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Research Article

Geospatial Mapping of Crime Hotspots in Michika Local Government Area of Adamawa State, Nigeria

Mohammed Abubakar Bashir[1], Pwosa Belongeb[2] and Alhaji Mohammed Musa[3]

[1, 2]Department of Surveying and Geoinformatics, Adamawa State Polytechnic, Adamawa State, Nigeria.

[3]Department of Crime Management, School of Social and Management Sciences, Adamawa State Polytechnic, Yola, Nigeria.

*Email: ask4mohammedbashir@gmail.com**

ABSTRACT: ***This research focuses on the utilization of geographic information system (GIS) technology as an essential tool for crime analysts in Michika, Nigeria. The study aims to gather valuable information for the Police force by integrating traditional law enforcement agency (Police) data with various datasets, including demographics, crime types, infrastructure, and offender tracking. The goal is to transform this information into actionable intelligence that can improve critical decision-making in a rapidly changing environment and enhance the safety of both the Police force and the citizens they serve. To identify areas with higher crime rates, the research employs the Inverse Distance Weighted and Getis-Ord GI* methods. Using software like ArcGIS, Global Mapper, Google Earth, and Surfer, these methods help determine crime hotspots in Michika. The identified hotspots cover a range of criminal activities, including stealing/house break-ins, child abuse, robbery, homicide, drug addiction, kidnapping, smuggling, terrorism, and murder. The results of the analysis provide crucial insights into the concentration of criminal incidents in specific areas of Michika. By visualizing and analyzing data using GIS technology, law enforcement agencies can gain a better understanding of crime patterns and make informed decisions to allocate resources effectively. This research emphasizes the importance of GIS as a valuable tool for crime analysis and highlights its potential to improve the safety and security of the Police force and the community they protect.***

KEYWORDS: ***GIS, Hotspot, Geospatial Analysis, GPS, Police Force.***

INTRODUCTION

In recent years, Nigeria has witnessed a surge in criminal activities, including theft, terrorism, kidnapping, rape, and murder. This increase in crime has been attributed to factors such as high youth unemployment rates and the country's economic challenges (Chinedu & Bartholomew, 2015). Despite the government's allocation of substantial funds to combat this growing issue, the desired results have not been achieved. Extensive investments have been made in acquiring and distributing equipment, such as vehicles, communication devices, weapons, bulletproof vests, as well as renovating police stations. Additionally, the Joint Task Force (JTF) operation Lafiya Dole was launched, which brought together the army, navy, and police to collaborate in addressing crime and acts of terrorism. However, despite these efforts, the effectiveness of the police force in controlling and managing crime in Michika remains limited due to outdated and manual crime-fighting approaches.

To address these challenges, this research aims to explore the potential of Geographic Information System (GIS) technology in crime analysis within Michika Metropolis. By adopting GIS as an innovative approach, the study seeks to significantly reduce the prevalence of crime in the area. GIS technology has revolutionized the analysis, processing, and presentation of spatially referenced data, which describe both the location and characteristics of various features on the Earth's surface (Chang, 2012; Boba, 2005). Its distinctive capability lies in handling and performing operations on geospatial data, where spatial data represents locations and attribute data represents associated characteristics (Chang, 2012; http://aurangabadcitypolice.gov.in, 2013).

Crime mapping and spatial analysis have been recognized as powerful tools for studying and addressing crime, enabling law enforcement agencies to identify problem areas with precision. GIS, in particular, plays a crucial role in information management for law enforcement, as it facilitates data integration, spatial analysis, suspect identification, resource allocation, and policy-making (Boba, 2005). By leveraging GIS technology, crime analysis mapping provides graphical representations of crime trends, high-density areas, and temporal information. This helps policymakers and police departments gain a better understanding of the underlying factors contributing to crime, enhance patrolling strategies, and allocate resources more effectively (Ahmed & Salihu, 2013).

Crime does not occur uniformly across geographical areas; instead, it tends to cluster in certain locations while being absent in others. This understanding influences people's daily decisions, as they actively avoid certain places and seek out safer ones. When choosing neighborhoods, schools, stores, streets, and recreational areas, individuals take into account the likelihood of becoming a victim of crime. In some areas, people take precautions such as locking their cars and securing their belongings, while in other areas, they feel more at ease and adopt a more relaxed attitude. The way people navigate different streets also varies: on some, they walk quickly and view strangers with suspicion, while on others, they leisurely stroll and warmly welcome encounters with interesting individuals. This demonstrates that people recognize the uneven distribution of crime and adjust their behavior accordingly. While some may argue that people's caution towards certain areas is unwarranted, the fact that individuals are not equally fearful in all places suggests an inherent understanding that crime is not evenly spread. While people may have misconceptions about the risks associated with specific locations, they are aware that their likelihood of falling victim to crime varies geographically.

In Nigeria, the role of the police organization is crucial. Given the recent increase in crime rates, it is imperative for the police to embrace current technologies to gain a competitive advantage and enhance their effectiveness in combating crime. Law enforcement agencies in many developing countries still lack computerization, which hampers their ability to maintain effective records, analyze cases, and easily reference and retrieve information. Without proper systems in place, storing and accessing data becomes challenging, making it difficult to provide reliable and comprehensive information around the clock. This lack of computerization also hinders trend prediction and decision support for police agencies.

Crime, as a phenomenon, possesses spatial attributes such as time, location, and process. Therefore, timely availability of spatial information on crime-prone areas is crucial for effective policing. Unfortunately, with outdated systems in place, law enforcement agencies are struggling to keep up with the increasingly sophisticated tactics employed by criminals. This creates an ongoing race between lawbreakers and law enforcers, with law enforcement agencies falling behind due to the limitations imposed by outdated technology.

LITERATURE REVIEW

Crime mapping, as described by Boba (2005), involves utilizing GIS technology to conduct spatial analysis of crime problems and police-related issues. It serves three main functions: unraveling the spatial nature of crime through visual and statistical analysis, connecting unlikely data sources to common geographic variables, and producing maps that effectively communicate analysis results. A geographic information system (GIS) integrates hardware, software, and data to capture, manage, analyze, and display geographically referenced information (Escobar et al., 2014). Over the past decade, the use of GIS and remote sensing in police departments has significantly increased, providing valuable crime mapping capabilities for patrolling neighborhoods and aiding investigators in solving cases. By accessing crime patterns and querying GIS databases, officers can examine specific types of crime occurrences, such as the location of recent burglaries within a designated radius of an intersection (Karen et al., 2003).

