Spatial Distribution Analysis of Crime against Person and Property Using GIS and Crime Stat, A case of Addis Ketema sub city, Addis Ababa

By: Alexander Takele Muleta

A thesis Submitted to the Department of Geomatics Engineering School of Civil Engineering and Architecture in Partial Fulfillment of the Degree of the Requirement for the Master's in Geoinformatics Engineering

Office of Graduate Studies

Adama Science and Technology University

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APPROVAL SHEET

We, the undersigned, members of the Board of Examiners of the final open defense by **Alexander Takele Muleta** have read and evaluated his thesis entitled " **Spatial Distribution Analysis of Crime against person and property using GIS and Crime stat software in Addis Ketema sub city; Addis Ababa**" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Master's in Geoinformatics Engineering.

Supervisor /Advisor	Signature	Date
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DECLARATION

I hereby declare that this MSc Thesis is my original work and has not been presented for a degree in any other university, and all sources of Material used for this thesis have been duly acknowledged

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This MSc Thesis has been submitted for Examination with My Approval as Thesis Co- advisor.

Co-advisor

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Date of Submission:-

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LIST OF ACRONYMS

CSA Central Statistical Agency

EPF Ethiopian Police Force

GIS Geographic information system

ICVS International Crime Victim Survey

KDE kernel density Estimation

OSA Overseas security Advisor Council

PAI Prediction Accuracy Index

STAC Spatial and Temporal Analysis of Crime

W.N Woreda Name

ABSTRACT

Crime can be either personal or property. A key component to tackle crime problems involves the analysis of where crimes took place. The location of crime is an important factor for crime mapping and analyzing. This study mainly focus on Spatial Distribution Analysis of crime against person and property using GIS and crime stat, in Addis Ketema Sub city. The study specifically focus on identification of crime hotspot site. Various data such as Crime incidents (4 years), Master plan and Population number were employed to map crime. Using the above-mentioned data, spatial analysis techniques (i.e. Spatial ellipse, Area (Choropleth) Mapping, Grid thematic Mapping, Point Density and KDE) Crime Hotspot were identified. Further, the analysis of crime incident with respect to land use were also studied and the result shows highest crime rate in Commercial (32.04 %) followed by Mixed (27.04 %) then, service (18.24 %) were more prone to crime. Whereas, very least at Manufacturing and storage (2.96 %) and negligible amount at open space (1.85%) and that of residential (8.33%) and Environment (9.54%) were intermediate site. Woreda number 7 and 8 were identified as hotspot site for crime incidents. On the other hand, the remaining Woreda are less vulnerable to crime incidents. The research is taken to the next level by employing Prediction Accuracy index to identify the best technique for Mapping Hotspot. The analysis of PAI shows that KDE has the highest potential of (6.074) to identify Crime Hotspot followed by other techniques such as Grid Mapping (3.126); STAC (2.569), Point density (2.052) and Area Mapping (1.870). Besides, the relationship between land use, population and crime incident were also analyzed. Thus, the Hotspot area of crime incidents found in 43475.23 -56700.94 population density range and in Commercial, Mixed and Service land use type. The result of study can be improved by utilizing high-resolution Crime data.

Key Words: Crime, Hotspot, GIS, PAI

CHAPTER ONE

1 INTRODUCTION

1.1 Background of the Study

Crime is understood to be related to the interaction of victims and offenders, and to the strength of guardianship (Cornish and Clarke, 1986). A key component to tackling crime problems involves the analysis of where crimes took place. This is based on recognizing that crime has an inherent geographical quality (Chainey and Ratcliffe, 2005), in that crime takes place at some location. Crime also does not occur randomly. It tends to concentrate at particular places for reasons that can be explained in relation to victim and offender interaction and the opportunities that exist to commit crime (Cohen and Felson, 1979; Brantingham and Brantingham, 1984; Cornish and Clarke, 1986). These concentrations or clusters of crime are commonly referred to as hotspots – geographic locations "of high crime concentration, relative to the distribution of crime across the whole region of interest" (Chainey and Ratcliffe, 2005).

A fundamental part of any society is to uphold law and order. The extent to which a nation can prevent crime is thus a major factor in the growth and prosperity of its citizens. Therefore, any initiative aimed at solving or preventing crime contributes immensely to the wellbeing of the society. Criminal activity continues to be a major concern in contemporary society. Most nations are faced with unacceptable levels of delinquency and crime. In many of the world's industrialized countries crime rates recorded by the police are many times those recorded 30 years ago. The International Crime Victim Survey (ICVS) has collected data on 55 countries, spread over six major world regions including Africa, Asia, Central and Eastern Europe, Latin America, and Western Europe. Findings showed that for the 1989–1996 period, more than half of the urban respondents reported being victimized at least once regardless of what part of the world they inhabit (Ackerman and Murray, 2004).

Since the advent of crime mapping technologies in the 1980s and 1990s intelligence led policing has become a major component in the fight against crime for police forces throughout the world (Brantingham and Brantingham, 1999). Analysts and police are expected to work hand in hand in the prevention and detection of crime and the effective deployment of resources (Eck *et al*., 2005).

In Ethiopia, the crime statistics of the federal police commission has shown that the rate of crime is increasing (Woldu, 2003). A sample survey conducted in the year 1996 by a research team of the federal police has shown that in 1986 about 5869 crimes were reported to the police. Taking the total population of the country during this period, it indicates that one crime was committed among 800 people during year. Whereas the research report has shown that in the year 1994 about 96,995 different crimes were reported. This reveals that during this period one crime were committed among 568 peoples. As compared to the year 1986, the total number of crime committed in the year 1994 have shown a significant increment. The national crime statistics report compiled by the federal police commission in 2003 for the year 2002 has shown that about 219,539 crimes were reported to police throughout the country and out of this, 51% were committed in urban area. The remaining 49% were occurred in rural areas. In addition, according to the report of Addis Ababa police commission the rate of crime fluctuating in the year 2006 – 2009. According to this statistics, crime reported to police including traffic accident during the year 2006 was 64437 whereas in the year, it decreased to 59422 in the year 2007. The report also shows that the crime incidents decreased to 56242 in the year 2008. However, there was significant change from 2008 to 2009 according to the report. Thus, it increased to 64092 in the year 2009(Report of federal police commission statistics bureau)

(Chainey *et al*., 2008) describe hotspot mapping as one of the most popular methods used by crime analysts to direct police resources. In these times of austerity, with reduced numbers of officers it becomes even more important for police forces to have a targeted approach, utilizing hotspot intelligence to ensure that police resources are concentrated on areas of high crime (Ratcliffe, 2010; Weisburd and Eck ,2004) concur that where hotspot policing efforts are in place a clear reduction in crime is observed. Though the usefulness of any hotspot mapping approach is only ever as good as the source crime data used to produce these maps in the first place. Describing areas of high crime has long been based purely on location (Brantingham and Brantingham, 1999; Ratcliffe and McCullagh, 1999; Weisburd and Eck, 2004) with the predictive ability of the resulting hotspot maps undisputed. Recent research (Townsley, 2008; Johnson, 2010; Tompson and Townsley, 2010) has started to evaluate both the ability with which hotspot techniques can predict future crimes (Chainey *et al*., 2008), and the use of spatio-temporal information to produce more dynamic crime forecasts (Vijaya-Kumar *et al*., 2011).

The association of crime with the physical environment has been spelled out in several studies (Cotton, 1986; Field, 1992 and Hipp *et al*., 2003). Land use, socio demographics, open spaces, residential and neighborhood do play an important role in affected people behavior, especially towards the type of Addressing crime and its intensity. This classical method of identifying and mapping crime neither provide accurate, reliable and elaborate data nor does it help in trend prediction and decision support. The way to forward is the adoption of sophisticated approaches (Information Technology). One of such promising technologies employed in the management of crime in developed world is the use of Geospatial information System (GIS).With the help of GIS, since each crime spot has a geographic location, maps well digitized and geo-referenced showing crime spots are generated. These maps help police force and other law enforcement agencies to effectively plan for emergency service delivery, thereby providing mitigation for such issues like theft, and other related crimes.

