Identifying the Relationship between Crime Patterns and Environmental Factors in the Colombo Municipal Council (CMC) Area of Sri Lanka

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ABSTRACT

Crime is becoming a major social problem in Sri Lanka. This study aims to identify the grave crime patterns and environmental correlations of urban crimes based on the Colombo Municipal Council area in Sri Lanka using Geographic Information Systems and Remote Sensing techniques. This study is important in crime prevention and law enforcement to enhance public safety. The main objective of this study is to identify patterns of crime and analyze their relationship with environmental factors. The research covers the year 2022 and concentrates on six major crime types: dangerous drug use, housebreaking and theft, theft, murder, rape, and robbery, which all constitute 21% of the total grave crimes reported in the region. Data collection included both primary and secondary sources. Crime data were collected by the Sri Lanka Police, and the coordination of crime locations was obtained by using the Global Positioning System. Analytical techniques such as buffer analysis, kernel density estimation, hotspots analysis, and inverse distance weighted interpolation were used. Seven wards were identified as urban crime hotspots such as Grandpass North, Borella, Aluthkade East, Aluthkade West, Kochchikade South, and Maligawatte East. Dangerous drugs and housebreaking were the most predominant crimes, especially in underserved settlement areas, near mainly used roads and commercial clusters. Temporal analysis indicated the crime peaks in April and December months, with high criminal activity between 12:00 and 16:00 hours on Saturday. A positive relationship between crimes and the road network, population density, commercial clusters, and settlements can be identified. Findings indicate the absence of a positive correlation between crime and the presence of water bodies or green spaces. The results developed by this research recommended that the Sri Lanka Police adopt high-resolution camera systems for road layers and hotspot areas, using Geographic Information Systems technology for crime mapping and crime analysis, and locate Police posts within hotspot areas.

Keywords: Colombo Municipal Council, Crime Patterns, Environmental Factors, Geographic Information Systems, Grave Crime,

Introduction

Crime, generally defined as activities that violate the law, has emerged as a pressing global issue with far-reaching impacts on societal well-being, economic development, and the international reputation of nations (Ready, Sainia, Ginika, & Mahajan, 2018). In Sri Lanka, the rising crime rate poses a significant threat to public safety and quality of life, necessitating more effective methods for crime prevention and control. Crime analysis has become an essential tool for law enforcement agencies, particularly the Sri Lanka Police, which plays a central role in combating crime. Conducting comprehensive crime analysis is crucial for identifying patterns, detecting trends, and shaping strategies to mitigate crime (Nizamani, Memon, Shah, Nizamani, & Ismaili, 2015).

Crime pattern analysis involves the systematic examination of crime incidents to understand their nature and characteristics. This process begins with identifying the crime, followed by the collection and analysis of relevant data. Data analytics is integral to uncovering hidden patterns and relationships within large datasets of crime information (Kapoor, Cherukuri, & Singh, 2020). A range of factors-including land use, socioeconomic conditions, and environmental attributes are associated with crime, underscoring the importance of geographic information systems (GIS) in understanding criminal behavior (Suryavanshi, 2001; Ahmad, Uddin, & Goparaiu, 2017). Despite substantial research on crime mapping and spatial-temporal analysis globally, there is limited research on the connection between crime patterns and environmental factors in Sri Lanka. This study aims to address this gap by focusing on crime analysis within the Colombo Municipal Council (CMC) area, offering insights to help practitioners and law enforcement reduce and prevent crime.

The Sri Lanka Police is tasked with maintaining social order and safeguarding the public by preventing and investigating crimes, addressing drug-related offenses, combating corruption, and protecting the environment. Over its 156-year history, the Sri Lanka Police has developed significantly; however, crime recording and investigation processes still rely on manual methods, including crime clocks, maps, and file-based systems. The Crime Record Division manages annual crime data and reporting, with the Western Province consistently recording the highest crime rates in the country. In 2020, 10,364 grave crimes were recorded in the Western Province, accounting for 33% of Sri Lanka's total grave crimes (31,098). This

number increased to 13,038 in 2021 and 13,730 in 2022, representing 37% of the country's total grave crimes (Sri Lanka Police, 2022).

Within the Western Province, the Colombo Central, Colombo North, and Colombo South police divisions report the highest crime rates, contributing 16%, 21%, and 19% of total crimes, respectively, between 2020 and 2022. According to the 2012 Census, Colombo District has a dense population of 2,324,349 residents spread across 676 km², with a population density of 3,438 people per square kilometer. Factors such as poverty, unemployment, education levels, and drug addiction have been closely linked to crime rates within the CMC area.

While previous studies in Sri Lanka have explored the distribution of crime in urban settings, no comprehensive research has examined the relationship between crime and environmental factors in the CMC area. This study seeks to fill that gap by investigating the connection between crime patterns and environmental factors, and their implications for public safety in the CMC region. Specifically, the study aims to address the following research questions:

1. What are the existing crime patterns in the Colombo Municipal Council area?
2. What is the relationship between crime patterns and environmental factors in the study area?
3. What strategies can be suggested for the reduction of urban crimes?

Crime analysis plays a pivotal role for the Sri Lanka Police and other law enforcement agencies in addressing safety issues and maintaining law and order. By analyzing crime data, agencies can detect patterns, understand criminal behavior, and anticipate future offenses, thereby facilitating proactive responses to criminal activities. Effective crime analysis enhances public safety, supports law enforcement in tackling organized crime, and optimizes resource management. This study focuses on identifying crime locations, timing, spatial patterns, and environmental factors that influence criminal activity, providing insights crucial for the Sri Lankan Police to conduct further investigations and implement targeted interventions.

The findings of this research will also inform decisions related to resource allocation, such as determining areas that require increased police presence or the establishment of new police

stations or posts. Additionally, crime analysis supports surveillance operations, prosecution strategies, and the efficient management of law enforcement resources. When applied effectively, geostatistical analysis offers valuable insights that strengthen law enforcement's ability to predict, prevent, and respond to criminal activities, thereby fostering a more comprehensive approach to public safety (Johnson, 2000; Gupta et al., 2012).

Objectives

The primary objective of this study is to identify the relationship between crime patterns and environmental factors within the Colombo Municipal Council (CMC) area. The specific objectives of the study are as follows:

- To identify existing crime patterns in the study area.
- To examine the relationship between crime patterns and environmental factors in the study area.
- To provide recommendations for reducing urban crime based on the findings.

This research will contribute to a deeper understanding of how environmental and socioeconomic factors influence crime patterns in urban settings. It aims to provide actionable insights for policymakers, law enforcement agencies, and urban planners to develop effective crime prevention strategies and improve public safety in Colombo.

Literature Review

Crime is legally defined as the violation of laws (Lamond, 2007), but its sociological interpretation is more nuanced. Brantingham and Brantingham (1991) argue that crime arises from the convergence of four key elements: a law, an offender, a target, and a location. When these elements intersect, a crime occurs. The importance of studying crime on a global scale has been well-documented, with Mohammed and Baiee (2020) underscoring the need for comprehensive research in this area. Crime analysis, which is essential for identifying trends and patterns, has been explored using various methodologies, though much of the existing research focuses predominantly on crime locations, often neglecting crucial factors such as the nature and timing of crimes.

Ahamdi (2003) describes crime as a broad concept that encompasses both legal and non-legal definitions. Meanwhile, Fajemirokun et al. (2006) highlight that many countries experience

high rates of delinquency and crime, which disrupt societal norms and hinder socio-economic development. This highlights the importance of analyzing crime data to support law enforcement efforts (Awal et al., 2016).

Boba (2001) categorizes crime into five primary types. Crimes against persons include offenses such as murder, aggravated assault, rape, and abduction, with these crimes disproportionately affecting young, urban, and impoverished populations, as well as racial minorities in the U.S. Property crimes, on the other hand, involve the theft of property without physical harm, such as burglary and auto theft (Crossman, 2017). Crimes against morality, often referred to as victimless crimes, include acts such as prostitution and drug abuse (Boba, 2001). White-collar crimes, such as embezzlement and tax evasion, are typically committed by individuals in positions of power (Boba, 2001). Finally, organized crime involves structured groups engaged in the illegal distribution of goods and services (Stickland, 2014). In Sri Lanka, crimes are categorized into grave offenses against persons and property and minor offenses, which encompass violations against individuals, property, and legislation (Sri Lanka Police, 2022).

Crime analysis is an essential discipline that employs both quantitative and qualitative methods to analyze data critical for law enforcement agencies and their communities (Wyckoff, 2014). Over time, advancements in crime mapping and spatial data techniques-such as spatial autocorrelation and heterogeneity have improved the statistical accuracy of crime mapping. These innovations have enhanced the understanding of why and where crimes occur, thereby strengthening law enforcement efforts (Yar & Nasiri, 2016; Sherman, 1995).

Early crime analysis faced challenges in identifying high-crime zones or "hot spots," particularly in accurately determining the time and location of crimes, often leading to errors in crime mapping (Yar & Nasiri, 2016). In the early 19th century, social theorists used simple techniques such as single-symbol points and graduated area maps to represent crime data, though these methods provided limited insights (Boba, 2001). By the early 20th century, the New York Police Department pioneered crime mapping by using wall maps with pushpins to indicate crime locations. However, these maps had notable limitations, such as difficulty tracking overlapping crimes or interpreting crowded maps with multiple crime types (Harries, 1999).

In the 1920s and 1930s, sociologists from the University of Chicago used crime mapping to study juvenile delinquency and associated social factors. Despite its limitations, wall mapping remained a common tool throughout the 20th century, and some police departments continue to use it for crime tracking today (Sherman, 1995; Harries, 1999).

The introduction of computer-generated crime maps in the 1960s and 1970s marked a pivotal moment in law enforcement technology, although their functionality remained limited (Boba, 2001). By the 1980s, desktop computers made crime mapping more accessible, yet the features were still rudimentary. A significant advancement occurred in 1986 when the National Institute of Justice funded a project with the Chicago Police Department to explore the use of computer-based mapping in support of community policing, greatly enhancing data management and proactive law enforcement strategies (Weisburd & McEwan, 1997; Loda, 2000).

The advent of Geographic Information Systems (GIS) in the 1990s revolutionized crime analysis (Yar & Nasiri, 2016). GIS, a computer-based tool, allows for the mapping and analysis of crime through physical and geographic features, aiding in the visualization of complex relationships between crime and infrastructure (Fajemirokun et al., 2006). GIS technology enables law enforcement to identify crime hotspots, recognize barriers influencing criminal behavior, and analyze crime proximity to infrastructure like roads (Karthik, 2004).

Modern GIS tools, such as kernel density estimation and buffer analysis, have further enhanced crime analysis by providing detailed spatial insights into crime patterns (Bailey & Gutrell, 1995). Hotspot analysis, a crucial function of GIS, identifies statistically significant crime clusters, helping prioritize law enforcement interventions (Haider & Iamtrakul, 2022).In conclusion, GIS has transformed crime analysis by integrating spatial data with crime patterns, enabling law enforcement to respond more proactively, optimize resource use, and predict future criminal activity. As crime becomes increasingly complex and interconnected across geographic boundaries, the role of GIS in crime analysis continues to grow in importance. These technological advancements have not only enhanced operational efficiency but also deepened our understanding of crime dynamics, making GIS an indispensable tool in the fight against crime.