In Nigeria, the occurrence of crime transcends social class boundaries, affecting both the affluent and the less privileged alike. The consequences of criminal activities, characterized by tragedy, suffering, significant losses, and societal distress, have left an enduring mark on the nation's collective consciousness. However, law enforcement agencies in Nigeria still lack computerization for effective record keeping, case analysis, easy referencing and retrieval, and comprehensive information storage necessary for strategic planning and crime eradication efforts. Crime, as an entity, possesses spatial attributes such as location, time, and process. Therefore, timely access to up-to-date spatial information regarding crime-prone areas is vital for enhancing overall policing across the entire state. However, the current policing methods in Nigeria remain manual and non-automated, relying on outdated filing systems for record keeping. This technological lag restricts law enforcement agencies from gaining the upper hand over increasingly technologically sophisticated criminals (Balogun et al., 2014).

Understanding crime theories is crucial for effective crime mapping as they provide insight into interpreting data and determining appropriate actions. These theories play a significant role in explaining hot spots, which are concentrated areas of crime. Various theories exist regarding crime and disorder concentration, and while they may differ, they often complement each other rather than contradicting one another. Instead, these theories explain different types of crime phenomena that occur at different geographic levels. Each level of analysis involves specific units that are examined, corresponding to the geographic areas depicted on maps. These units can be points, lines, or polygons. Certain theories help explain the concentration of crime in specific points, while others elucidate linear patterns or hot spot crime polygons. However, the usefulness of crime theories in guiding crime and disorder mapping relies on selecting an appropriate theory that aligns with the level of analysis being conducted.

The topic of neighborhood crime theories has been extensively explored in various studies. Shaw and McKay's work in "Social Factors in Juvenile Delinquency" (1931) highlighted the persistent conditions of certain neighborhoods, unaffected by time or changes in residents. Bursik and Grasmick (1933) discuss the control residents have over deviant behavior in local communities. Social disorganization theory emphasizes the impact of social networks in preventing deviance. In some neighborhoods, the constant turnover and outmigration disrupt these social networks or hinder their formation. The concept of social efficacy, referring to the willingness of locals to intervene for the common good, also plays a role in influencing deviant behavior. Neighborhoods with high levels of social efficacy tend to have lower crime rates compared to areas with low levels.

The broken windows theory, introduced by Wilson and Kelling in 1982, explains how minor violations of social norms create social pressures to restore compliance. When a place is neglected or untended, it weakens the residents' ability and willingness to enforce social order. Consequently, they withdraw from adhering to these norms, allowing further deviant behavior to occur.

Ahmadi (2013) emphasized the following details regarding crime analysis:

1. *Definition of crime and crime analysis*: Crime refers to the violation of criminal laws within specific jurisdictions, aiming to protect the lives, property, and rights of citizens. Crime analysis involves studying and analyzing crime data to understand patterns, trends, and factors contributing to criminal activities. From a legal perspective, crimes are categorized based on State/Territory legislation, covering offenses related to persons, property, and regulation. However, the definition of crime can also vary from a non-legal point of view, considering acts that violate socially accepted ethical or moral behavior.

2. *Methods for automating the geographical analysis of crime incident data*: The Geographical Analysis Machine (GAM) system developed by Alex and Kate (2001) offers a way to automate crime analysis for analysts without extensive geographical knowledge. GAM assists in identifying clusters or hotspots of crime incidents within a given area. It also provides explanations by pointing to relevant geographical data sets that may explain the identified clusters. Many law enforcement agencies use geocoded crime reports, allowing for automated analysis that yields reliable and self-evident results.

3. *Spatial perspectives on crime*: The study of crime has primarily been conducted by criminologists, sociologists, and legal scholars. However, professional geographers have entered the field in recent years. Spatial and ecological perspectives on crime have evolved over time. The cartographic school, originating in France and spreading to other European countries in the 19th century, used maps to illustrate regional and seasonal variations in crime patterns. The Chicago ecological school of the 1920s and 1930s focused on mapping the homes of juvenile offenders to identify delinquency patterns. The factor analytic school of the 1950s explored statistical correlations between various factors and crime rates. The current stage involves the geography of crime and environmental criminology, examining the spatial distribution of crime and its relationship with social, cultural, and economic factors.

4. *Tools in the spatial analysis of crime*: Several statistical mapping techniques are useful for spatially analyzing crime patterns:

- Block aggregation: This technique involves aggregating crime incidents into geographical areas and creating chloropleth maps that shade the areas based on the number of incidents. Block aggregation helps identify areas with a high incidence of crime and serves as an initial analysis before employing more sophisticated techniques. It also allows for examining the associations between crime and socio-economic conditions.
- Voronoi diagrams: These diagrams are used to analyze individual crimes by creating coverage areas based on proximity. They help identify areas where crimes occur more frequently and contribute to understanding crime patterns.
- Kernel smoothing: Kernel density estimation is a statistical method that generates continuous crime density surfaces from point data. It creates density maps that illustrate geographic variations in the intensity of crime. Kernel smoothing is valuable for

identifying crime hotspots and visualizing crime patterns that may not follow regular geometric shapes.

- Animation: Animation in crime analysis involves displaying maps dynamically in sequence, representing continuous change over time. This tool is useful for visualizing temporal patterns and changes in crime incidence. It allows analysts to control the duration and rate of change in the animation, providing a comprehensive view of crime dynamics.

In summary, crime analysis utilizes various tools and methods, including GIS and remote sensing, to visualize crime data, analyze patterns, and make informed decisions for effective crime control. It integrates geographical perspectives, statistical techniques, and advancements in technology to better understand and address criminal activities.

PROBLEM STATEMENT

There is a lack of effective strategies and tools for identifying and analysing crime hotspots in the area. This hampers law enforcement agencies' efforts to combat criminal activities and ensure community safety. Therefore, there is a need to implement a geospatial mapping system to accurately identify and analyse crime hotspots. By utilizing geospatial technologies, law enforcement agencies can gain valuable insights into the spatial patterns and characteristics of crime, enabling them to develop targeted strategies and allocate resources effectively. The implementation of a geospatial mapping system is crucial for improving crime prevention, law enforcement, and overall community safety in Michika.

Manual recording of crime events cannot be the way ahead if the police authorities want to improve crime management (crime prevention) in Michika metropolitan. The numerous police stations within the Michika police command are in charge of addressing the many criminal occurrences in the area under their purview, however, at present, they are experiencing issues with their recording system and the aggregated reporting of crime incidents across all security forces.