Crime using latest technology like the one GIS may be widely used in other country but in Ethiopia's perspective towards using this technology in crime analysis study has yet not been widely utilized. This issue is probably due to the insufficient knowledge, skill and technology usage. Due to their spatial operation capability, GIS and crime stat helps police and other people who are interested in incidents, to visualize and analyze the spatial relationship between different data layers such as incidents and land use to forecast and take precautions for future incidents.

1.2 Problem Definition

The focus of problem oriented policing at national, regional or city level is solving problem. In order to achieve this goal, police department were using different mechanism and approach to solve the problem and to maintain law and order. Many studies have been conducted to analyze the problem and community policing were also applied to the whole country in addition to Addis Ababa city (Frehiywot, 2015). But the counter measure to solve the problem should be using geospatial technology like Geographic information system (GIS) and statistical tool like crime stat with occurrence of crime incident in time and type.

Identification of high crime area what we call "Hot spot" is most important issue in crime mapping and spatial analysis, because precaution in infrastructure assessment and resource allocation in policy planning and also maintaining the peace and order of city. The crime incident may be caused by level of people living standard like low income (poverty level), middle income

(Fitsum *et al*.,2016) and lack of job and another factor to crime occurrence may be the land use type (commercial, residential, mixed use) transportation system and road network

Addis Ketema sub-city, where the research neighborhoods are located and which is renowned for its high rate of crime, lies within one of the oldest parts of Addis Ababa, making up part of the city center where the capital's largest market (Mercato) and the main bus terminal are located. The major characteristic feature of Addis Ketema area is the extraordinarily high concentration of slum neighborhoods that are dominantly inhabited by socially disadvantaged people who live in extreme poverty (Adler *et al*., 2007; Hagan, 2008; Siegel, 2012).

The neighborhoods are rife with commercial sex work, chat and shisha houses, video houses showing obscene materials, and drinking houses, which sell homebrewed alcoholic beverages such as tella, tej, and araqe - factors that contribute to the high prevalence of crime and delinquency (Fitsum *et al*.,2016). After detecting this problem in the study area, it is important to analyze the distribution of crime that varies in time or space using GIS and Crime stat software.

1.2.1 Research Question

- What parameters are useful for crime mapping and spatial analysis?
- Where does crime tend to concentrate?
- If high concentration of crime identified, what will be the next pattern of crime? (Prediction accuracy index estimation)

1.3 Objective of the study

1.3.1 General objective of the study

✓ The General Objective of the Study is to analyze the Spatial Distribution Analysis of Crime against person and crime against property using GIS and Crime stat software in case of Addis Ketema Sub city, Addis Ababa

1.3.2 Specific objective

- To identify different level of crime sites using hotspot identification techniques.
- To evaluate the relation between crime incident, land use and population density.
- To Map the Pattern of Crime Distribution Using Spatial Analysis tools.
- To assess the prediction accuracy index of different hotspot identification techniques

1.4 Significance of the Study

This study attempted to focus on spatial distribution of crime against person and property using Geospatial technology like GIS and statistical tool like crime stat techniques. Hence the city police and law enforcement body will be benefited by the study and those concerned body will know the spatial distribution as well as concentration (hotspot) of the crime to manage the peace and security of the city. In addition to this, the police and law enforcement agency will take the proactive response to crime situation before they become problematic. Finally, it will be used to allocating resource and educating people with visual information to clarify crime concern in active community participation.

1.5 Scope of the Study

The focus of this Research is directed toward visualization of spatial distribution of crime against person and property in Addis Ketema Sub city using GIS and CrimeStat and this study focus only in Addis Ketema Sub city due to its highly Market (Business) Area. In this research the crime data and other population census data, structural plan and boundary were stored in geo-database of ArcGIS environment for analysis. The study specifically uses GIS and CrimeStat for identification of hotspot area using point mapping, Area (Choropleth) mapping, spatial ellipse, and Grid thematic mapping and Kernel density estimation using the recorded crime incident data over the period of four (4) year 2006 - 2009. But the study not focus on both legal and non-legal point of view of crime, Nature of crime, how crime incident occurred, who participated in crime (violence), What measure were taken and will be taken.

Generally, the focus of this research was identification of hotspot area of crime against person and property in its spatial view (concept) using mainly GIS and analyzing the relationship between population densities, Land use and crime incident

1.6 Limitation of the Study

For proper conducting of the study, the researcher faced the following problem. The first problem was data constraint in which all the crime incident data are not available in suitable format like digital format and in website. In addition to this, Criminal record like photo and other personal information were not police station, status of recorded crime data were also not updated. However, the researcher solved the problem by taking the photo of all recorded data from hard copy and converting it in to digital format using Microsoft excel and finally converting to ArcGIS environment attribute. The second problem that the researcher faced was unwillingness of some officials to give raw data like master plan. Not all the crime analysis can be carried out using single geospatial software; hence, author used multiple geospatial software (Crime Stat, ArcGIS).

1.7 Structure of the Thesis

This thesis is divided into five chapters. The first chapter provides an introduction to the study, which consists of different sections: Background, Statement of the problem, Objectives, Significance of the study and its Limitations. The second chapter deals on the Review of related literatures. Which mainly included the basic categories of crime, condition of crime in Ethiopia, application of GIS and crime stat software in crime mapping, Hotspot mapping theories and routine activity approach, Techniques of hotspot mapping ,Crime activities and land use, Role of hotspot analysis in crime mapping and prediction accuracy index. The third chapter deals with Materials and Methods employed in the research. These include description of the study area, data used in the research and data analysis. The fourth chapter deals with Result and Discussions of the analysis for the study area. Chapter five is about Conclusions and Recommendation.

CHAPTER TWO

2 REVIEW OF LITERATURE

2.1 Basic Categories of Crime

Crime cane be categorized in to four groups (Dambazzua, 1997), which are personal crime: "Offenses against the Person". These crimes result in physical or mental harm to another person. Personal crimes include Beating, kidnapping, attempt to kill. Property Crime: "Offenses against Property". These crimes do not necessarily involve harm to another person. Instead, they involve an interference with another person's right to use or enjoy their property. It includes Robbery, auto theft, snatch, shoplifting, check fraud and pickpocket. Inchoate Crimes: "Inchoate" translates into "incomplete", meaning crimes that were begun, but not completed. This requires that a person take a substantial step to complete a crime, as opposed to just "intend" to commit a crime. It includes Attempt, Solicitation and Conspiracy. Statutory Crimes – A violation of a specific state or federal statute and can involve either property offenses or personal offense. But this study focus only on personal and property crime.

2.2 Condition of Crime in Ethiopia

In Ethiopia, the crime statistics of the federal police commission has shown that the rate of crime is increasing (Woldu, 2003). A sample survey conducted in the year 1996 by a research team of the federal police has shown that in 1986 about 5869 crimes were reported to the police. Taking the total population of the country during this period, it indicates that one crime was committed among 800 people during year. Whereas the research report has shown that in the year 1994 about 96,995 different crimes were reported. This reveals that during this period one crime were committed among 568 peoples. As compared to the year 1986, the total number of crime committed in the year 1994 have shown a significant increment. The national crime statistics report compiled by the federal police commission in 2003 for the year 2002 has shown that about 219,539 crimes were reported to police throughout the country and out of this, 51% were committed in urban area. The remaining 49% were occurred in rural areas. Yet another report of Addis Ababa police commission in the year 2006 and 2007 shows the crime situation is changing in each year. The reported crime to the police during this year is 64437 and 59422 respectively. This implies that condition of crime varies from year to year and place to place.