Methodology

This study aims to analyze patterns of serious crimes and examine the relationship between crime and environmental factors, focusing on six selected grave offenses recorded within the Colombo Municipal Council in 2022. Additionally, this section outlines the study areas and methodologies employed to achieve the research objectives.

Background of the Study Area

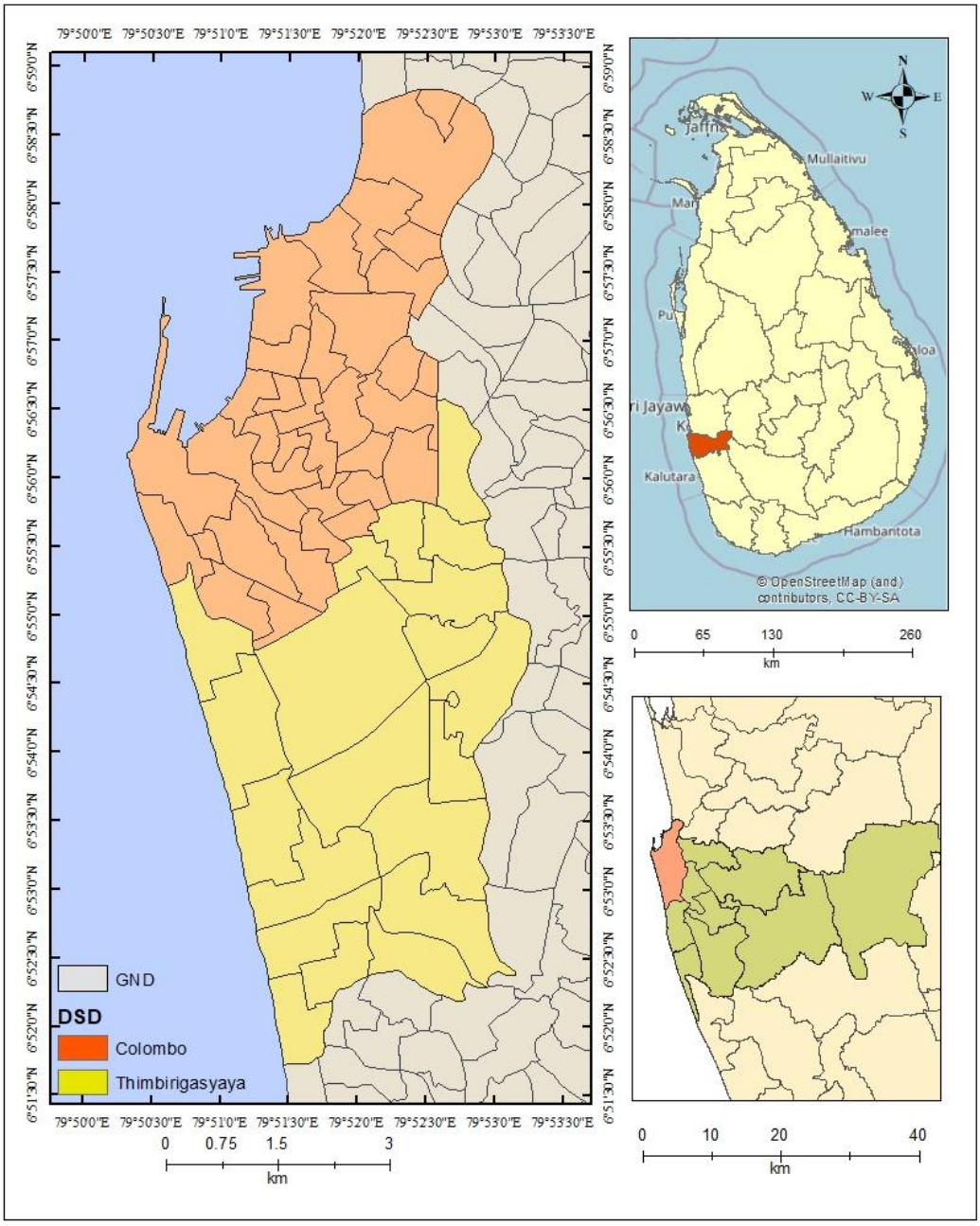
The Colombo Municipal Council (CMC) was selected for this study as it serves as the commercial capital of Sri Lanka and recorded the highest crime rate in 2022. Located on the west coast of Sri Lanka within the Western Province, Colombo functions as a key administrative, financial, and economic hub. Geographically, the CMC lies between 6.9157°N latitude and 79.8636°E longitude, covering an area of 678 km² with a population density of 3,438 persons per km². As per the 2012 Census, Colombo's population was 561,314, with an additional influx of approximately 500,000 individuals daily due to the city's transient population.

The CMC is divided into two Divisional Secretariat (DS) divisions: the Colombo DS Division and the Thimbirigasyaya DS Division, comprising 20 Grama Niladhari (GN) divisions and 35 GN divisions, respectively. Colombo’s urban landscape is highly diverse, encompassing commercial hubs, slum settlements, recreational areas, and key tourist destinations.

The CMC was chosen for this research due to its consistently high crime rate, especially in 2022 when it reported the highest number of crimes in Sri Lanka. Various socio-economic factors, including a significant transient population, active nightlife, and the presence of numerous financial institutions, contribute to Colombo’s complex crime patterns.

Crime data in Sri Lanka is compiled and published by the Crime Records Division of the Sri Lanka Police. Between 2017 and 2022, the Western Province consistently recorded the highest number of crimes nationwide. According to the statistical reports, 37% of all crimes in Sri Lanka in 2022 occurred in the Western Province. The province is divided into four police ranges as Colombo, Western Province North, Western Province South, and Kalutara comprising ten police divisions across these districts.

The Colombo is divided into three police divisions as Colombo North, Colombo Central and Colombo South. Further analysis of the statistical reports, the Colombo North, Colombo South, and Colombo Central police divisions accounted for 19% of the total crimes reported in the Western Province in 2022. Furthermore, the Colombo North division consistently recorded the highest crime rate between 2017 and 2022, contributing 39% of the total crimes in the province. Figure 1 shows the Study Area Map by DSD in the Colombo Municipal Council.



Source: Based on Survey Department Data

Figure 1: Study Area Map by DSD in Colombo Municipal Council

Data and Data Collection Techniques

This research utilized both primary and secondary data sources. Primary data were collected through field surveys, observations, questionnaires, and interviews with households and police officers in the study area.

The primary data collection process involved gathering GPS coordinates of crime locations and conducting field observations to assess the area's natural context. Additionally, key informant interviews were conducted with police officers and local authorities to gain insights into socio-economic variables, such as unemployment rates, education levels, and income, and their potential correlation with criminal activity.

Secondary data were obtained from official sources, including the Sri Lanka Police, the Department of Census and Statistics, and the Urban Development Authority. The dataset included census data, crime statistics, and land-use information. Satellite imagery and geospatial data were also used to assess land-use changes within the study area. From the 26 grave crimes outlined in the Sri Lankan Penal Code, six were selected for detailed analysis due to their high incidence in 2022: housebreaking and theft, theft, murder, rape, robbery, and drug-related crimes. A total of 551 cases of these selected crimes were analyzed.

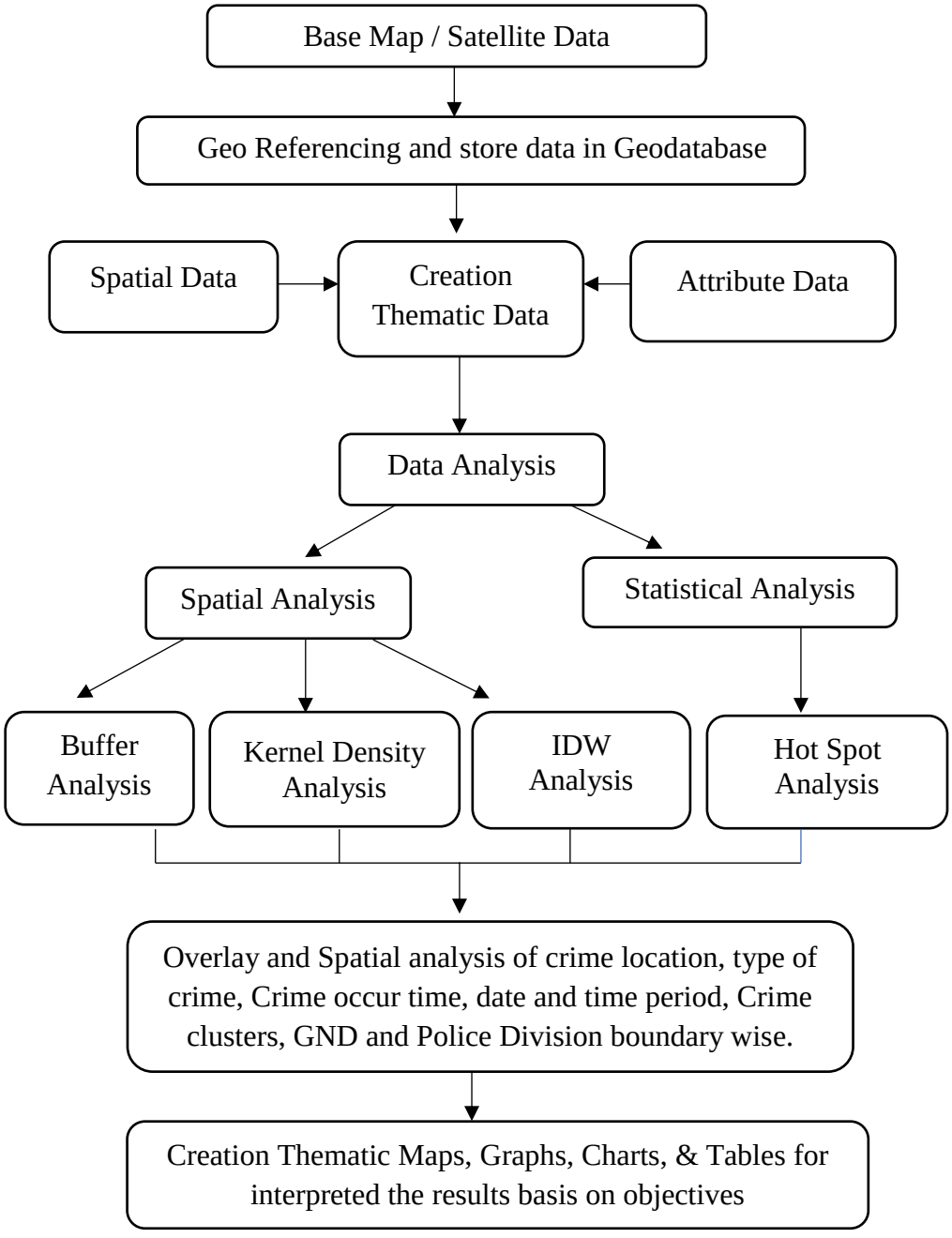
Data Analysis

A combination of quantitative and spatial analysis methods was applied to investigate crime patterns and their relationship with environmental factors within the Colombo Municipal Council (CMC) area. Primary data, including the geographic coordinates of crime locations, were analyzed using ArcMap 10.4.1 software. Spatial data were projected onto the Sri Lanka grid system (WGS84 to Kandawala) and digitized for analysis. Attribute data, such as crime type, date and time of occurrence, and the associated police station, were integrated with spatial data for comprehensive analysis.