STUDY AREA

The study area, situated within the Basement Complex of North-eastern Nigeria, encompasses an aerial extent of approximately 188.5km2. It is located between latitudes 10°32'N to 10°14'N and longitudes 13°19'E to 13°25'E. Michika is bounded by the Republic of Cameroon to the east, Mubi Local Government Area of Adamawa State to the south, Askira Uba Local Government Area of Borno State to the west, and Madagali Local Government Area to the north. The region is intersected by a major highway connecting Yola to Maiduguri. Additionally, there are minor roads such as Michika-Yammu/Warakanza, Michika-Kopa-kwapale/Villegwa, and Michika-Moda/Mandara roads, which provide access to villages and hilly areas. Despite the hilly terrain in some parts of the study area, there is a well-developed network of roads, footpaths, and tracks that make it easily accessible. The hilly topography is more prominent in the eastern portion, while the western part is relatively flat. These geographical features are depicted in Figure 1 of the provided source.

MATERIALS AND METHODS

Method of Data Collection and Analysis

The research work utilized a combination of primary and secondary data sources to conduct the analysis.

Primary Data Source: The primary data was collected in the field using GPS (global positioning system), obtaining coordinates such as eastings, northings, or latitude and longitude for police stations, hot spots, and the demarcation of new police station boundaries within the research region. These coordinates were then overlaid on a georeferenced Rapid-eye image of the study area for visual interpretation and geographical analysis.

Secondary Data Source: The majority of the secondary data was sourced from police records, encompassing various crimes like murder, sexual assault, theft, robbery, pickpocketing, and drug use. To facilitate information mining and analysis, a database of these records was created in the ArcGIS 10.8 environment. The Hotspot method, depicted in Figure 2, was applied to this database during the Results and Analysis section.

The data collection process comprised six stages. Initially, data collection was conducted, followed by the georeferencing of the raster dataset. Subsequently, spatial information was digitized from the dataset to map out police stations, highways, rivers, wards, crime hotspots, security checkpoints, and other relevant elements. The fifth stage involved creating and mapping a criminal database, implementing the Hotspot technique on the dataset, and finally, executing the Results and Analysis phase.

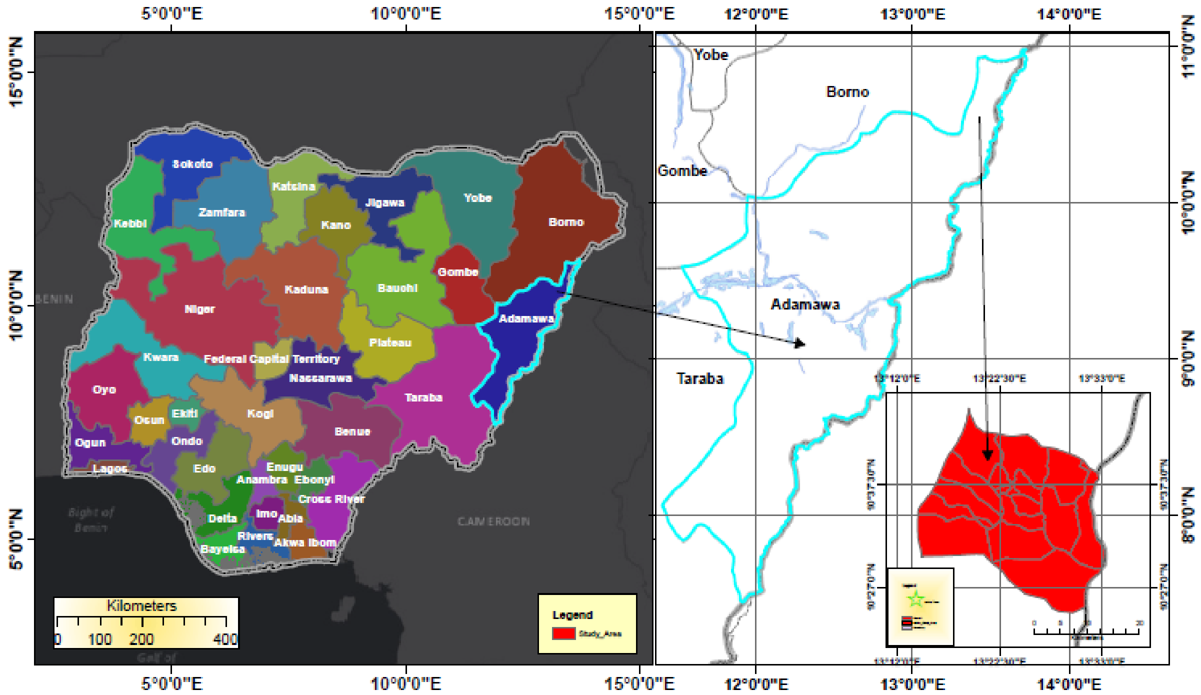

Figure 1: Locational map of the study area

Spatial data used in this study include:

1) GPS coordinates of crime hotspots in Michika metropolis
2) GPS Coordinates of police stations in the research area

Attribute data include:

1) Records of types of crime
2) Attributes of police stations in the research area
3) Attribute of crime hotspot

In the realm of spatial analysis, Interpolation Methods played a crucial role by leveraging points with well-established values to estimate values at unknown points. This approach proved especially valuable in domains such as elevation modelling and other spatial phenomena, where the task involved predicting values at geographic points lacking direct measurements. By approximating surface values at unsampled sites based on known surface values of neighbouring points, we employed the TIN (Triangulated Irregular Networks) surface model as a raster technique to perform interpolation.

Spatial Analysis Methods played a pivotal role in this study as they scrutinized the positions, properties, and interrelationships of spatial data features through overlay and various analytical procedures. The primary objective was to extract valuable insights that could be applied to multiple facets of the research analysis. By employing spatial analysis, a diverse range of novel information was generated and extracted from geographic data, enriching the overall understanding of the research domain.