According to the Overseas Security Advisor Council (OSAC), criminals are active throughout Ethiopia. For example, the most common crimes that are committed in Addis Ababa are Pickpocket, beating, stubbing, Harassment, Snatch, and Run including occupied vehicles. In 2011, purse snatching and harassment by gangs of youths in bole area of Addis Ababa have increased. This incident has occupied the day and night time.

2.3 GIS and Crime Mapping

(Block, 1995) note that pin maps have been used in the police chiefs' rooms since the pin was discovered. In addition, those maps were used to identify which areas were affected by criminals and in what kind of pace they were occurring at glances. The developments in computer hardware and software have given further advancement in usage of digital map. Many different organization, agencies and law enforcement use GIS and crime map and this enhance police executive for making reasonable decision about patrol assessment, better personnel policies and proactive crime prevention programs.

In practice, GIS and crime mapping are used to find out the question "Where?" such as "Where should we focus efforts to catch a serial killer?" or "Where should we build a new police station to fight the crime problem?" or "Where the crime is highest?" By analyzing the data provided from various sources, users at various organizational levels can make observations, conclusions, and policies. (Heikkila ,1998) defines Geographical Information Systems as "GIS is an organized collection of computer hardware, software, geographical data and personnel designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced materials." GIS not only has the potential of storing the data, but also has the capacity to create a map that makes the data visible.

2.4 GIS Application in Crime Pattern Analysis.

Crime patterns can be analyzed and explained using GIS because it offers a medium to analyze criminal activities data for a better understanding of the factors that influence crime offenders. It can also be used to generate a model that would predict potential crime spots. GIS can be applied for the analysis and the mapping of crime data for both academic research and practical law enforcement (Murray *et. al*., 2001). This is more so because it offers tools for the modelling of statistical surfaces that facilitate approximate visualizations of point densities (Harries 2006). The level of analysis achieved using GIS could determine even the density of crime within every

spatial scale. Spatial statistics function can be utilized to help authorities such as the police department to map crime scene. This would further assist the authority to understand crime behavior's and find the best action to prevent crime. The methodology employed could assist authorities to better understand the pattern of crime spatially and predict potential crime. Thus, preventive measures can be taken through proper physical planning for new development areas while 'target hardening' measures can be taken for existing developed areas. GIS provide an alternative tool that can aid policy makers, decision makers and the security operatives in particular discharge their core responsibility of ensuring peace and security in the society. The integration of spatial statistics technique and GIS can assist local authorities and police departments to identify hotspots for crime incidence

2.5 Crime Stat

CrimeStat, developed over the last 13 years by Ned Levine & Associates with funding from the National Institute of Justice, has sought to aggregate all of the various spatial statistics used by criminologists and crime analysts. Crime stat is spatial statistics package that can analyze crime incident location data and it is able to link with GIS (Levine, 2002).

CrimeStat is a Microsoft Windows-based application that reads geo-referenced files in multiple formats, performs the spatial calculations, and renders output files in formats read by most modern GIS applications (including ArcGIS and MapInfo). CrimeStat is not itself a GIS; it does not create or display crime maps. To use it effectively, the analyst or researcher must use it in conjunction with a GIS to create the source data and analyze the results. Analysts will switch back and forth between CrimeStat and the GIS frequently.

2.6 Crime and Hotspot Theories

A hotspot is defined as an area of high concentration of crime relative to the distribution of crime across the entire study area (Chainey and Ratcliffe, 2005; Home Office, 2005; Sherman, 2009). In these terms, hotspots can exist at different geographic scales of interest, whether it is at the city level for examining localities where crime is highest, or at a local residential housing estate level, identifying particular streets or clusters of buildings where crime is seen to highly concentrate. Researcher and police uses the term in different ways. Some refer to hot spot addresses (Eck and Weisburd, 1995; Sherman *et al*., 1989), others refer to hot spot blocks (Taylor, Gottfredson and Brower, 1984; Weisburd and Green, 1994), and others examine clusters of blocks (Block and Block, 1995).

Crime theories are useful for crime mapping because they aid in the interpretation of data and provide guidance as to what action are most appropriate (Eck, 1998). Therefore, understanding how crime theories account for hot spots is critical. The first theory of crime hotspot is place theories, which concerns on "why crime events occur at specific locations". It deals with crimes that occur at the lowest level of analysis at specific places. Crime phenomena at this level occur as points, so the appropriate units of analysis are addresses, street corners, and other very small places. The second theory of crime hotspot is that of Street theories which deal with crimes that occur at a slightly higher level than specific places that is over small, stretched areas such as streets or blocks. A prostitution stroll is also an example. The third and last theory of crime hotspot is neighborhood theories. This theory mainly focusses at higher level than place or street, neighborhood theories deal with larger areas. The appropriate units of analysis are quite varies and can include square blocks, communities, and census tracts, to name a few.

2.7 The Crime Pattern Approaches

2.7.1 The Routine Activity approach

The routine activity approach originally started as a macro-level explanation of predatory crime (Cohen and Felson, 1979), but has progressed over the years to provide a worthwhile mechanism to examine criminal opportunity and crime prevention in a variety of settings. The original work examined changing patterns of employment, and the new criminal opportunities that are created when there are fewer people staying at home during the day. The routine activity approach is based on the simple idea that the behavior of victims helps explain the occurrence of crime, and that for a crime to occur, three components are necessary. There must be the presence of a likely offender, the presence of a suitable target, and the absence of a capable guardian. The target does not necessarily have to be a person, but instead could be buildings, cars, or other property and objects. Similarly, a guardian may not just be a person, such as a police officer, security guard, neighbour or even passer-by, but could also include closed circuit television surveillance systems or a car alarm. The three components – offender, target and lack of a guardian –must meet in time and space to provide the necessary chemistry for crime (Felson, 1998).This meeting in time and space is not random but is dictated by the natural rhythm of daily life – people going about their routine activities.

2.7.2 Crime Pattern approach (offender activity theory)

While the routine activity approach provides a model to predict if a crime has all of thev chemistry to occur, crime pattern theory can help to explain where and when crime is likely to occur. Crime pattern theory helps to bring together the two areas of offender spatial distribution and offence spatial distribution by examining the ‘relationship of the offence to the offender’s habitual use of space’ (Bottoms and Wiles, 2002). Crime pattern theory (sometimes also referred to as offender search theory) suggests that offenders are influenced by the daily activities and routines of their lives, so that even if they are searching for a criminal opportunity they will tend to steer towards areas that are known to them (Brantingham and Brantingham, 1984). In an offender’s day-to-day activities they will be watching for targets that have no guardians or place managers. Two important theoretical concepts associated with crime pattern theory are the least effort principle and the distinctions between how crime opportunities concentrate.

offenders also have awareness spaces. They also move between places such as work, school, shops and home, and for many offenders, the search for criminal opportunities takes place around these areas. Opportunities are not spaced evenly throughout the landscape, and some offenders will only be able to take advantage of some offence opportunities. Also, some of the awareness areas will not be conducive to crime due to the presence of guardians or place managers .

The theoretical principles of crime pattern theory were modelled by (Brantingham and Brantingham, 1984) and an adaptation of the principles by (Chainey and Ratcliffe, 2005) can be seen in Figure 2.1. This shows that awareness space consists mainly of the places that are routinely frequented and the routes between those places. We may be more familiar with distant places that we frequent regularly than local places just around the corner that we never visit; therefore, proximity does not always mean the same thing as familiarity.