The results were presented through thematic maps, graphs, charts, and tables to visually depict the spatial distribution of crimes and emphasize key patterns. The analysis identified high-risk areas and uncovered relationships between crime hotspots and environmental factors, including population density, land use, and socio-economic conditions.

In conclusion, the integration of spatial and statistical analyses provided a comprehensive understanding of crime patterns within the CMC and their relationship with environmental variables. The thematic maps generated during the analysis offered clear visual representations of the distribution of grave crimes, contributing to more effective crime prevention and urban planning strategies.

Conceptual Model for Data Analysis



Source: Crated by Researcher

Figure 2: Flow Diagram of Data Analysis

Results and Discussion

The year 2022 was selected as the year of study according to the statistical reports of the Crime Record Division in Sri Lanka Police (CRD).

Existing Patterns of the Crime in the CMC

Out of 26 grave crimes, six grave crimes were selected for the study based on the number of incidents reported in the year 2022. The selected grave crimes are,

- Dangerous Drugs
- Housebreaking and theft
- Theft
- Murder
- Rape
- Robbery

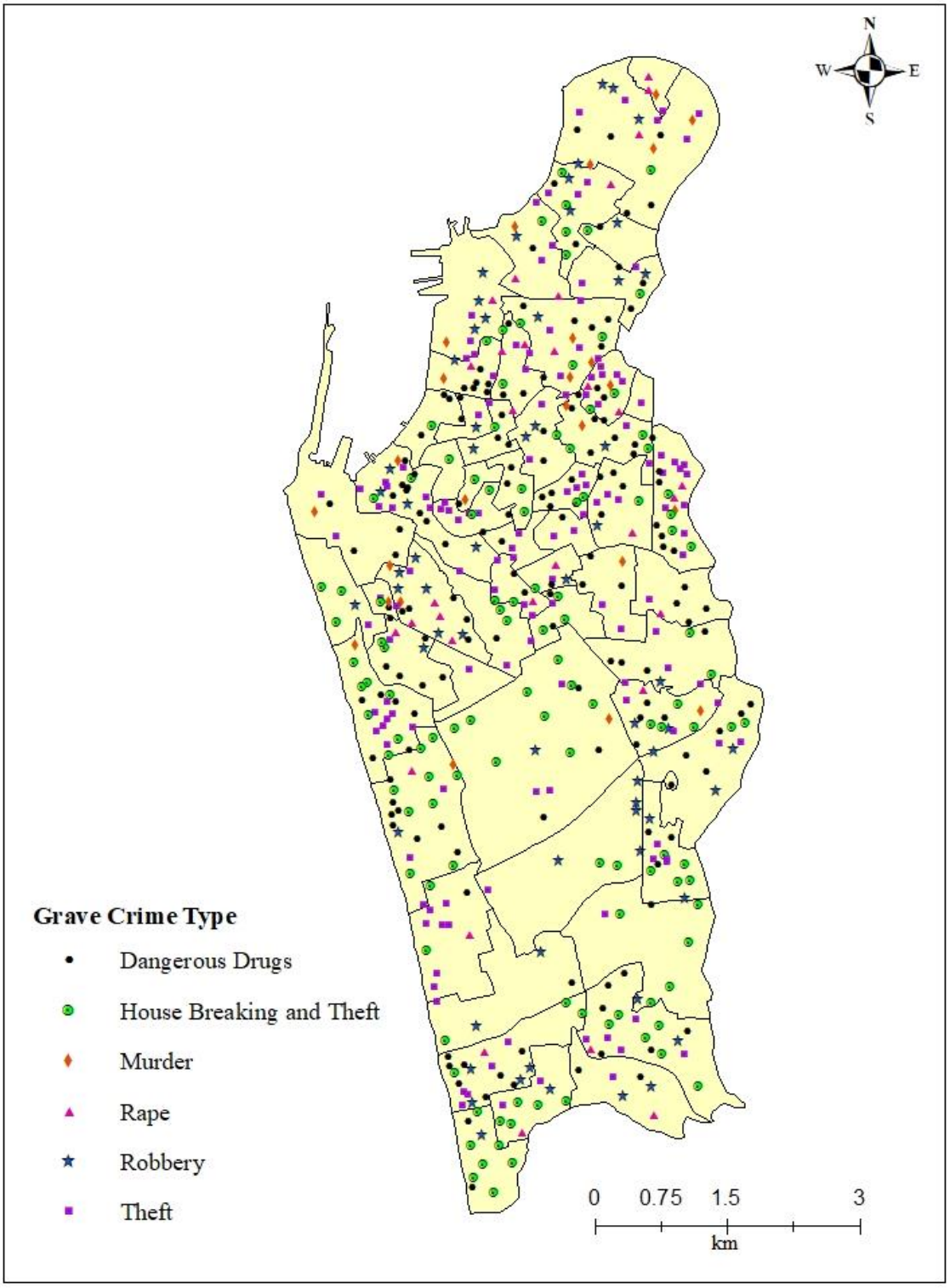
According to the grave crime record of Sri Lanka Police in the year 2022, 551 cases have been reported by above six grave crimes in Colombo Municipal Council. It is about 21% of total grave crimes were reported in Colombo Municipal Council as shown in Table 1.

Table 1: Percentage of Selected Grave Crimes in the Year 2022

Selected Grave Crimes	**Percentage out of selected Grave Crimes in CMC**	**Percentage out of selected Grave Crimes in CMC**
Dangerous Drugs	30%	30%
Theft	27%	27%
House breaking and Theft	22%	22%
Robbery	11%	11%
Rape	6%	6%
Murder	5%	5%
Total	100%	21%

Source: Sri Lanka Police, 2022

This study examines crime patterns within the Colombo Municipal Council (CMC) in 2022, focusing on six major offenses among the 26 grave crimes tracked by the Sri Lanka Police: Dangerous Drugs, Housebreaking, Theft, Murder, Rape, and Robbery. These six crimes accounted for 21% of all grave crimes within the CMC, totaling 551 reported cases.



Source: Sri Lanka Police, 2022

Figure 3: Distribution Pattern of Reported Grave Crimes in CMC - 2022

Grave crime reported by Police Division is another spatial pattern. According to the Police Boundaries, there are three Police Divisions in Colombo Municipal Council such as Colombo South Division, Colombo North Division and Colombo Central Division. As illustrated in Figure 5 - 7, the Colombo South Police Division accounted for 40% of the selected grave crimes within the Colombo Municipal Council in 2022, representing the highest proportion. In contrast, the lowest number of grave crimes were reported in the Colombo Central Police Division, comprising 26% of the total. The Colombo North Police Division ranked second, with 34% of the recorded grave crimes in the same year.

Another important aspect of the study is the analysis of crime by type. As shown in Figure 5 - 7, Housebreaking and Theft occurred across all three police divisions. Additionally, Dangerous Drugs and Theft cases recorded the highest number of incidents within the Colombo Municipal Council in 2022. In contrast, Rape and Robbery cases were reported at relatively low rates across the three divisions, while Murder cases represented the lowest incidence overall.

Among these, Dangerous Drugs (30%) and Theft (27%) were the most prevalent, while Murder (5%) and Rape (6%) were the least common, indicating a distinct imbalance between property-related crimes and crimes against individuals.

Crime distribution across the three police divisions of the CMC-Colombo South, Colombo North, and Colombo Central-varies significantly. Colombo South, a largely residential and affluent area, recorded the highest crime incidents, accounting for 40% of total crimes within the CMC. Housebreaking and Theft were the most common in Colombo South (26%), while Murder had the lowest incidence (2%).

In contrast, Colombo North, dominated by slums and low-income settlements, accounted for 34% of total reported crimes, with Dangerous Drugs representing a high proportion (29%). Colombo Central, comprising both residential and commercial areas, reported 26% of the total crimes, with Dangerous Drugs (35%) and Theft being the most prevalent, while Murder remained the least frequent.

A notable pattern that emerges is the significant variation in the total number of grave crimes reported across different police areas within the Colombo Municipal Council. According to

the data, Borella recorded the highest incidence of grave crimes, accounting for 10%, followed by Grandpass with 9%, and Kotahena and Wellawatte with 7% each. Other key police stations include Dematagoda, Kollupitiya, Maradana, Kirulapone, Bambalapitiya, and Modara. In contrast, the Harbour Police Station reported the lowest number of crimes.

Figure 3 illustrates that 57% of the total recorded grave crimes occurred during the daytime, represented by red points, while 43% occurred at night, indicated by black points.

Monthly analysis reveals significant crime spikes in April and December, accounting for approximately 14% and 13% of total crimes in the Colombo Municipal Council (CMC), respectively.

Daily crime data shows that Saturdays report the highest number of incidents. Additionally, crimes are most frequent between 12:00 and 16:00, comprising about 22% of all recorded crimes in the CMC.

These findings suggest that crime distribution is closely linked to socioeconomic factors and population density. Property crimes, such as Housebreaking and Theft, are more common in wealthier areas, whereas crimes against persons, such as Murder and Rape, are concentrated in low-income, densely populated regions.

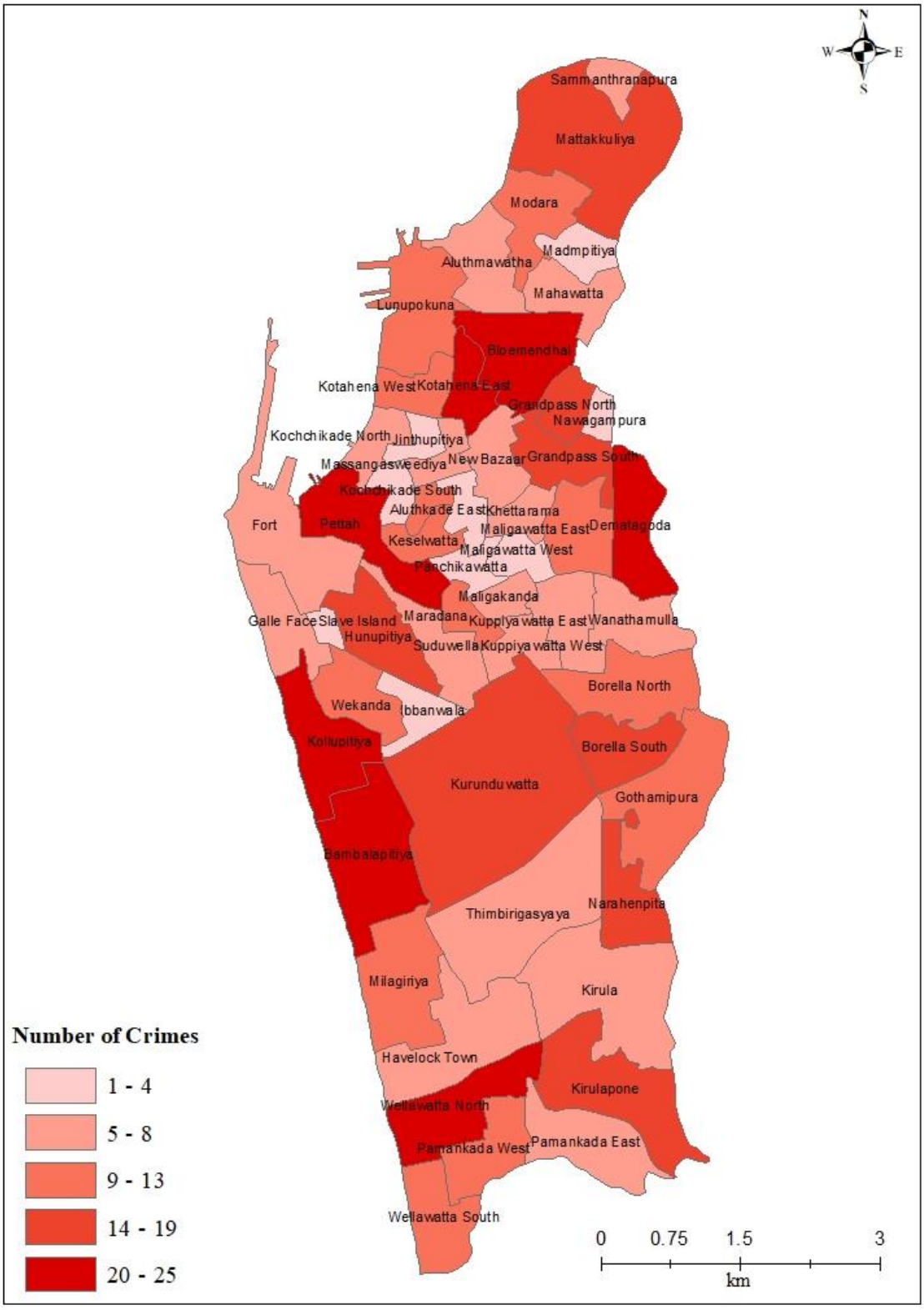
Environmental Factors Affecting Crime Patterns