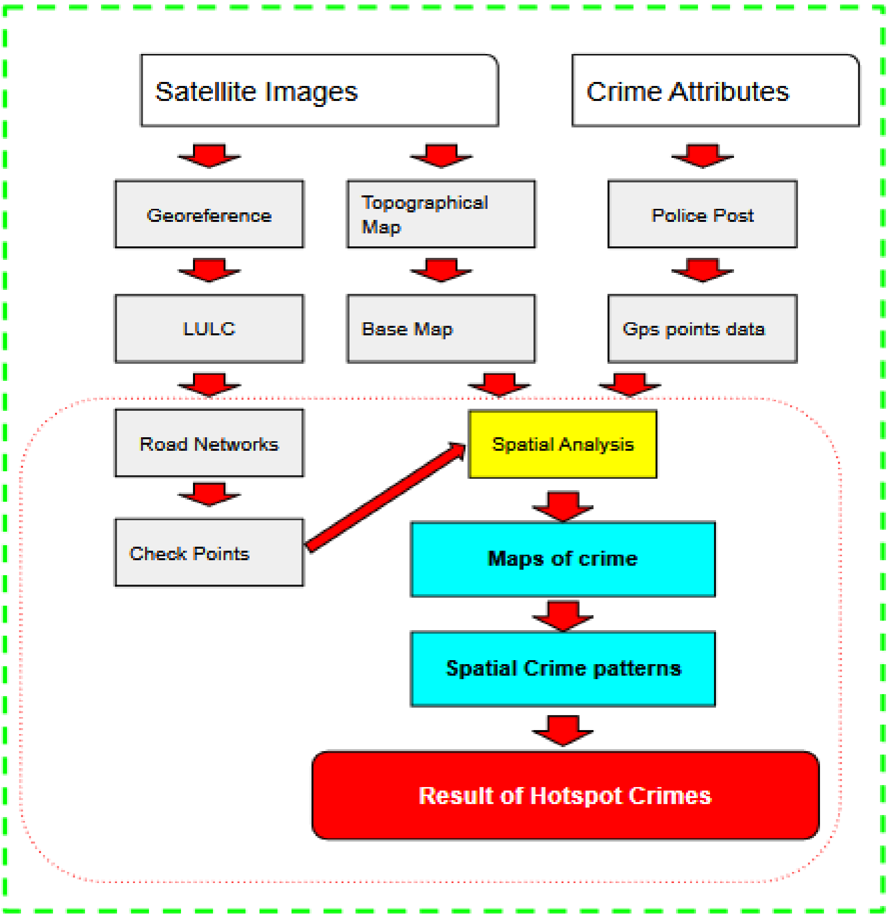

Figure 2: Methodological flowchart of the analysis

Spatial Autocorrelation analysis was conducted to assess the level of correlation between spatial features and their associated data values. This analysis revealed whether the features exhibited a tendency to cluster together (positive spatial autocorrelation) or scatter widely (negative spatial autocorrelation) in space. By examining the spatial patterns and relationships within the dataset, valuable insights were gained regarding the spatial dependencies and trends present in the data. For further details, refer to the following source:

http://aurangabadcitypolice.gov.in/police_juridiction.php (accessed on 19-09-2013).

The Georeferencing process involved aligning the Toposheet to real-world coordinates by referencing identifiable points and registering the features onto the Geographic Coordinate System (GCS). Specifically, for the region of Michika, the GCS used was WGS_84, which corresponds to the Universal Transverse Mercator (UTM) zone 33 N. By digitizing the features and assigning them accurate geographic coordinates, the Toposheet was transformed into a spatially referenced dataset, enabling precise spatial analysis and integration with other geospatial data sources. Upon adding the dataset into ArcMap 10.8, it was observed that a pyramid was not automatically generated when uploading a raster dataset. To address this, the application was employed to construct a pyramid, as pyramids play a crucial role in enhancing the performance of raster datasets presented at lower resolutions by accelerating the drawing process.

For the digitization process, the Editor Toolbar was utilized to extract the Road network from the spatial features. Among the available features, such as Point, Line, and Polygon, Line Features were specifically chosen to represent the Road Network. The Network Index of the road network was then determined to identify the optimal route for reaching crime scenes and police stations, facilitating efficient navigation and response planning. During the phase of mapping police stations and their boundaries, a meticulous process was followed. Firstly, all the police stations were accurately placed on the map based on their coordinates. To ensure precise locations, a field survey was conducted, collecting reliable data for the coordinates. Each police station was represented as a Point Feature on the map.

In the initial phase, zone boundary information was gathered, and this data was instrumental in mapping the boundaries in relation to the police stations. The boundaries were depicted using the polygon feature, providing a clear visual representation of the spatial extent of each police station's jurisdiction. This comprehensive mapping approach enabled a thorough understanding of the distribution and coverage of police stations within the study area. The KDE (Kernel Density Estimation) method played a crucial role in this analysis by accurately estimating cell densities within a raster dataset using a sample of known points. Through this technique, each known point was associated with a kernel function, which can be described as a bivariate probability density function. Visualized as a "bump," the kernel function centers at the known point and gradually tapers off to zero within a defined bandwidth or window area. This approach enabled the generation of a smooth density surface, providing valuable insights into the spatial distribution of the analyzed phenomenon. By utilizing the KDE method, the study effectively captured and represented the varying intensities and concentrations of the measured attribute across the study area.

The IDW (Inverse Distance Weighted) method played a significant role in this study by employing an interpolation technique that enforced the principle that the estimated value of a point is influenced more by nearby known points than by those located farther away. This approach allowed for the creation of a layered shaded area depicting the incidence of crimes. By considering the distances and values of surrounding known points, the IDW method assigned weights to each point based on their proximity, resulting in a gradual blending of values across the study area. The resulting layered shaded area provided a visual representation of crime incidence, allowing for a better understanding of spatial patterns and areas of higher or lower crime intensity. This approach facilitated the identification of hotspots and enabled informed decision-making in crime prevention and resource allocation. The Getis-Ord Gi* method, utilizing G-statistics, played a crucial role in identifying clusters with high and low values within the research area. By analyzing the spatial distribution of data, this method enabled the identification of Hotspot and Coldspot regions, which were visually represented using different colors. The Gi* results further smoothed the impacts of layering, providing a point-wise Hotspot detection that enhanced the accuracy of identifying areas with elevated or reduced values.

Moreover, the application of the Getis-Ord Gi* method not only allowed for hotspot analysis but also facilitated the display of police station boundaries along waith their corresponding crime rates, including data on murder frequency, daytime home invasions, and nighttime home invasions within each boundary. This comprehensive display provided valuable insights into the spatial relationship between crime rates and police station locations. Utilizing presumed hypothetical data based on the coordinates of the Toposheet, the Getis-Ord Gi* method enabled the identification of locations with the highest and lowest crime rates. This information served as a valuable resource for decision-making processes, such as resource allocation, crime prevention strategies, and targeted interventions aimed at reducing crime rates in specific areas. The Getis-Ord Gi* method proved to be an effective tool in analyzing spatial patterns and highlighting areas of concern for law enforcement agencies and policymakers.

RESULT AND DISCUSSION

The data necessary for the production of the crime maps and analysis was obtained through a field survey. Subsequently, the collected data was imported into Global Mapper software, where selected layers were converted into shapefile format (.shp). Shapefiles are widely regarded as the most suitable and compatible format for various GIS platforms, ensuring seamless integration and analysis.