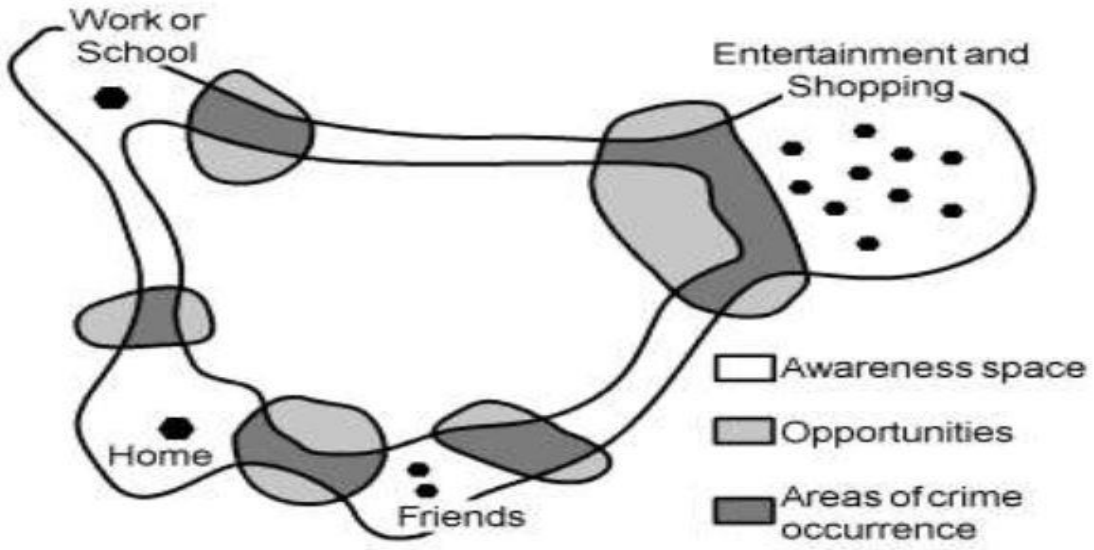


Figure 2.1 Hypothetical Model of Criminal Occurrence (Source: Chainey and Ratcliffe, 2005)

The adaptation by (Chainey and Ratcliffe, 2005) of the original Brantinghams' model shown in Figure 2.1 includes the location of friends as an influential component on offender awareness space. Although for most people work or school play a significant part in daily life, this can be less so for offenders. (Costello and Wiles, 2001) found that many offenders in Sheffield who could have been in the workforce had never had full time employment, while (Rengert and

Wasilchick, 2006) reported interviews with a number of offenders who had quit legitimate employment in order to pursue a professional criminal career.

2.8 Crime Hotspot Identification Techniques

For the identification of crime hotspot and to analyze it, (Boba ,2009; Chainey and Ratcliffe ,2005) point out that currently there is no standard threshold for what constitutes a hot spot nor is there clarity about what the best method is to identify them. Both suggested that "areas appearing to be hot spots will vary depending on the unit of analysis, scale of the map and the amount of data mapped" (Boba, 2009). Nonetheless, technological advancements such as computerized databases and automated crime mapping can assist analysts in identifying crime clusters (Braga, 2006). The (National Institute of Justice, 2010) outlines two general ways that an analyst can identify a hot spot: (1) through the use of GIS (geographic information system) maps and (2) the by applying statistical tests.

2.8.1 Spatial Ellipse

One of the earliest crime mapping software applications that became widely available to practitioners for hotspot analysis was Spatial and Temporal Analysis of Crime (STAC) (Illinois Criminal Justice Information Authority, 1996). STAC is not a GIS, but instead acts as an aid to researchers who already have a GIS or desktop mapping capability. STAC is a spatial tool to find and examine hotspot areas within the study area. STAC works by first finding the densest concentration of points on the map (hot clusters), and then fitting a standard deviational ellipse to each one. Size and alignment of each hotspot is easily visualized and No reliance on defined geographical boundaries. Examples, demonstrating the use of STAC include (Martin *et al*., 1998) in their study of crime patterns in Detroit; (Bowers and Hirschfield, 1999). They explored links between crime and disadvantage in North West England; (Block and Block ,2000) who analyzed hotspots around rapid transit stations in Chicago; (Lang worthy and Jefferis ,2000) who examined the influence of the school holiday period on the spatial distribution of crime hotspots in the Bronx, New York. Baltimore County Police Department has also used STAC extensively to analyze a range of crime types (Block and Perry, 1993).The limitation to this technique is Standard deviational ellipses do not reflect the actual spatial distribution of crime.

2.8.2 Thematic Mapping of Geographic Boundary

Hotspot areas are based on defined administrative or political areas. For example, geographic boundary areas can be police beats, census output areas, wards or districts. Offences as points on a map can be aggregated to these geographic unit areas and then shaded in accordance with the Number of crimes that fall within them. (Williamson *et al*., 2001) assert that maps created in this way are quick to produce and require little technical expertise to interpret. Due to the varying size and shape of most geographical boundaries, thematic shading can beguile the map-reader into identifying the existence of the highest crime concentrations (Eck *et al*., 2005). Hence, thematic mapping of geographic boundary areas can fail to reveal patterns across and within the geographical division of the boundary areas (Chainey and Ratcliffe, 2005)

Thematic mapping of boundary areas continues to see widespread application, such as comparing the different volumes of unique and repeat burglaries across a study area's census zones (Ratcliffe and McCullagh, 2001), comparing vehicle theft in relation to land use in Overland Park, Kansas (Harries, 1999), and analyzing and presenting crime patterns across partnership administrative zones (Chainey, 2001; Home Office, 2005).

2.8.3 Grid Thematic Mapping (Quadrat Analysis)

In order to address the problems associated with different sizes and shapes of geographical regions, Uniform grids are drawn over a study area and thematically shaded based on the number of crime points within each grid square (Chainey *et al*.,2008). Equally sized grid squares mean hotspot areas can be easily identified without risk of misinterpretation. (Bowers *et al*., 2001) used this method as a component of a GIS-based database application set up to identify vulnerable residences where target hardening was implemented. This approach does have some limitations; the usage of grids still restricts how the hotspots can be displayed. Spatial detail within and across each quadrat is correspondingly Lost because the crime events have to conform to one specific quadrat, which can then lead to inaccurate interpretation by the map user. Additionally, many comments have been made about the "blocky" appearance of this technique (Home Office, 2001; Chainey and Ratcliffe, 2005; Eck *et al*., 2005), which is affected by grid cell size. The solution, reducing the size of each cell, can destroy the resolution of the thematic map by making it look "speckly" and can fail to provide any useful information about where crime clusters (Chainey and Ratcliffe, 2005).

2.8.4 Point Mapping

Point mapping is popular mainly because it is a simple digital version of a familiar and traditional method of placing pins representing crime events onto a wall map (Jefferis, 1999). The goal is to identify isolated high-crime locations, which can be done in a number of ways. One of the is to use the number of crime incident to find density of incident in ArcGIS.Then converting raster to polygon ,then from converted polygon the number of crime and its area is identified. This method allows the depiction of repeat and non-repeat places on the same map and permits comparison among repeat places about the number of crimes. Graduated dots also allow one to find concentrations of hot places. One can use graduated dots, so that dot size is proportional to the number of crimes at the location. These dots can then be displayed using suitable symbology representing the crime number displayed. A graduated point symbol mapping is not appropriate if too many data are analyzed at once. Because, graduated dots can obscure nearby features (e.g., a large dot may overlap nearby smaller dots), the technique is best if it is used on large-scale maps (Boba, 2009).