Various environmental factors, including population density, land use, proximity to road networks, green spaces, and commercial clusters, were examined to understand their relationship with crime patterns in the CMC.

Population Density

A positive correlation was found between population density and crime rates. Areas with high population densities, such as Wellawatta North, Bambalapitiya, and Pettah, recorded the highest crime rates, particularly in low-income, densely populated regions. These areas, characterized by overcrowded settlements and inadequate infrastructure, are more vulnerable to crimes, especially those against persons, such as Murder and Rape. The elevated crime

rates in these areas reflect the socioeconomic challenges faced by residents, contributing to higher levels of criminal activity.

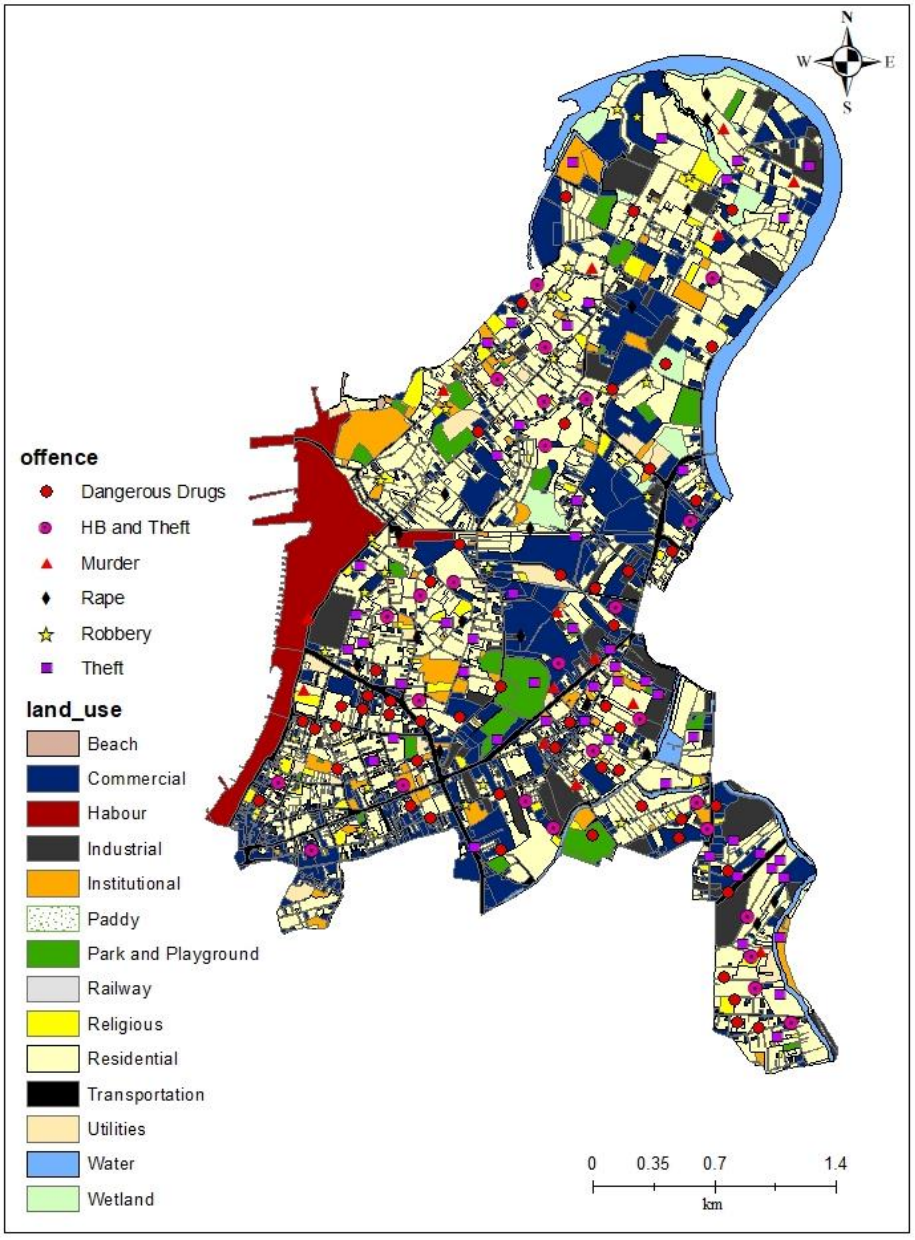


Source: Sri Lanka Police, 2022

Figure 4: Distribution Pattern of Grave Crimes by GND in CMC – 2022

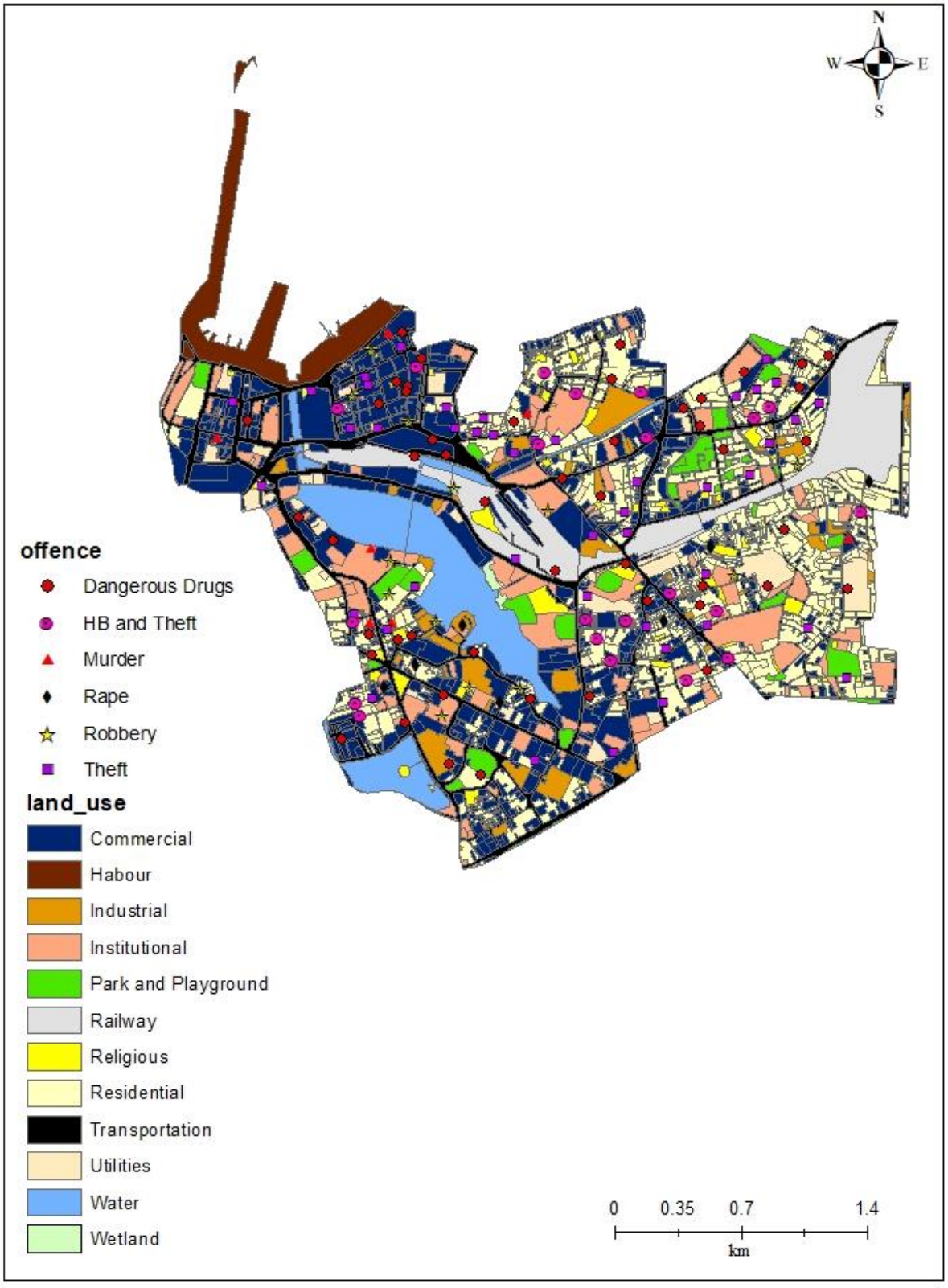
Land Use and Crime

Land use patterns provide clear insights into environmental influences on criminal behavior. Colombo North, characterized by a significant proportion of slums, reported higher levels of crimes against individuals, particularly in relation to Dangerous Drugs and Murder. In contrast, Colombo South, which encompasses wealthier, low-density residential areas, experienced fewer violent crimes but a higher incidence of property crimes such as Housebreaking and Theft. Colombo Central, a mixed-use area combining residential and commercial activities, exhibited moderate crime levels, reflecting its diverse socio-economic composition (Figures 5 - 7).