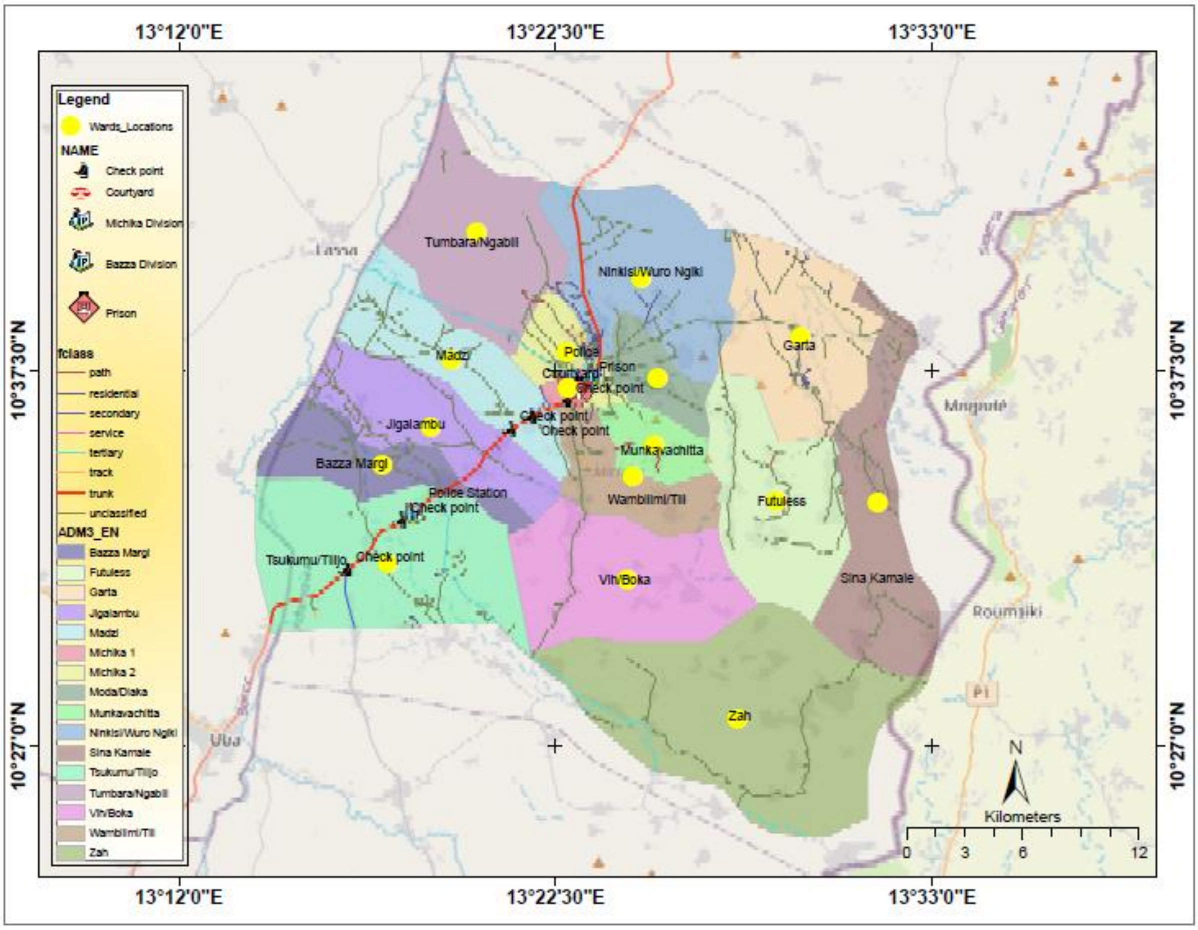

Figure 3: Spatial distribution of wards and security post

Once the layers were in GIS format, the Google high resolution image georeferenced image of the study area was downloaded and incorporated into the analysis, allowing for a comprehensive understanding of the spatial context.

For this research, the coordinates and projection system employed were the Universal Transverse Mercator (UTM) projection system with the World Geodetic System 1984 (WGS84) datum, specifically in Zone 33. This choice of coordinate system and projection facilitated accurate spatial referencing and alignment of the data layers, ensuring consistent and reliable analysis across the study area. Additionally, ground control points (GCPs) were acquired using the coordinator hand held GPS receiver, further enhancing the accuracy and precision of the spatial data.

By capturing and integrating the field survey data, converting it into GIS-compatible shapefiles, and incorporating high-resolution georeferenced imagery, the research was able to produce comprehensive and accurate crime maps and conduct in-depth spatial analysis. These results form a solid foundation for further discussions and insights regarding crime patterns, hotspots, and potential strategies for crime prevention and law enforcement. The spatial distribution of roads, wards, police stations, and checkpoints was analyzed to gain insights into their distribution patterns and spatial relationships in Figure 3.

The following results were obtained:

1. Roads: The analysis revealed the distribution and connectivity of roads within the study area. The road network was extracted through the digitization of spatial features, utilizing the Editor toolbar in the GIS software. Point, line, and polygon features were chosen, with the line feature specifically used to represent the road network. This information is crucial for determining optimal routes for reaching crime scenes and police stations, aiding in efficient law enforcement and emergency response.

2. Wards: The boundaries of different wards within Michika local government area were identified and mapped, it comprises of sixteen wards. These boundaries were determined based on the zoning information collected during the initial phase of the research. The polygon feature was used to represent the ward boundaries, providing a clear visual depiction of their spatial extent. Understanding the distribution of wards helps in analyzing crime patterns within specific administrative divisions, allowing for targeted interventions and resource allocation.

3. Police Stations: The locations of police stations were mapped according to their coordinates obtained through field surveys. Accurate geospatial data collection techniques, such as GPS, were employed to ensure the precise positioning of the police stations on the map. Each police station was represented as a point feature, facilitating easy identification and spatial referencing. The mapping of police stations provides critical information for assessing the coverage and accessibility of law enforcement services across the study area.

4. Checkpoints: The spatial distribution of security checkpoints was also analyzed. Checkpoints play a crucial role in maintaining public safety and preventing criminal activities. By mapping the locations of these checkpoints, law enforcement agencies can strategically position their resources to enhance security and deter crime. The checkpoint locations were captured and represented as point features on the map.

These results on the spatial distribution of roads, wards, police stations, and checkpoints offer valuable insights into the infrastructure and resources available for crime prevention and control. They serve as a basis for further analysis and decision-making processes aimed at improving public safety and enhancing the efficiency of law enforcement operations. Figure 4 shows the spatial distribution of the crime pattern in Michika LGA.