2.8.5 Kernel Density Estimation

The kernel density estimation has been agreed by several researchers as being the most suitable Hotspot mapping technique (Chainey and Ratcliffe, 2005; Chainey *et al*., 2008). It is also a very popular method among crime analysis practitioners. It is one of the continuous surface smoothing methods, which interpolate values based on intensity values of known points. It works by first imposing a regular grid with a specified cell size over points across the study area. Then, a user-defined three-dimensional kernel function of a user-defined search radius will visit each point and calculate densities for all the cells within the search radius. The final kernel density estimate for one cell is then calculated by summing up all values obtained from all kernel density functions for that particular cell. Point data (recorded crime) are aggregated within a user specified search radius and a continuous surface that represents the density of the points across the study area is calculated. A smooth surface map is produced, showing the variation of crime density across the study area, with no need to conform to geometric shapes such as ellipses or other geographic units. There is flexibility when setting parameters such as the grid cell size and bandwidth size (Search radius); however, despite many useful recommendations (Chainey and Ratcliffe, 2005; Eck *et al*., 2005, Ratcliffe and McCullagh, 1999), there is no universal doctrine on how to set these parameters and in what circumstances. However, the user's role is to specify

search radius and cell size for estimation, which play a decisive role. When the bandwidth is set, too large, important information may be lost. In case of a small bandwidth, local data information has a more significant impact on the result.

2.9 Criminal activities and Land use

As land use change with new development and redevelopment, the structure of urban form will change as well (Brantinghams 1981; Felson 1987). Urban forms are dynamics; any change in land use may bring about other changes to nearby areas. For instance, the development of a new community facility may change the routine activities of the community involved. According to (Felson, 1987), routine activities would create crime opportunities for the offender. Property crimes are higher at places where there are dispersed shopping and strip commercial developments. Commercial areas in cities have been found to be prone to burglaries and thefts while residential areas are conducive to crimes such as sexual offence and murders. Studies have also indicated that child-sex offences and juvenile crimes are much higher near areas where high schools are located (Suryavanshi, 2005).

2.10 The Role of Hotspot Analysis in Tackling Crime Problems

The mapping of hotspots of crime has become common practice in police agencies as well as law enforcement area and in different level of municipality administration across the world and have been applied to many forms of crime. For example, hotspot mapping has been used in the analysis of residential burglary, street robbery and vehicle crime in London (Eck *et al*., 2005), violent crime in Philadelphia (Ratcliffe *et al*., 2011), and street assaults in Melbourne, Australia (Mashford, 2008).

The primary purpose of hotspot analysis is to visualize and identify where crime tends to be highest, and from this aid decision-making on where to target and deploy resources to tackle the crime problem. The ability to be able to identify where crime concentrates, and direct law enforcement and crime prevention activity to these areas, is used routinely in policing and public safety for helping to address crime problems. Examples includes the following.

Hotspot analysis is routinely used in policing to support the operational briefing of police patrols (Goldsmith *et al*., 2000; Harries, 1999; Home Office, 2005; LaVigne and Wartell, 1998, 1999; Osborne and Wernicke, 2003; Hough and Tilley, 1998) illustrate an example of hotspot maps

that were used in police patrol briefings by the Metropolitan Police in the London Borough of Brent.

A more focused use of hotspot analysis for informing the targeting of police patrols is hotspot policing. This involves the dedicated targeting of police patrols to high crime locations (Sherman *et al*., 1989; Weisburd and Braga, 2006) where the patrols typically remain stationary for 15 to 20 minutes (and returning each hour for the duration when crime is determined to be high). This patrolling approach aims to create a visible police presence that emphasises a higher certainty of detection if an offender decides to attempt an act of crime (Kennedy, 2009). In the first documented example of hotspot policing in Minneapolis, USA, doubling the number of patrols at hotspots reduced crime by 6-13% and disorder by 50% (Braga, 2007). In a more recent study of hotspot policing tactics in Philadelphia, targeted patrols reduced violent crime by 23% (Ratcliffe *et al*., 2011).

The use of intelligence products has become a key component in modern policing (Chainey, 2012; Chainey and Chapman, 2013). The production of intelligence, requiring the gathering of information and its interpretation, is fundamental to the intelligence-led policing approach, with its use at the core of informing police business and decision-making (Ratcliffe, 2008). Intelligence products include tactical assessments for informing the regular briefing, tasking and coordination of front line resources; problem profiles that aim to help better understand particular crime problems; and strategic intelligence assessments that identify the key issues and threats in a police command area to determine the strategic priorities that require specific attention. Hotspot analysis is a common feature within these products, informing operational tactics, helping to identify persistent problem areas and support a strategic targeted approach for crime reduction (Chainey and Ratcliffe, 2005; Clarke and Eck, 2003; Home Office, 2005). (Chainey and Chapman, 2013) for Newcastle-upon-Tyne illustrated an example of hotspot analysis that was used to assist the strategic targeting of crime reduction initiatives. This example showed how hotspot analysis of youth-related anti-social behavior assisted in identifying where to focus strategic interventions for tackling this issue in certain persistently problematic areas.

Hotspot analysis has also been a common feature in Comp stat-style performance meetings (Chainey and Ratcliffe, 2005; Harries, 1999; McDonald, 2002; Schick, 2004; Walsh, 2001). Comp stat is a policing management meeting process, with meetings held regularly (from every week to every month depending on adoption by police agency) to inform on recent events and

trends, determine future activity, and build in a process of accountability to these activities. The use of hotspot analysis is a regular feature in these meetings for helping to review performance and determine future actions.

Hotspot analysis has therefore become a regular application in policing and public safety, helping determine where crime may happen next by using data from the past to inform future actions. In this sense, it acts as a basic technique for predicting where crime may occur, using the premise that retrospective patterns of crime are a useful indicator of future patterns. Similar applications of hotspot analysis have been used in epidemiology, using data on where incidents of disease have occurred in order to target (and hence predict) where other incidents of disease are likely to occur in the future (Atkinson and Molesworth, 2000).

2.11 Prediction Accuracy Index

In their study (Chainey *et al*., 2008a) that compared common hotspot techniques and introduced the Prediction Accuracy Index (PAI). The index was devised as a simple method to allow comparisons between different types of hotspot maps. The index considers the hit rate value (the proportion of crime that occurs within the areas where crimes were predicted to occur i.e. the hotspots) against the size of the areas where crimes were predicted to occur (i.e. the areas determined as hotspots), relative to the size of the study area. The PAI is calculated by dividing the hit rate percentage by the area percentage (the area of the hotspots in relation to the whole study area.

The use of the PAI has since been discussed further by (Pezzuchi, 2008) and (Levine, 2008) and (Chainey *et al*., 2008b; 2008c), with researchers concluding it to be a useful measure for comparing multiple hotspot mapping outputs. This has included minimizing chance expectation by using the mean PAI results and observing the variation in the standard deviation generated from the many experiments. The PAI is also a measure that is applicable to any study area, to any crime point data, and to any analysis technique that aims to predict spatial patterns of crime. Many practitioners still, though, find great use in the hit rate as a measure to predict how many crimes they may be able to impact upon by targeting resources to just the hotspot areas. As the hit rate is calculated as part of the PAI, the hit rate can be considered alongside a PAI calculation.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Study Area Description

Addis Ababa is capital and largest city of Ethiopia. It has a population of 3,384,569 according to the 2007 population census, with annual growth rate of 3.8%. This number has been increased from the originally published 2,738,248 figure and appears to be still largely underestimated. From these, the total population of the study area (Addis Ketema) accounts 1,372,010

3.1.1 Geographical Location

Addis Ababa lies at an elevation of 2,300 meters and is a grass land biome, located at 9° 1′ 48″ N 38° 44′ 24″ E Coordinates. The city lies at the foot of Mount Entoto and forms part of the watershed for the Awash. From its lowest point, around Bole International Airport, at 2,326 meters above sea level in the southern periphery, the city rises to over 3,000 meters in the Entoto Mountains to the north.