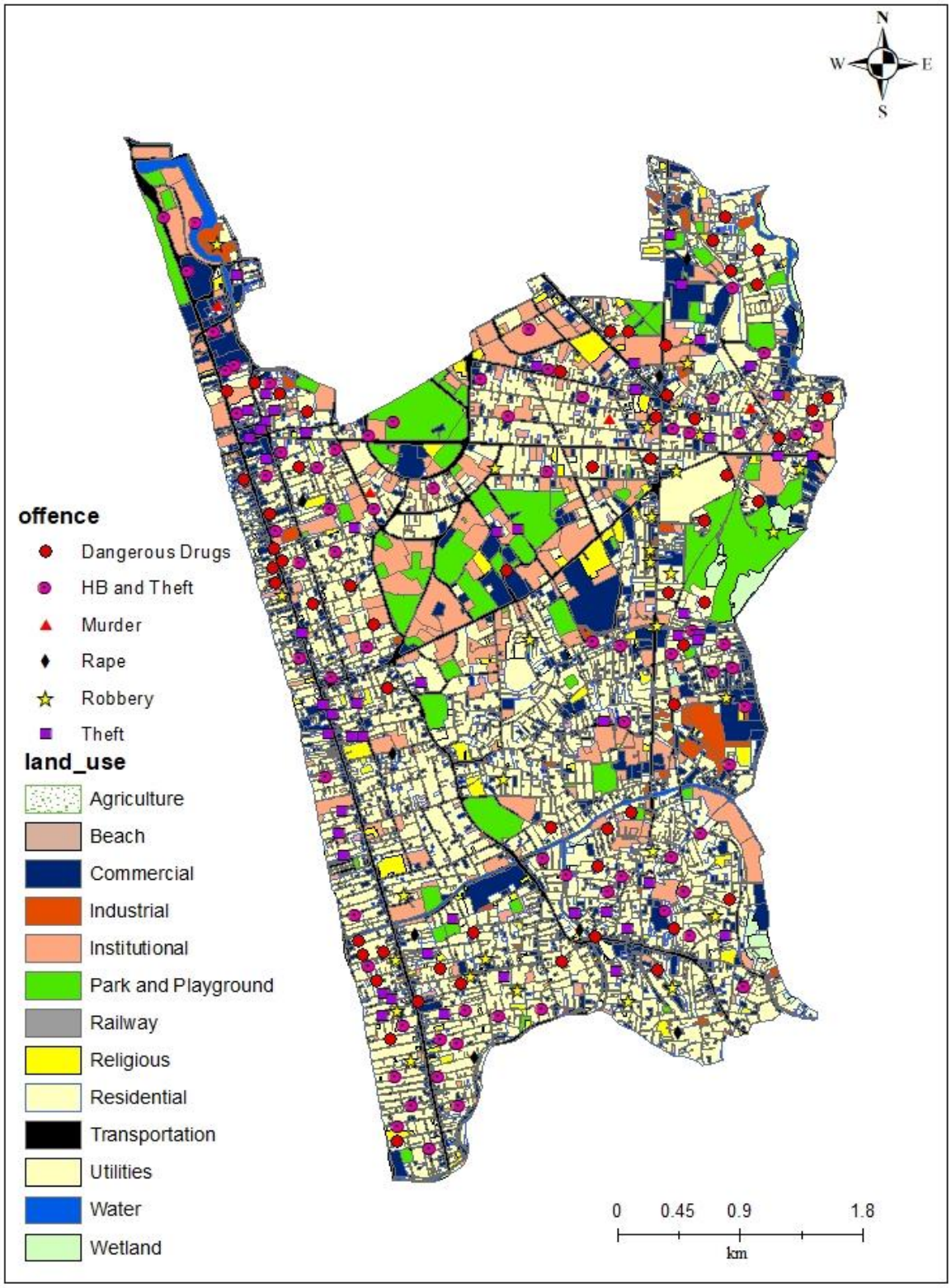
Source: Sri Lanka Police, 2022

Figure 5: Relationship between Land Use and Crime, Colombo North Police Division - 2022



Source: Sri Lanka Police, 2022

Figure 6: Relationship between Land Use and Crime, Colombo Central Police Division -2022



Source: Sri Lanka Police, 2022

Figure 7: Relationship between Land Use and Crime, Colombo South Police Division - 2022

Road Networks

A strong link has been found between proximity to road networks and crime rates, with 63% of reported crimes occurring within 100 meters of major roads. This relationship is especially evident in drug offenses, where 68% of cases are concentrated near road networks. While road networks support movement and economic activity, they also create opportunities for crime, such as drug trafficking, theft, and robbery.

Roads provide criminals with easy transportation and rapid escape routes, especially in densely populated cities, where major roads facilitate both legal and illegal activities. Intersections, bus stops, and transport hubs further contribute to crime by increasing the flow of people, offering anonymity, and allowing quick escapes after criminal acts.

The presence of informal economies and street vendors near roadways, often lacking proper security and oversight, also contributes to higher crime rates. According to routine activity theory, crime rates increase where offenders, targets, and lack of guardianship converge—common near road networks.

These findings call for targeted interventions near major roads, such as enhanced surveillance, street lighting, and increased police patrols. Urban planning should also address the crime-enabling potential of road networks by implementing traffic management, secure public spaces, and strategic law enforcement infrastructure to reduce crime and improve public safety.

Green Areas

Contrary to initial expectations, the analysis found no significant correlation between proximity to green spaces and crime incidence. Only 33% of reported crimes occurred within 250 meters of green areas, indicating that parks and open spaces in Colombo are not major hotspots for criminal activity. This challenges the prevailing assumption that green spaces, due to their relative seclusion or lower levels of surveillance, attract crime or serve as havens for illicit activities.

Although drug offenses and theft were the most common crimes near green areas, their occurrence was significantly lower compared to areas near road networks or commercial hubs, where crime rates were markedly higher. This contrast underscores the greater

influence of infrastructural and commercial environments on criminal behavior in urban contexts. Informal social control, facilitated by the frequent public use of green spaces for recreation and social interaction, may contribute to deterring more serious offenses, thus reducing overall crime rates in these areas.

Furthermore, urban planning strategies should prioritize green spaces for their social and health benefits, while focusing security efforts on areas more vulnerable to crime, such as road networks and commercial zones, to create safer, sustainable cities.

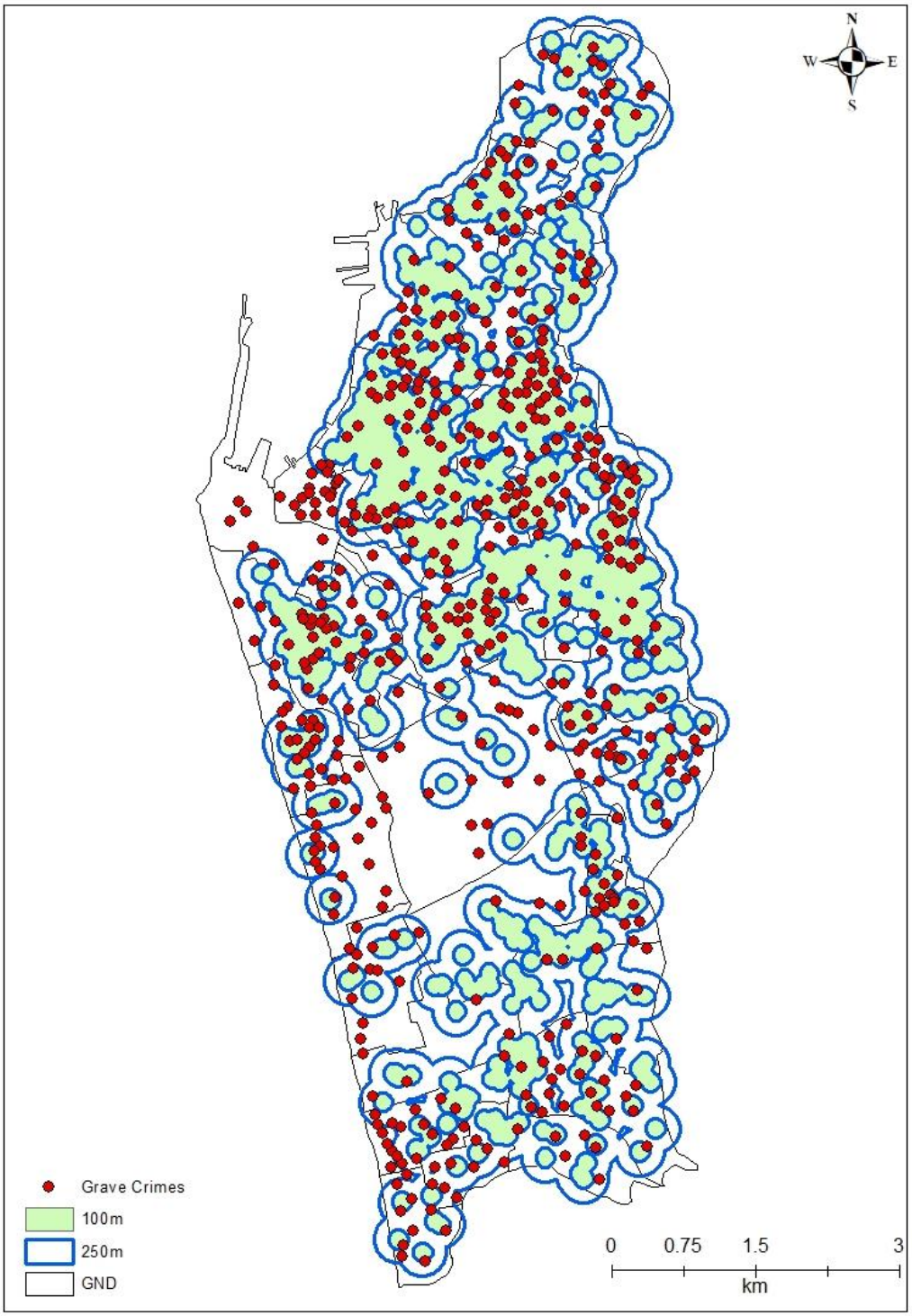
Settlements and Commercial Clusters

A significant correlation has been identified between crime incidence and proximity to both residential settlements and commercial clusters. Approximately 32% of all reported crimes occurred within 100 meters of residential areas, with a notable concentration in low-income neighborhoods. These areas are disproportionately affected by crime, particularly drug-related offenses, which accounted for 90% of such incidents near residential settlements. This trend reflects the heightened vulnerability of impoverished communities to crime, driven by socio-economic factors such as high unemployment, limited access to education, and overcrowded living conditions.

The spatial relationship between crime and residential areas aligns with broader patterns of urban inequality, where marginalized populations experience greater exposure to criminal activity. These communities often face inadequate law enforcement and social services, exacerbating their susceptibility. According to social disorganization theory, poverty, social instability, and poor infrastructure in such areas undermine social cohesion and community control, increasing the likelihood of criminal behavior.