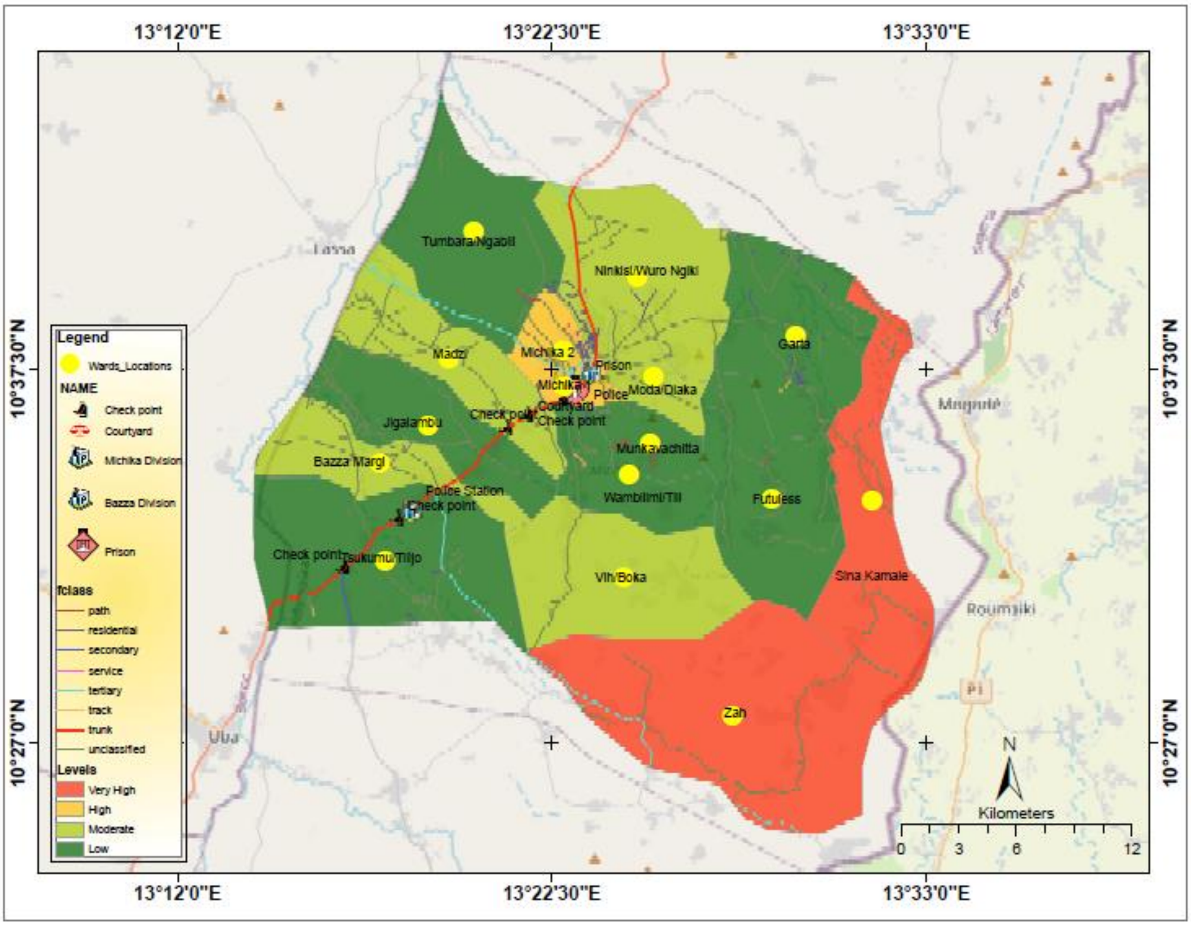

Figure 4: Spatial Crime map of the study area

The crime hot-spots map of Michika Local Government Area as shown in Figure 5 reveals areas within the region that have a high concentration of criminal activities.

The following are the key results obtained from the analysis:

1. Hot-spot Identification: Through spatial analysis techniques, crime incidents were analyzed to identify clusters or hot-spots where criminal activities were more prevalent. The analysis considered various types of crimes, such as theft, robbery, assault, and drug-related offenses. By examining the spatial distribution of these incidents, areas with a higher frequency of crimes were identified as hot-spots.
2. Hot-spot mapping: The hot-spots were mapped onto the geographic area of Michika Local Government. Different colors or symbols were used to visually represent the intensity or severity of crime incidents within each hot-spot. This mapping allows for a clear understanding of the spatial distribution and concentration of criminal activities across the region.
3. Crime Rates: The hot-spots map also provides information on crime rates within specific areas of Michika. By analyzing the frequency and severity of crime incidents within each hot-spot, it is possible to identify areas with higher crime rates compared to others. This

information is essential for law enforcement agencies and policymakers to prioritize resource allocation and crime prevention strategies.

4. Hot-spot Analysis: The hot-spots map enables a deeper analysis of crime patterns and trends. By examining the characteristics of hot-spots, such as their proximity to certain locations or demographic factors, further insights can be gained into the underlying factors contributing to crime concentration. This analysis aids in the development of targeted interventions and law enforcement strategies to address the identified hot-spots.

