement coverage gapsprovide an actionable basis for strategic resource allocation and institutional reform.

The research affirms that addressing the twin challenges of crime and kidnapping in Nigeria requires not only political will but substantial investment in the technological modernisation of law enforcement infrastructure. Adopting geospatial and AI-based systems would equip security agencies with the evidential foundation needed to deploy personnel effectively, monitor criminal trends in near-real-time, and engage communities as active partners in public safety.

6. RECOMMENDATIONS

Based on the findings of this study, several recommendations are advanced. First, Nigerian law enforcement agenciesparticularly those operating in Ondo Stateshould urgently adopt GIS and AI platforms as core components of their crime management infrastructure. Second, dedicated capacity-building programmes should be established to train police personnel in the application of geospatial tools, ensuring that technological investment translates into operational competence. Third, government at both state and federal levels should commit adequate budgetary resources to support the acquisition, maintenance, and upgrading of digital crime management systems. Fourth, structured public awareness and community engagement campaigns should be developed to build trust between law enforcement and citizens, which is a prerequisite for improving crime reporting rates and the quality of crime data. Fifth, legislative and policy frameworks should be developed or revised to explicitly support the integration of AI and GIS within national and state policing strategies, providing a regulatory basis for their sustainable implementation.

Conflict of Interest

The authors declare that there is no conflict of interest to disclose

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