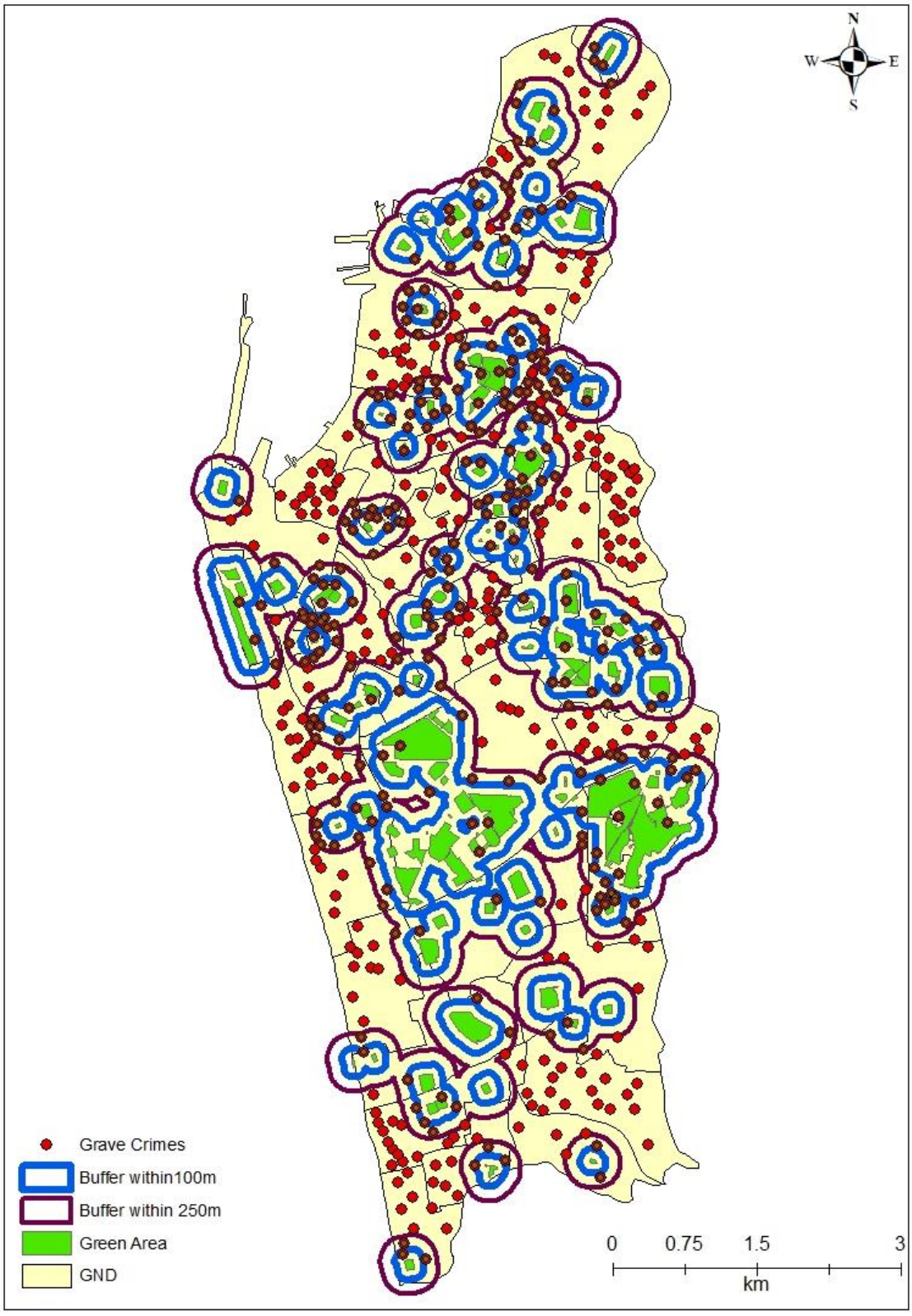
Commercial clusters also play a significant role in crime distribution. Due to high foot traffic and economic activity, 64% of drug-related offenses and 60% of total crimes occurred within 100 meters of commercial zones. These findings highlight the need for enhanced security in commercial areas, as they present key opportunities for crimes such as theft, robbery, and drug-related activities.

Integrating spatial analysis into urban planning and addressing socio-economic disparities in low-income areas, alongside improving security in commercial zones, are essential for reducing crime in urban settings.



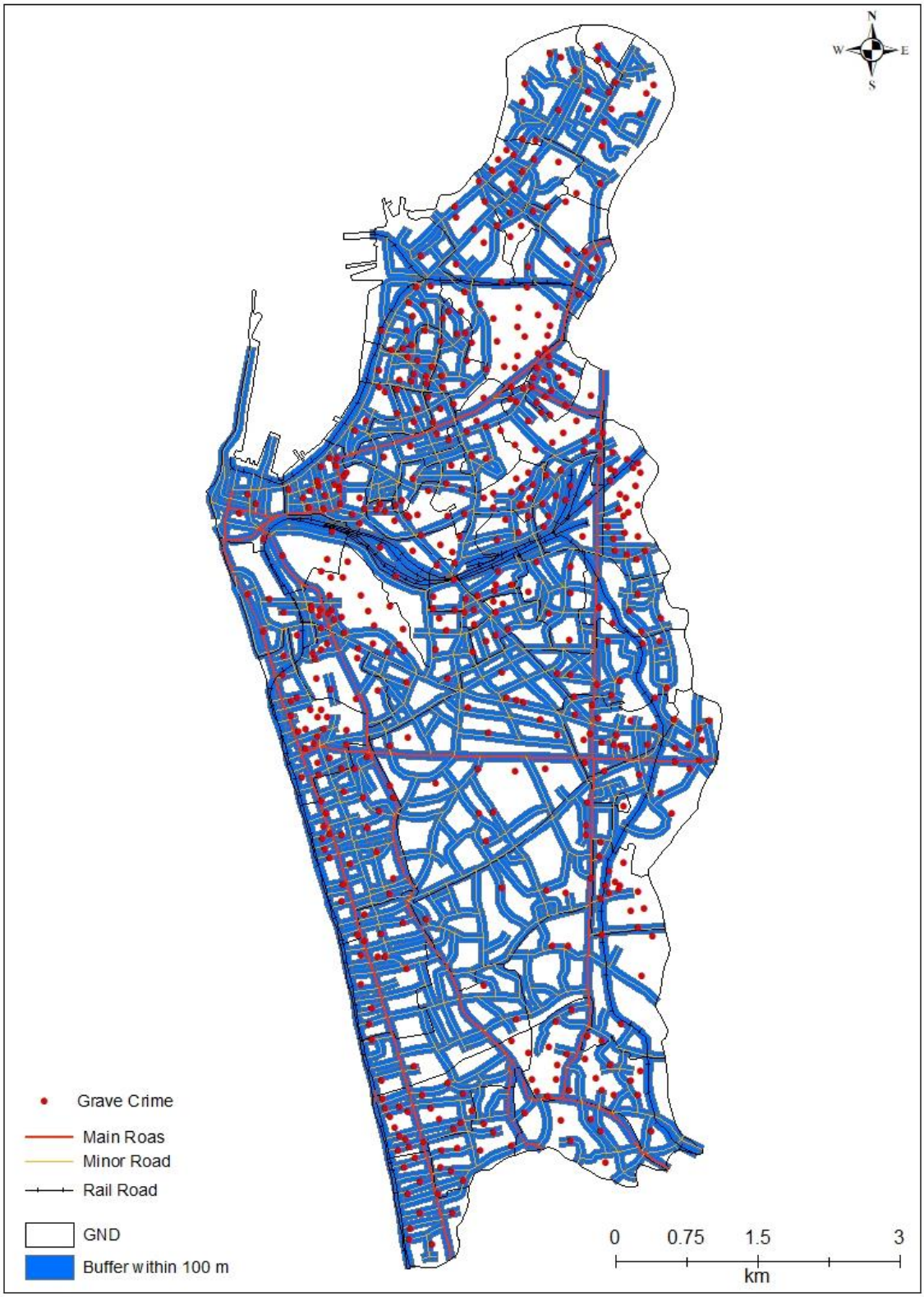
Source: Sri Lanka Police, 2022

Figure 8: Relationship between Settlements and Crime in CMC - 2022



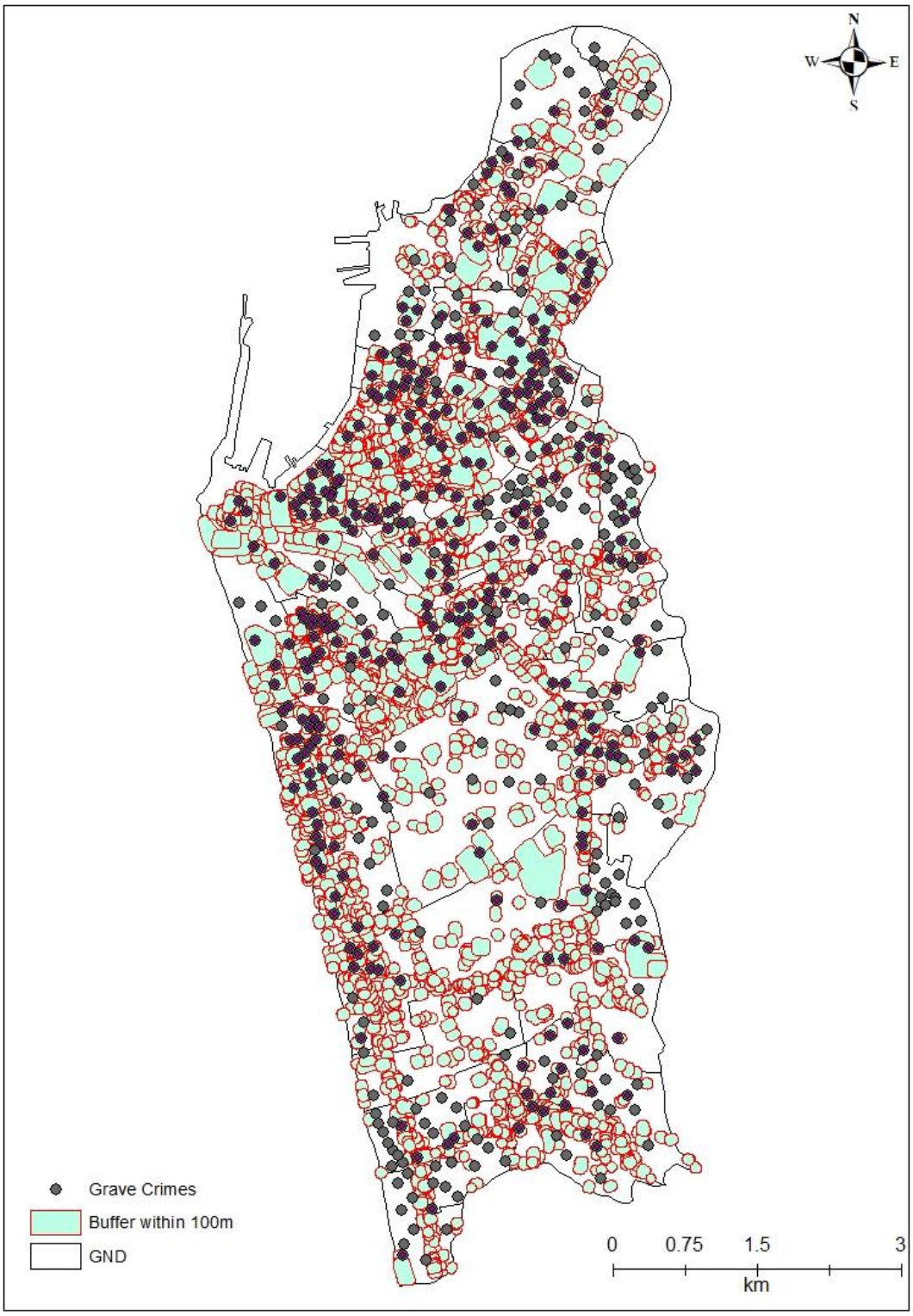
Source: Sri Lanka Police, 2022

Figure 9: Relationship between Green Area and Crime in CMC - 2022



Source: Sri Lanka Police, 2022

Figure 10: Relationship between Road Network and Crime in CMC - 2022



Source: Sri Lanka Police, 2022

Figure 11: Relationship between Commercial Clusters and Crime in CMC - 2022

As illustrated in Figure 11, buffer analysis was conducted to examine the relationship between crime and environmental factors, particularly the proximity to road networks. The analysis utilized buffers at distances of 100 meters, 200 meters, and beyond 200 meters from the road network to reveal patterns in crime distribution.