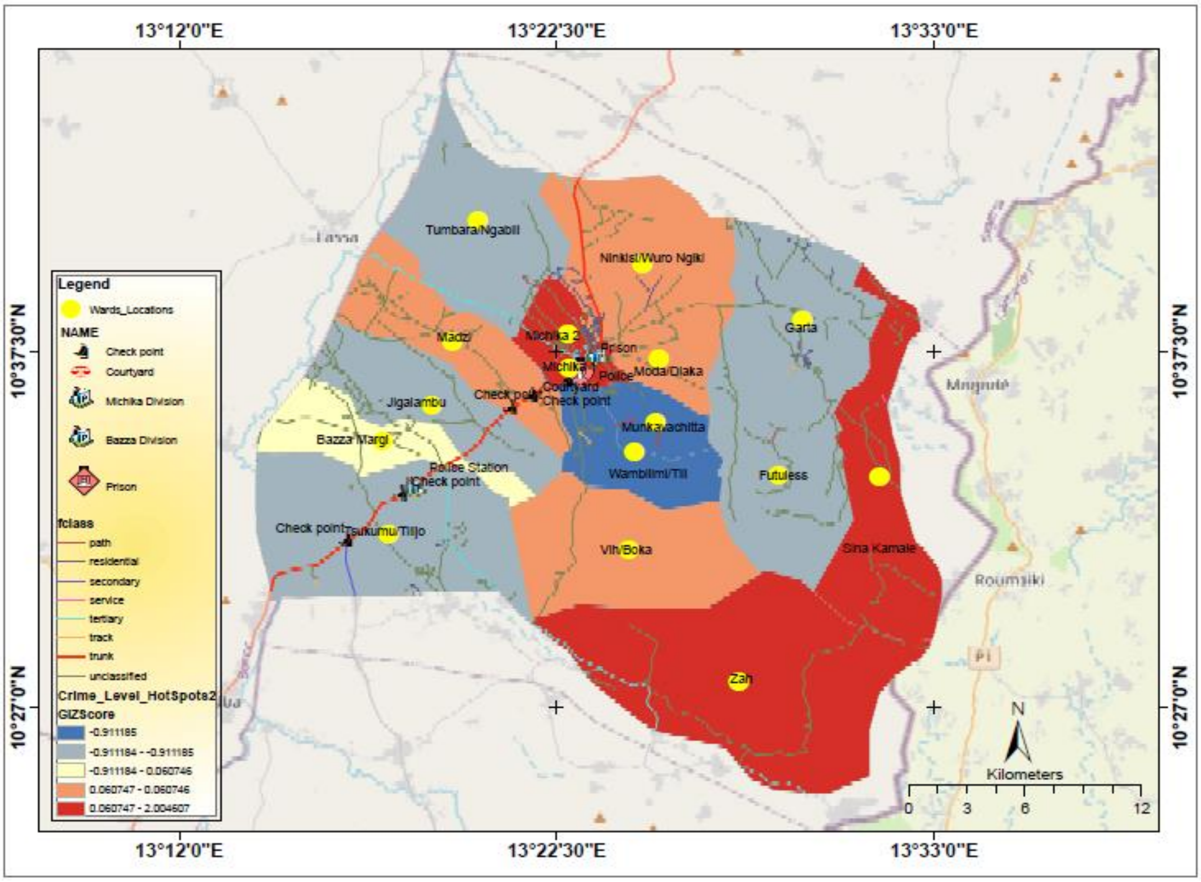

Figure 5: The crime hot-spots map of Michika Local Government Area

The crime hot-spots map of Michika Local Government Area serves as a valuable tool for law enforcement agencies, policymakers, and community stakeholders. It provides a visual representation of areas with higher crime incidence and helps in identifying priority areas for crime prevention efforts. Sina, Zah, Michika and Michika are the highest crime area and most hotspots to focus resources and interventions on these hot-spots, authorities can work towards reducing crime rates and improving public safety in Michika.

The topographical map of the Michika crime area as shown in Figure 6 offers valuable insights into the spatial distribution of criminal activities in relation to the natural and man-made features of the region. The results obtained from the analysis are as follows:

1. Crime Incident Overlay: By superimposing the crime incident data onto the topographical map, the spatial relationship between criminal activities and the topographical features was examined. This overlay allows for the identification of areas with a higher concentration of crime incidents, which may correlate with specific topographical characteristics.

2. Elevation and Crime Correlation: The topographical map provides information about the elevation levels across Michika. By analyzing the crime incident data in conjunction with elevation data, it is possible to determine if certain elevation ranges are associated with higher crime rates. For example, areas at lower elevations, such as valleys or urban centers, may exhibit higher crime incidence due to higher population density and accessibility.
3. Water Bodies and Crime Patterns: The topographical map includes water bodies such as rivers, lakes, or ponds. The analysis may reveal a correlation between crime incidents and proximity to water bodies. Criminal activities might be more prevalent near water bodies due to their strategic importance for transportation or access to resources.

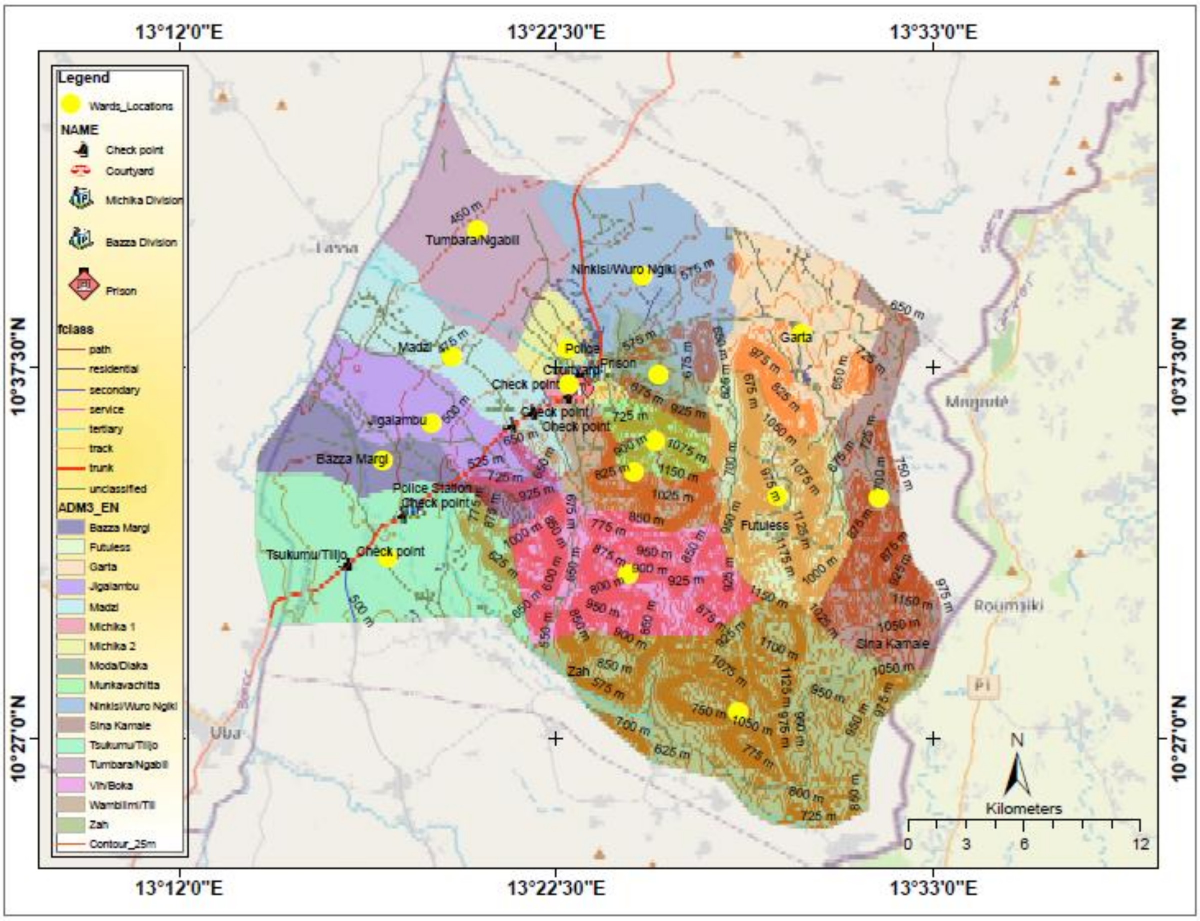

Figure 6: The topographical map of the Michika crime area

4. Road Networks and Crime Hot-spots: The road network displayed on the topographical map can help identify crime hot-spots along major highways, intersections, or remote roads. Criminals may target specific locations based on their accessibility and escape routes. Analyzing crime incidents in relation to the road network can provide valuable information for law enforcement in planning patrols and security measures.
5. Terrain and Crime Hiding Spots: The topographical map highlights various terrain features such as hills, forests, and rugged areas. Criminals might exploit these terrains as hiding spots or escape routes after committing crimes. Understanding the spatial relationship between crime incidents and terrain features can aid law enforcement in locating potential hiding spots and conducting targeted search operations.