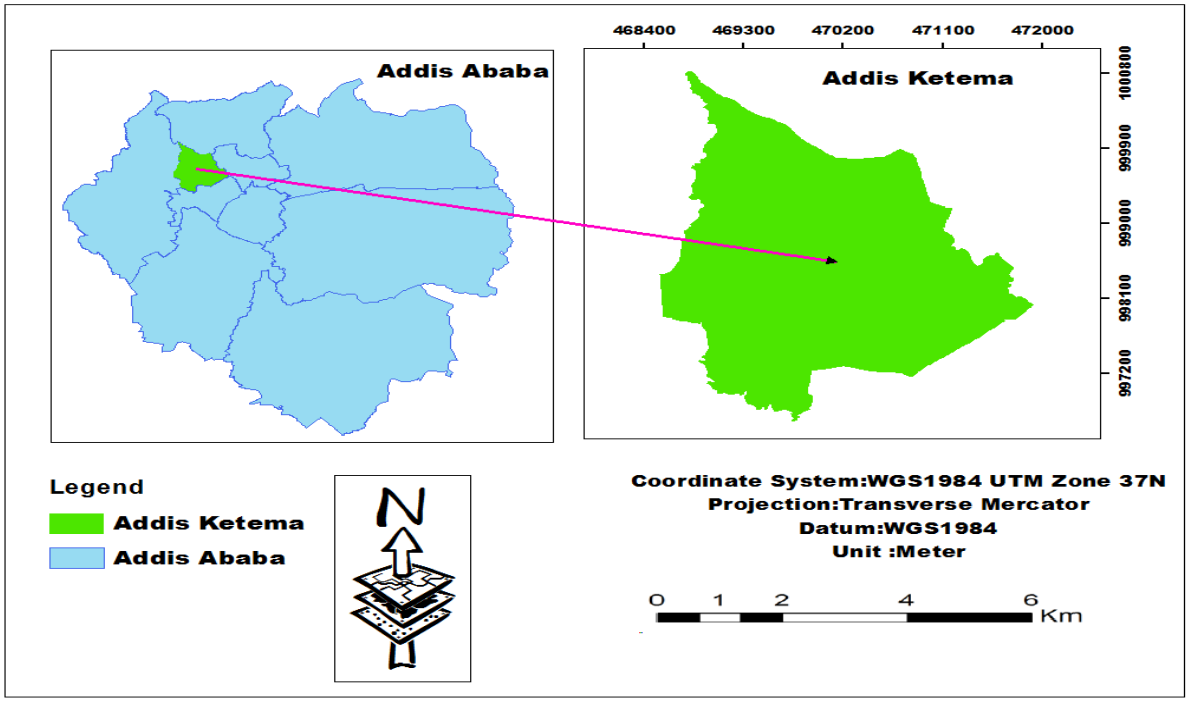


Figure 3.1 Study Area

3.1.2 Climate

Addis Ababa has a subtropical highland climate. The city has a complex mix of highland climate zones, with temperature differences of up to 10°C, depending on elevation and prevailing wind patterns. The high elevation moderates temperatures year-round, and the city's position near the equator means that temperatures are very constant from month to month. As such, the climate would be maritime if its elevation was not taken into account, as no month is above 22 °C (72 °F) in mean temperatures. The highest record temperature was 32°C 27 August 1996, while the lowest record temperature was 0°C on 23 November 1999.

3.2 Data and Materials

For conducting of this research, historical crime incident data from 2006 -2009 were collected from Addis Ababa police commission. The data include both personal crime and property crime. In addition to this crime data, administrative boundary, Master plan and population data are used. These data and their source is as shown in table 3.1 below. In addition to this, ArcGIS, CrimeStat software and other materials shown in table 3.2 below are used in the study for conducting the research.

Table 3.1 Data and Its Source

No	Data	Source
1	Administrative boundary	Municipality of Addis Ababa
2	Crime data	Addis Ababa police commission
3	Master plan(structural plan)	Municipality of Addis Ababa
4	Population data	Central Statistical Agency

Table 3.2 Materials and Software

No	Materials Name	Source	Purpose
1	Computer,8Gb RAM	-	Processing raw data and report writing
2	External hard disk	-	Data back up
3	Handheld GPS with 3m accuracy	ASTU	Collection of crime incident data (x and y coordinate of crime incident location)
4	Crime stat III	-	Processing statistical data
5	ArcGIS	-	Data processing and thematic map preparation
6	Microsoft word, excel		Integrating attribute data and compositing final thesis

3.2.1 Population

For conducting of this study, the projected population number from 2006 – 2009 were collected from Central Statistical Agency (CSA). According to the census result, Addis Ketema had 1,372,010 population. The projected population number in the 2006 was 327,404 from this, Male accounts 168,200 and Female accounts 159,204. The census result of population number in 2007 also show that, Addis Ketema had 331,425. From this, 173,016 were males and 158409 were females. In the same manner, total number of male population and female population in the year 2008 and 2009 counted is shown in the following table 3.3 below.

In general, the percentage of population in each year were in 2006, 2007, 2008 and 2009 23.83 %, 24.15 %, 26.04 % and 25.95 % respectively. The projected population number of study area increases gradually between 2006 and 2008 and then decreased between 2008 and 2009.

Table 3.3 Population in Addis Ketema in 2006 -2009

W.N	2006				2007				2008				2009			
	Male	Female	Total	Total in (%)	Male	Female	Total	Total in (%)	Male	Female	Total	Total in (%)	Male	Female	Total	Total in (%)
1	19,545	19,235	38,780	11.84	20034	19692	39726	11.99	20533	20149	40683	11.38	21046	20632	41678	11.71
2	16,512	15,142	31,654	9.67	16925	15502	32427	9.78	17348	15862	33210	9.29	17780	16241	34021	9.56
3	17,012	16,869	33,881	10.35	17438	17270	34708	10.47	17873	17671	35544	9.95	18319	18094	36413	10.23
4	19,026	19,537	38,563	11.78	19502	20001	39503	11.92	19989	20466	40455	11.32	20487	20956	41443	11.65
5	12018	11073	23091	7.05	12318	11336	23654	7.14	24225	11599	35824	10.03	12940	11877	24817	6.97
6	17103	16293	33396	10.20	17900	11580	29480	8.89	17968	17068	35036	9.80	18416	17476	35892	10.09
7	14217	12838	27055	8.26	14573	13143	27716	8.36	14937	13448	28385	7.94	15309	13770	29079	8.17
8	19813	18270	38083	11.63	20309	18704	39013	11.77	20816	19138	39954	11.17	21335	19596	40931	11.50
9	17592	15696	33288	10.17	18032	16069	34101	10.29	18482	16442	34924	9.77	18943	16835	35778	10.05
10	15,362	14,251	29,613	9.04	15985	15112	31097	9.38	17102	16223	33325	9.33	18221	17568	35789	10.06
Total	168,200	159,204	327,404	100	173016	158409	331425	100	189274	168066	357340	100	182796	173045	355841	100

Table 3.4 Crime Incident in Addis Ketema (2006 – 2007)

W.N	Number of Crime in the year 2006				Number of Crime in the year 2007			
	Crime against person	Crime against property	Total	Percentage of Crime	Crime against person	Crime against property	Total	Percentage of Crime
1	18	11	29	10.37	4	12	16	6.61
2	6	7	13	4.64	7	6	13	5.37
3	2	0	2	0.71	5	1	6	2.47
4	7	8	15	5.36	4	4	8	3.30
5	4	0	4	1.43	3	10	13	5.61
6	17	2	19	6.80	6	3	9	3.71
7	18	49	67	23.92	25	45	70	28.90
8	26	74	100	35.71	26	64	90	37.19
9	10	12	22	7.85	5	4	9	3.72
10	5	4	9	3.21	5	3	8	3.30
Total	113	167	280	100	90	152	242	100

Table 3.5 Crime Incident in Addis Ketema (2008 – 2009)

W.N	Number of Crime in the year 2008				Number of Crime in the year 2009			
	Crime against Person	Crime against Property	Total	Percentage of crime	Crime against Person	Crime against Property	Total	Percentage of crime
1	14	21	35	11.07	23	18	41	14.33
2	5	8	13	4.11	8	9	17	5.94
3	4	0	4	1.26	3	3	6	2.10
4	7	12	19	6.01	8	6	14	4.93
5	6	9	15	4.74	15	4	19	6.64
6	15	6	21	6.64	16	8	24	8.39
7	26	53	79	25.01	25	36	61	21.32
8	23	81	104	32.91	35	43	78	27.27
9	8	10	18	5.69	9	11	20	6.99
10	5	3	8	2.56	5	1	6	2.10
Total	113	203	316	100	147	139	286	100

3.2.2 Land use

In order to analyze the relationship between crime incident and land use, the structural pan of Addis Ketema and its boundary were collected from Addis Ababa city administration municipal office. The study area comprises majorly Mixed area and Commercial land use type. Moreover, service area like religious places, parking, health centers, and schools and other governmental and non –governmental institution, Residential, Manufacturing and storage, Open space and Environment like water bodies are included. The study area totally covers 8.53 square kilometer From this, 7.64 square kilometers is covered by different land use type and the remaining is road segment. Mixed, residential and commercial area covers 2.90, 1.70 and 1.66 square kilometers respectively.