The findings, summarized in Table 2, demonstrate distinct crime patterns relative to road proximity, highlighting the spatial correlation between crimes and the road network.

Table 2: Crime Reported Distance from Road Network - 2022

Distance From Road Network	Da. Drugs	HB and Theft	Theft	Robbery	Murder	Rape	Total
100m	110	71	97	39	13	17	347
100m - 200m	36	28	36	16	7	9	132
>200m	17	21	16	7	5	6	72
Total	163	120	149	62	25	32	551

Source: Sri Lanka Police, 2022

Table 4.2 presents the distribution of crimes in relation to their proximity to the road network within the Colombo Municipal Council (CMC) area. The table categorizes crime occurrences based on three buffer distances from the road network: within 100 meters, 100 - 200 meters, and beyond 200 meters.

The results indicate that 63% of total crimes occurred within 100 meters of the road network, underscoring the significant influence of road proximity on crime patterns. Dangerous drug offenses are particularly concentrated near roads, with 110 cases (68% of total drug-related crimes) reported within the 100-meter buffer. Housebreaking and theft (71 cases), theft (97 cases), and robbery (39 cases) also show high concentrations within this buffer zone.

Crime occurrences decrease as the distance from the road network increases, with only 72 total cases reported beyond 200 meters. This trend suggests a clear positive correlation between crime frequency and proximity to roads, with the highest number of offenses occurring closer to the road network.

The Colombo Municipal Council area contains numerous green spaces, prompting the use of buffer analysis to investigate any potential relationship between these areas and crime occurrences. This analysis aimed to determine whether proximity to green areas influenced crime patterns. As depicted in Figure 4.18 and detailed in Table 4.3, the results indicate that there is no significant or direct relationship between crime and green spaces within the Colombo Municipal Council.

Table 3: Crime Reported Distance from Green Area – 2022

Distance From Road Network	Dan. Drugs	HB and Theft	Theft	Robbery	Murder	Rape	Total
100m	31	13	35	11	7	2	99
100m -250m	57	41	42	23	9	14	186
>250m	75	66	72	28	9	16	266
Total	163	120	149	62	25	32	551

Source: Sri Lanka Police, 2022

According to the analysis presented in Table 4.3, approximately 33% of the total crimes in the CMC area were reported within 250 meters surrounding green areas. This highlights a significant spatial relationship between the proximity to green spaces and crime occurrences.

Further analysis reveals that specific crime types, such as dangerous drug-related offenses and theft, are more likely to occur near green areas, accounting for about 19% and 10% of the total crimes for these categories, respectively. These findings suggest that proximity to green areas may influence the distribution of certain types of crimes.

In addition to the relationship between green areas and crime, the analysis also identified a connection between settlements and crime incidence. The study employed multiple ring buffer tools to examine this relationship, using a distance unit of 100 meters for each ring buffer zone surrounding settlements. This method provided a clearer understanding of how the spatial configuration of settlements influences crime patterns, contributing to the broader spatial analysis of urban crime distribution.

Table 4: Crime Reported Distance from Settlement - 2022

Distance From Road Network	Dan. Drugs	HB and Theft	Theft	Robbery	Murder	Rape	Total
100m	51	35	55	11	8	17	177
200m	96	60	72	44	14	13	299
>200m	16	25	22	7	3	2	75
Total	163	120	149	62	25	32	551

Source - Sri Lanka Police, 2022

As presented in Figure 11 and Table 4, a significant portion of the most serious crimes, such as murder and rape, have been reported within 100 meters of settlements. Notably, approximately 32% of the total crimes occur within this distance, underscoring the spatial correlation between settlements and high crime rates. This finding is particularly relevant for dangerous drug-related offenses, where an overwhelming 90% of these cases were reported in the Colombo Municipal Council (CMC) area, further emphasizing the close association between settlements and drug-related crime. This spatial analysis reveals a positive relationship between crime and settlements, suggesting that densely populated areas, or areas with human activity, tend to experience higher incidences of certain crimes, especially those involving dangerous drugs.

In addition to the connection between settlements and crime, another critical environmental factor that influences crime is the presence of commercial clusters. As shown in Figure 13 and further supported by the data in Table 5, buffer analysis indicates that commercial clusters are significant hotspots for criminal activity. Together, these factors demonstrate the importance of urban spatial planning and crime prevention strategies, particularly in and around settlements and commercial clusters.

Table 5: Crime Reported Distance from Commercial Clusters – 2022

Distance From Road Network	Dan. Drugs	HB and Theft	Theft	Robbery	Murder	Rape	Total
100m	105	60	91	38	19	19	332
>100m	58	60	58	24	6	13	219
Total	163	120	149	62	25	32	551

Source: Sri Lanka Police, 2022

As outlined in Table 5, a significant proportion of crimes in 2022 occurred within close proximity to commercial clusters. Specifically, 60% of the total crimes were reported within 100 meters of commercial areas. This pattern is particularly pronounced for dangerous drug-related offenses, with 64% of drug cases occurring within 100 meters of commercial clusters. The data indicate that all major crime types-ranging from housebreaking and theft to robbery, murder, and rape-are concentrated near commercial hubs. This demonstrates a clear positive relationship between crime and commercial clusters, highlighting these areas as critical hotspots for criminal activity.

In addition to proximity to commercial clusters, the relationship between crime and the environment can be further analyzed using density analysis, particularly through Kernel Density Estimation (KDE). KDE calculates the density of crime occurrences by fitting a smoothly curved surface over each crime point, with the surface's value being highest at the point itself and tapering off with increasing distance. This method is especially useful for identifying crime hotspots, as it accounts for spatial patterns and concentration of incidents.

The hotspot analysis conducted for this study focused on all 551 crime incidents and examined the six major crime types (dangerous drugs, housebreaking and theft, theft, robbery, murder, and rape) separately. The resulting maps, generated using Kernel Density Estimation (Figures 12 and 13), visually depict areas with the highest crime density. These maps help to identify specific areas where crime is concentrated, providing valuable insights for urban planning, law enforcement resource allocation, and crime prevention strategies.

Crime Hotspots and Density Analysis

Kernel Density Estimation (KDE) was employed to identify crime hotspots across the CMC, offering valuable insights into the spatial distribution of criminal activities in relation to environmental factors. Dangerous Drug cases were predominantly concentrated in the northern parts of the city, particularly in Pettah, Grandpass, and Kotahena. Meanwhile, Housebreaking and Theft were more common in affluent southern areas like Kollupitiya and Bambalapitiya (Figures 12 and 13).

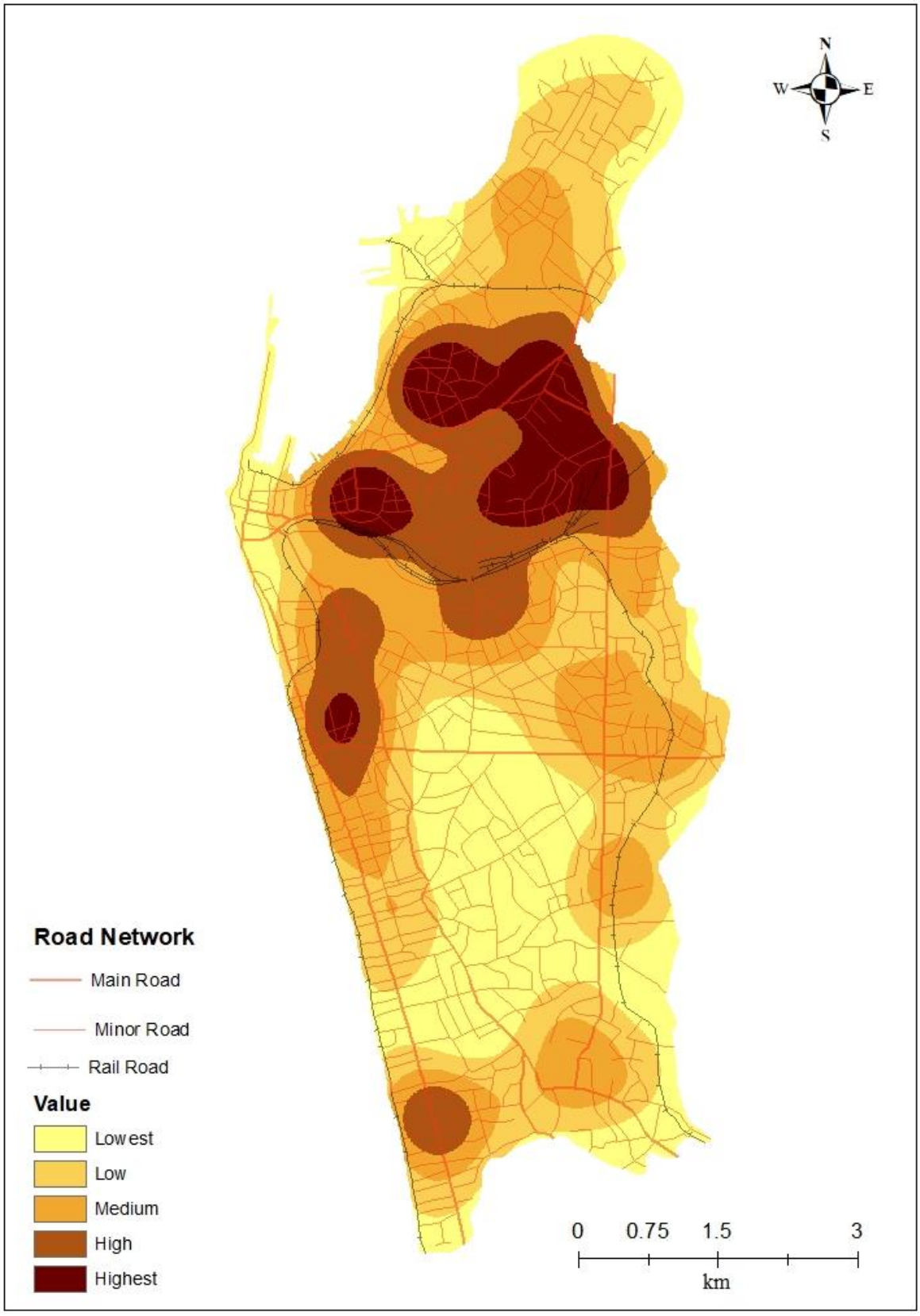
The analysis identified theft and robbery hotspots predominantly concentrated in high-density commercial zones, further reinforcing the well-documented link between crime and economic hubs. Commercial areas, characterized by a high volume of economic transactions and human

activity, tend to attract opportunistic crimes such as theft and robbery due to the availability of potential targets and the relative ease of escape. This spatial concentration of crime around economic centers underscores the critical need for enhanced security measures, such as surveillance, police presence, and urban design strategies that deter criminal activities in these high-risk zones.

In contrast, crimes against persons, including murder and rape, were primarily concentrated in northern, low-income neighborhoods, particularly in areas such as Grandpass and Kotahena. This spatial distribution highlights the profound impact of socioeconomic conditions on the incidence of violent crime. These areas are often characterized by chronic poverty, overcrowded living conditions, and limited access to essential services, all of which contribute to social instability and an environment more conducive to violent behavior. The correlation between crime and socioeconomic factors is particularly pronounced in these regions, where low educational attainment, high unemployment rates, income inequality, and substandard housing are prevalent.