Overall, the topographical map of the Michika crime area provides a comprehensive perspective on how criminal activities are distributed across the landscape. It helps law enforcement agencies and policymakers gain a better understanding of the geographical factors that may influence crime patterns. By integrating this information with other socio-economic and demographic data, authorities can develop effective crime prevention strategies and enhance public safety in the region.

6. The LULC classification for this study Figure 7. Provides valuable information for various applications, including urban planning, environmental management, and natural resource assessment. It helps in understanding the spatial distribution of different land cover types, their changes over time, and their relationships with environmental factors.

The accuracy of the LULC classification depends on several factors, including the quality of the satellite imagery, the representativeness of the training data, and the classification algorithm used. Therefore, it is important to consider these factors when interpreting the results and drawing conclusions.

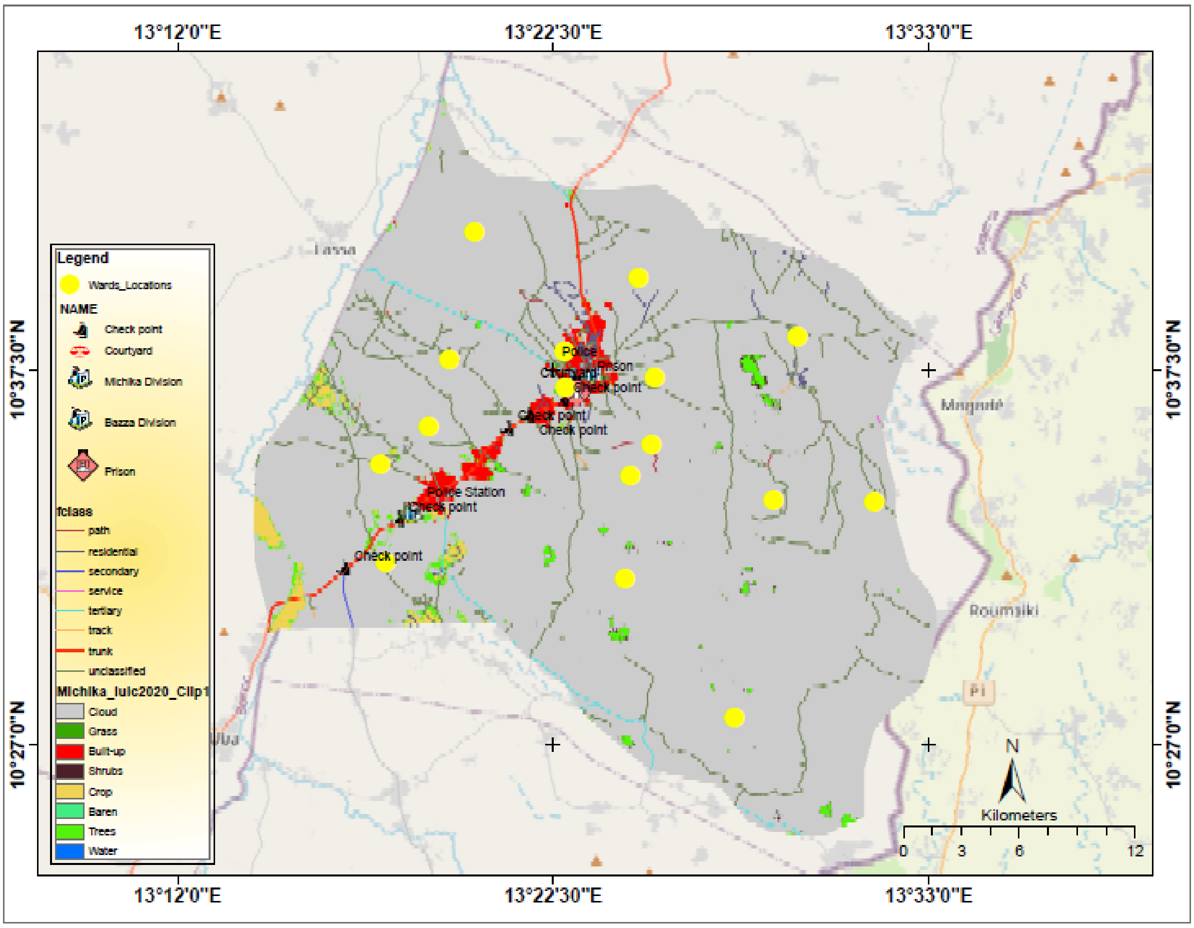

Figure 7: The LULC classification

CONCLUSION

In conclusion, this research work has focused on the geospatial mapping of crime hotspots in Michika Local Government Area of Adamawa State, Nigeria. Through the use of various spatial analysis methods and techniques, valuable insights have been gained into the spatial distribution of crime, the identification of hotspots, and the understanding of underlying factors influencing crime patterns. The research findings have revealed the significance of utilizing geospatial tools and techniques for crime mapping and analysis. The results obtained from the study provide important information for law enforcement agencies, policymakers, and urban planners to devise effective strategies for crime prevention and control. The study also employed a combination of data collection methods, including field surveys, GPS positioning, and the analysis of secondary data from police records. By georeferencing and digitizing the relevant information, accurate spatial representations of police stations, road networks, and crime hotspots were generated.

Spatial analysis methods such as interpolation techniques, spatial autocorrelation, and hotspot analysis (such as KDE, IDW, and Getis-Ord Gi*) were applied to examine the spatial relationships, identify clusters of high and low crime incidents, and provide valuable insights into crime patterns. The use of these methods allowed for a better understanding of the distribution and intensity of crime within the study area. Additionally, the research work highlighted the importance of land use/land cover (LULC) classification in understanding the spatial context of crime. By classifying the study area into different land cover types, such as urban areas, agricultural land, forests, and water bodies, a comprehensive picture of the environmental factors influencing crime patterns was obtained. This information can be valuable for urban planning, resource allocation, and crime prevention strategies.

In conclusion, the findings of this research contribute to the existing body of knowledge on crime mapping and analysis, particularly in the context of the study area. The insights gained from this research can inform evidence-based decision-making, resource allocation, and the development of targeted interventions to address crime-related challenges in Michika Local Government Area and similar regions.

Further research and analysis are recommended to explore additional factors influencing crime patterns, expand the scope of the study to encompass a larger geographic area, and evaluate the effectiveness of implemented crime prevention strategies. By continuing to deepen our understanding of crime patterns and their spatial dynamics, we can work towards creating safer and more secure communities.

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