3.2.3 Data Collection

To achieve the objective of this research, primary data like location of crime incident and police station were collected through direct field observation and that of secondary data like population census data, master plan and boundary data were collected from the concerned source. In addition to this, various journal papers, thesis, textbooks, internet (Wikipedia) are also used as secondary data. The type of incident, the location where the incident occurred and the year in which the incident occurred were recorded in hard copy file of the main police station. These file were taken by digital camera and smartphone to convert the hard copy file (paper-based data) to digital format. Following this, the data were filled in Microsoft excel format. From the recorded data, 1124 incident that include both crime against person and property were reported from Four Police Station in the year 2006 - 2009 in Addis Ketema Sub city. Finally, the spatial location of each crime incident were collected using Hand held Gps and downloaded using DNR Garmin downloading software in to csv format.

In the ArcGIS Environment, the X and Y coordinate of the incident including incident type is filled in attribute table and projected in Universal Transverse Mercator projection for the software analysis. In addition to this, population census data over period of four (4) year (2006 - 2009) were collected from CSA .These data also filled in ArcGIS environment for further analysis. Finally, Addis Ketema sub city structural plan and Woreda boundary collected from Addis Ababa City Administration were imported in ArcGIS for Land use classification analysis.

3.2.4 Methodology

Methodological considerations for this research were centered on identification of hotspot area using different hotspot mapping techniques and how best to explore the range of mapping techniques with data that was suitable for this analysis. The calculation of rate of crime against person and property per 1000 person applied to get which Woreda and which land use type have high crime rate in terms of person and property. The creation of hotspots and the analysis of their prediction ability were conducted. Finally, the relationship between the crime incident, land use and population were also conducted. The overall methodology used for conducting this research is as shown in fig 3.2 below.

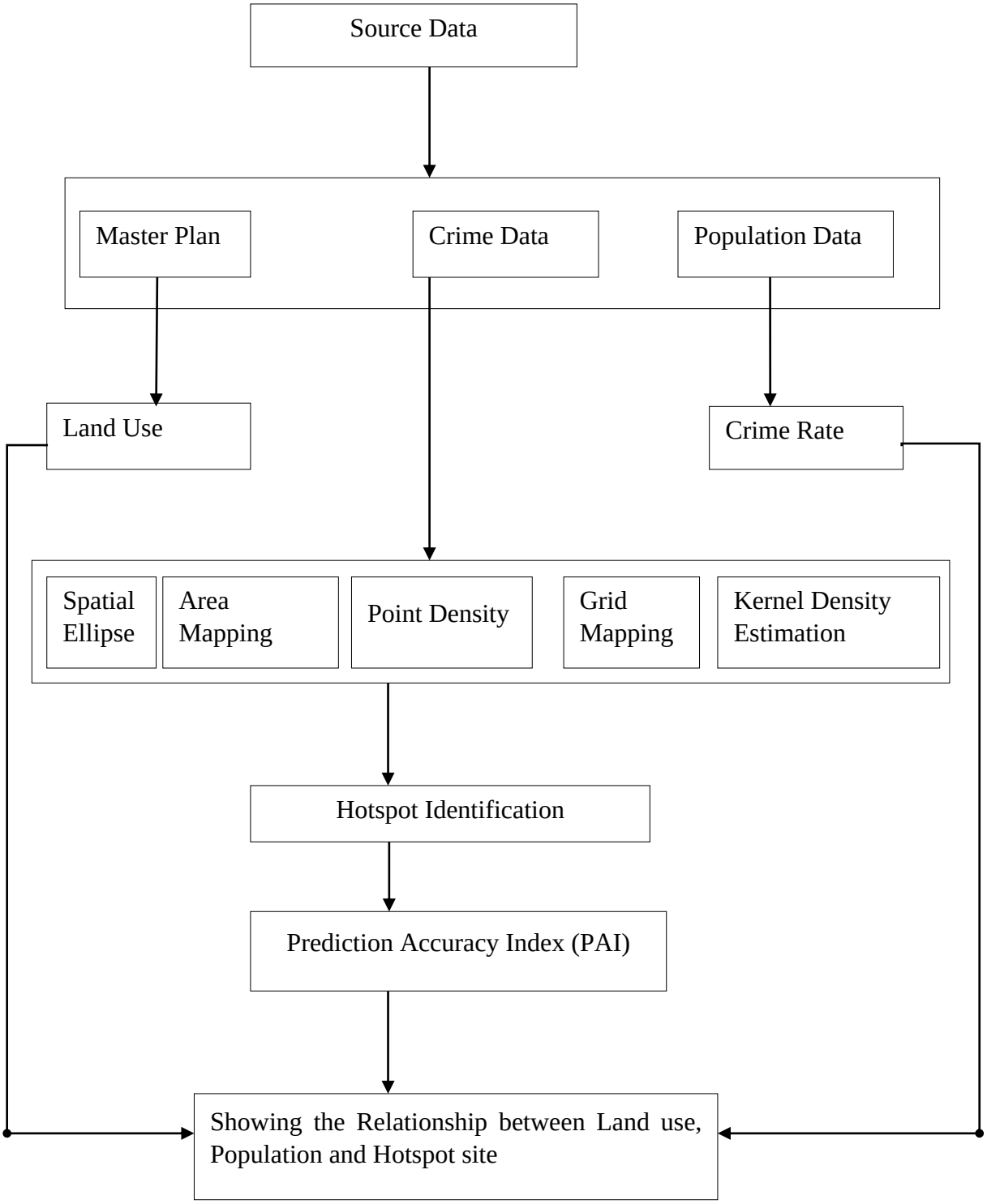


Figure 3.2 Methodology

3.3 Data Analysis

3.3.1 Crime Rate Computation

Crime rate is a technique, which used to examine how the number of incidence differs from one place to another place. It can be expressed as the number of crime per 1000 person or number of crime per area square kilometer or per patrol district (Bruce, 2004) and this rate can be expressed as follows in equation (1)

$$\text{Crime Rate} = \frac{\text{number of crime}}{\text{population}} * 1000 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

From this point of view, the rate per 1000 person is calculated for both crimes against person and property for each Woreda of Addis Ketema sub city in the year 2006-2009 as depicted in the table below.