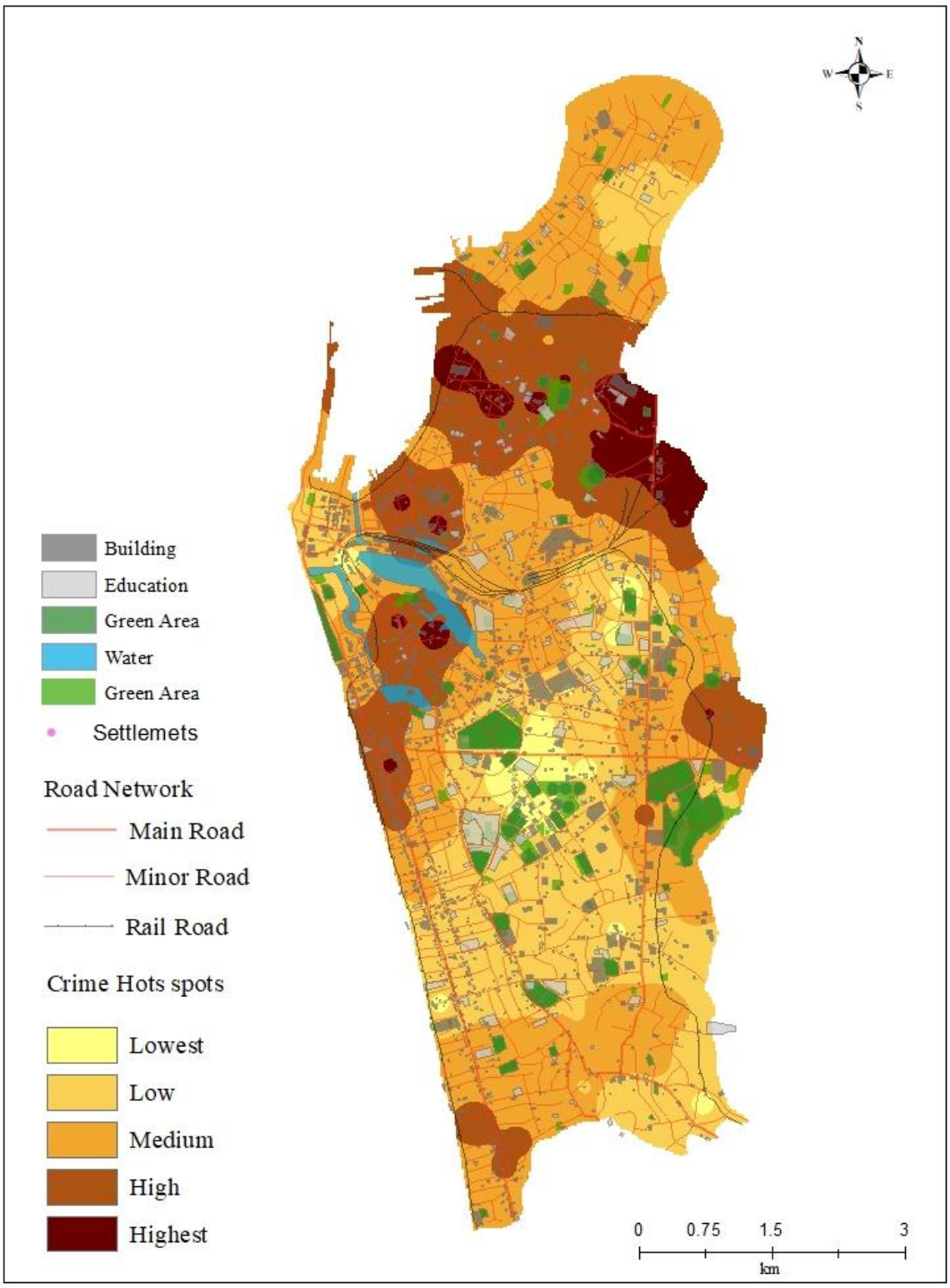
The concentration of violent crimes in low-income areas is consistent with the social strain theory, which suggests that individuals in economically disadvantaged environments are more likely to engage in criminal behavior due to limited legitimate opportunities for success. The social disorganization present in these areas, coupled with inadequate policing, often leaves residents more vulnerable to victimization, perpetuating a cycle of crime and poverty. Furthermore, the lack of community resources and social support systems in these neighborhoods exacerbates the risks, as residents are left with few avenues to improve their circumstances or deter criminal activity.

This spatial analysis underscores the urgent need for multifaceted interventions in crime-prone, low-income areas. In addition to traditional law enforcement efforts, targeted investments in education, employment opportunities, and urban infrastructure are crucial to addressing the root causes of violent crime. By improving living conditions and creating socioeconomic opportunities, policymakers can reduce the disparities that contribute to the concentration of violent crimes in impoverished regions. Urban regeneration programs and community-based initiatives should be prioritized to foster social cohesion, improve public safety, and mitigate the factors that drive crime in these vulnerable neighborhoods.



Source: Sri Lanka Police, 2022

Figure 12: Hotspot for Crimes using Kernel Density Map in CMC - 2022



Source: Sri Lanka Police, 2022

Figure 13: Relationship between Land Use and Crime, using IDW Map in CMC - 2022

The findings of this study reveal a robust relationship between crime patterns and environmental factors within the Colombo Municipal Council (CMC), offering critical insights into the spatial dynamics of criminal activity in an urban setting. Key factors such as population density, land use, proximity to road networks, and commercial clusters emerged as significant contributors to crime rates. Notably, densely populated, low-income areas and major commercial zones experienced the highest levels of criminal activity, underscoring the influence of both socioeconomic conditions and urban infrastructure on crime distribution.

The strong correlation between crime and road networks highlights the pivotal role that urban infrastructure plays in facilitating criminal activities, particularly drug trafficking, theft, and robbery. Roads, by providing ease of access and escape, are not only vital for the city's economic flow but also inadvertently create opportunities for criminal behavior. The clustering of crime along major thoroughfares suggests that these areas, especially where transportation hubs intersect with commercial activities, are particularly vulnerable to illicit activities, necessitating targeted security measures such as surveillance, policing, and crime prevention through environmental design.

Interestingly, green spaces and water bodies exhibited minimal impact on crime distribution, challenging the traditional assumption that parks and open spaces either attract or deter criminal activity. Contrary to expectations, only a small percentage of crimes were associated with proximity to these natural features. This finding suggests that other environmental and socioeconomic factors, such as road connectivity, commercial density, and poverty, exert a far more substantial influence on crime patterns. It also calls into question the emphasis on green spaces in crime prevention strategies, proposing that their role in crime dynamics may be more nuanced than previously thought.

In conclusion, the relationship between crime and environmental factors in the CMC underscores the critical importance of addressing urban infrastructure, land use planning, and socioeconomic disparities as part of a comprehensive crime prevention strategy. High-density, low-income areas remain particularly vulnerable to violent and property crimes, suggesting a need for multifaceted interventions that not only enhance law enforcement but also address underlying social and economic inequities. Policies that promote affordable housing, employment opportunities, and community-based initiatives can help reduce the social strains that contribute to higher crime rates in these areas.

Furthermore, enhanced urban planning that prioritizes security in commercial zones, especially near road networks and transport hubs, is essential for mitigating crime. Implementing strategies such as improved street lighting, closed-circuit television (CCTV) monitoring, and community policing in crime hotspots can significantly improve public safety. These findings offer valuable insights for policymakers, urban planners, and law enforcement agencies, providing a data-driven basis for crafting effective interventions aimed at reducing crime and enhancing public safety in Colombo's urban landscape.

Ultimately, a holistic approach that integrates social, economic, and environmental factors is crucial for addressing the root causes of crime in the CMC. By focusing on both preventive and reactive measures, policymakers can create safer, more resilient communities, fostering long-term reductions in crime while promoting social well-being and economic development.

Conclusion

This study demonstrates a strong relationship between crime patterns and socioeconomic and environmental factors in the CMC area. The integration of GIS technology in crime mapping provides valuable insights into the spatial distribution of crimes, enabling law enforcement to implement more effective crime prevention strategies. By focusing on targeted interventions in crime hotspots and adopting data-driven approaches in policing, it is possible to reduce crime rates and enhance public safety in urban areas.

These findings underscore the importance of combining geospatial and statistical analyses with traditional policing methods to effectively address urban crime.

This encompasses the following seven urban wards indicated as significant crime hotspots: Grandpass North, Borella, Aluthkade East, Aluthkade West, Keselwatte, Kochchikade South, and Maligawatte East. The most common crimes in these areas were drug-related offenses and theft, while murder was the least frequent.

A further breakdown by Police Divisions revealed that Colombo South had higher incidences of crime, with police stations in Borella, Grandpass, Wellawatta, and Dematagoda recording the highest number of grave crimes. In contrast, Jampettah Street and Harbour police stations recorded fewer crimes.

Temporal analysis showed two peaks of criminal incidents: April and December. Criminal activity was highest on Saturdays, particularly between 12:00 and 16:00 hours. In low-income residential areas, robbery, drug arrests, and rape were more prevalent. Drug-related crimes were concentrated near major road networks and commercial zones.

Spatially, persistent hotspots were identified in Kotahena West, Kotahena East, Grandpass North, Grandpass South, Nawagampura, Hunupitiya, Slave Island, and Borella South. Population distribution, education levels, and income variations were significant factors influencing crime rates.

The following correlations between crime and environmental characteristics were detected during the analysis:

- Positive correlations with man-made features, such as road networks and commercial clusters.
- Low-income settlements were closely associated with higher crime rates, especially drug-related offenses.
- No direct relationship was observed between crime and green spaces, population density, or water bodies within the CMC area.

These findings highlight the complex interaction between geographic, environmental, and socioeconomic factors influencing urban crime.

Recommendations

Based on the findings, several recommendations are proposed for the Sri Lanka Police to enhance crime prevention and decision-making in urban areas:

Centralized Crime Data Network: Establish a central Crime Record Division for systematic storage and analysis of police crime data using GIS and statistical tools. This would improve the ability to identify emerging crime trends, hotspots, and patterns.

Public Complaints Computerization: Implement a computerized, GIS-based database system for recording public complaints, facilitating real-time crime analysis and enabling predictive policing strategies.

Enhanced Crime Scene Documentation: Utilize high-resolution cameras for crime scene documentation, integrating the data with GIS for more accurate crime mapping. Targeted Crime Prevention Measures:

- Install CCTV systems in identified hotspots, integrated with GIS technology for monitoring road networks and crime-prone areas.
- Increase police visibility in identified hotspots by establishing police posts and conducting regular patrols, particularly on peak crime days (Saturday and Wednesday) and between 12:00 and 16:00 hours.
- Strengthen community policing, especially engaging at-risk youth and focusing on rehabilitation programs for drug addicts to reduce drug-related crimes.

Proactive Crime Monitoring: Police should adopt proactive strategies for high-risk areas, with enhanced surveillance in low-income residential zones and commercial clusters with a history of high crime activity. Spatial and temporal data should also be used to predict and prevent future crimes.

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