Table 3.6 Rate of Crime against Person & Property (2006)

W.N	Population 2006	Crime Against Person	Crime Against Property	Total	Person crime rate	Property crime rate	Total Crime Rate	Total Rate in (%)
1	38780	18	11	29	0.46	0.28	0.75	8.88
2	31654	6	7	13	0.19	0.22	0.41	4.88
3	33881	2	0	2	0.06	0.00	0.06	0.70
4	38563	7	8	15	0.18	0.21	0.39	4.62
5	23091	4	0	4	0.17	0.00	0.17	2.06
6	33288	17	2	19	0.51	0.06	0.57	6.78
7	27055	18	49	67	0.67	1.81	2.48	29.41
8	38083	26	74	100	0.68	1.94	2.63	31.19
9	33288	10	12	22	0.30	0.36	0.66	7.85
10	29613	5	4	9	0.17	0.14	0.30	3.61
Total	327,404	113	167	280	3.40	5.02	8.42	100

Table 3.7 Rate of Crime against Person & Property (2007)

W.N	Population 2007	Crime Against person	Crime Against Property	Total	Person crime rate	Property crime rate	Total Crime Rate	Total Rate in (%)
1	39726	4	12	16	0.10	0.30	0.40	5.36
2	32427	7	6	13	0.22	0.19	0.40	5.34
3	34708	5	1	6	0.14	0.03	0.17	2.30
4	21503	4	4	8	0.19	0.19	0.37	4.95
5	23654	3	10	13	0.13	0.42	0.55	7.32
6	34480	6	3	9	0.17	0.09	0.26	3.48
7	27716	25	45	70	0.90	1.62	2.53	33.63
8	39013	26	64	90	0.67	1.64	2.31	30.72
9	34101	5	4	9	0.15	0.12	0.26	3.51
10	31097	5	3	8	0.16	0.10	0.26	3.43
Total	331,425	90	152	242	2.82	4.69	7.51	100

Table 3.8 Rate of Crime against Person & Property (2008)

W.N	Population 2008	Crime Against Person	Crime Against Property	Total	Person Crime Rate	Property Crime Rate	Total Crime Rate	Total Rate in (%)
1	40683	14	21	35	0.34	0.52	0.86	9.36
2	33210	5	8	13	0.15	0.24	0.39	4.26
3	35544	4	0	4	0.11	0.00	0.11	1.22
4	40455	7	12	19	0.17	0.30	0.47	5.11
5	24225	6	9	15	0.25	0.37	0.62	6.73
6	35036	15	6	21	0.43	0.17	0.60	6.52
7	28385	26	53	79	0.92	1.87	2.78	30.27
8	39954	23	81	104	0.58	2.03	2.60	28.31
9	34924	8	10	18	0.23	0.29	0.52	5.61
10	33325	5	3	8	0.15	0.09	0.24	2.61
Total	35,7340	113	203	316	3.33	5.87	9.19	100

Table 3.9 Rate of Crime against Person & Property (2009)

W.N	Population 2009	Crime Against Person	Crime Against Property	Total	Person Crime Rate	Property Crime Rate	Total Crime Rate	Total Rate in (%)
1	41678	23	18	41	0.55	0.43	0.98	12.07
2	34021	8	9	17	0.24	0.26	0.50	6.13
3	36413	3	3	6	0.08	0.08	0.16	2.02
4	41443	8	6	14	0.19	0.14	0.34	4.14
5	24817	15	4	19	0.60	0.16	0.77	9.39
6	35892	16	8	24	0.45	0.22	0.67	8.20
7	29079	25	36	61	0.86	1.24	2.10	25.74
8	40931	35	43	78	0.86	1.05	1.91	23.38
9	35778	9	11	20	0.25	0.31	0.56	6.86
10	35789	5	1	6	0.14	0.03	0.17	2.06
Total	355,841	147	139	286	4.22	3.93	8.15	100

`

3.4 Hotspot Identification Techniques

3.4.1 Spatial Ellipse

CrimeStat (Levine, 2010) was used for generating STAC standard deviational spatial Ellipses. STAC is a spatial tool to find and examine hotspot areas within the study area. In concise terms this means that STAC first find the densest concentration of points on the map (hot clusters), and then fits a "standard deviational ellipse" to each one. The ellipses themselves indicate through their size and alignment the nature of the underlying crime clusters. Using spatial ellipse techniques, the size and alignment of each hotspot can be easily visualized. The parameter that user is required to enter are the Search Radius, the minimum number point- per- hotspot, the number of standard deviation for the generation of spatial ellipse and scan type. The triangular scan type was selected due to the irregular road network within the study area (Levine, 2010). Spatial ellipses were created to one point five standard deviation. This is because of if default standard deviation is taken, the resulting ellipse will be too small which is hard to view .on the other hand, two standard deviation tend to exaggerate the size of the hot spot and leaving it at one unless the ellipses are too hard to see, and increasing it to 1.5. Setting the minimum points-per-hotspot and the number of ellipses proved to be more complex as it is difficult to universally apply a fixed number of points-per-hotspot with the different periods of input data using STAC since the number of crime occurred in the study area from 2006 - 2009 varies in number. The only guidance for applying a suitable search radius was experimentation and experience (Levine, 2010). As a result, two search radii were used to determine hotspots – 500m, 600m where in the case of search 600m, the spatial ellipse created fall outside the study area. To overcome this problem only 500m search radius were used and result for these data were processed in CrimeStat software and ArcGIS and it is shown in the following figure 3.3 and 3.4 below.

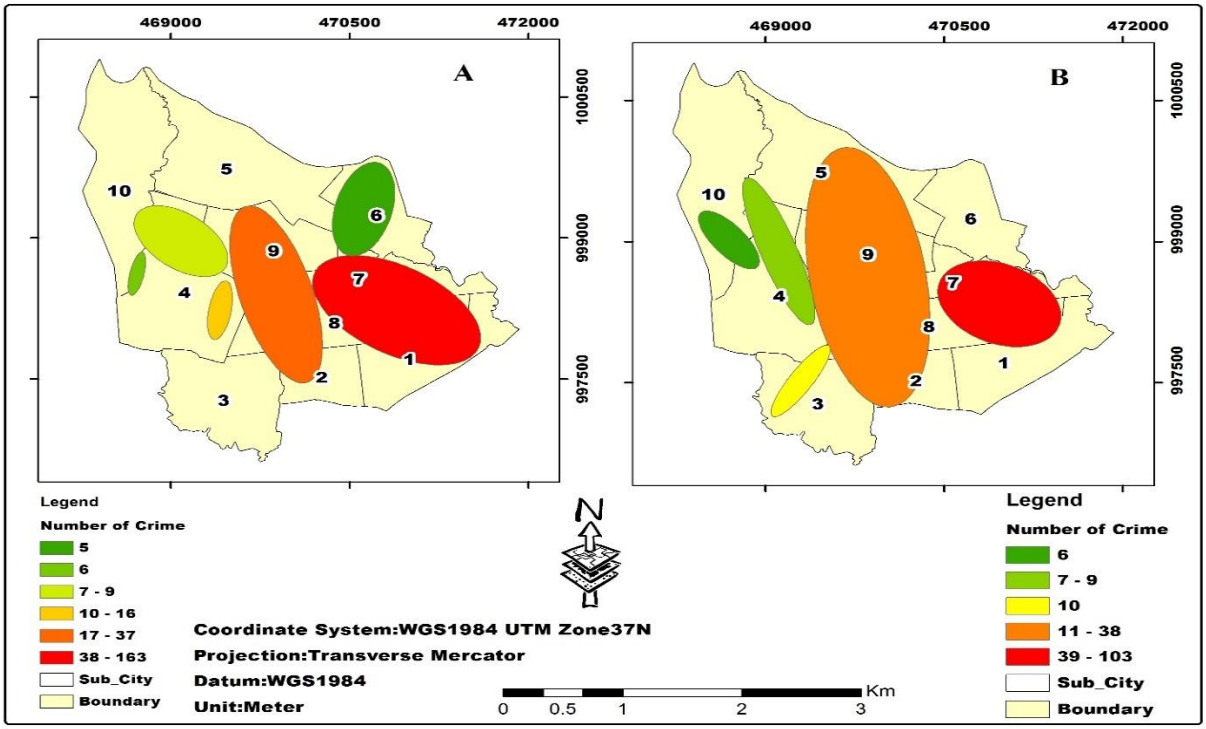


Figure 3.3 (A and B) Spatial Ellipse Map (2006 & 2007)

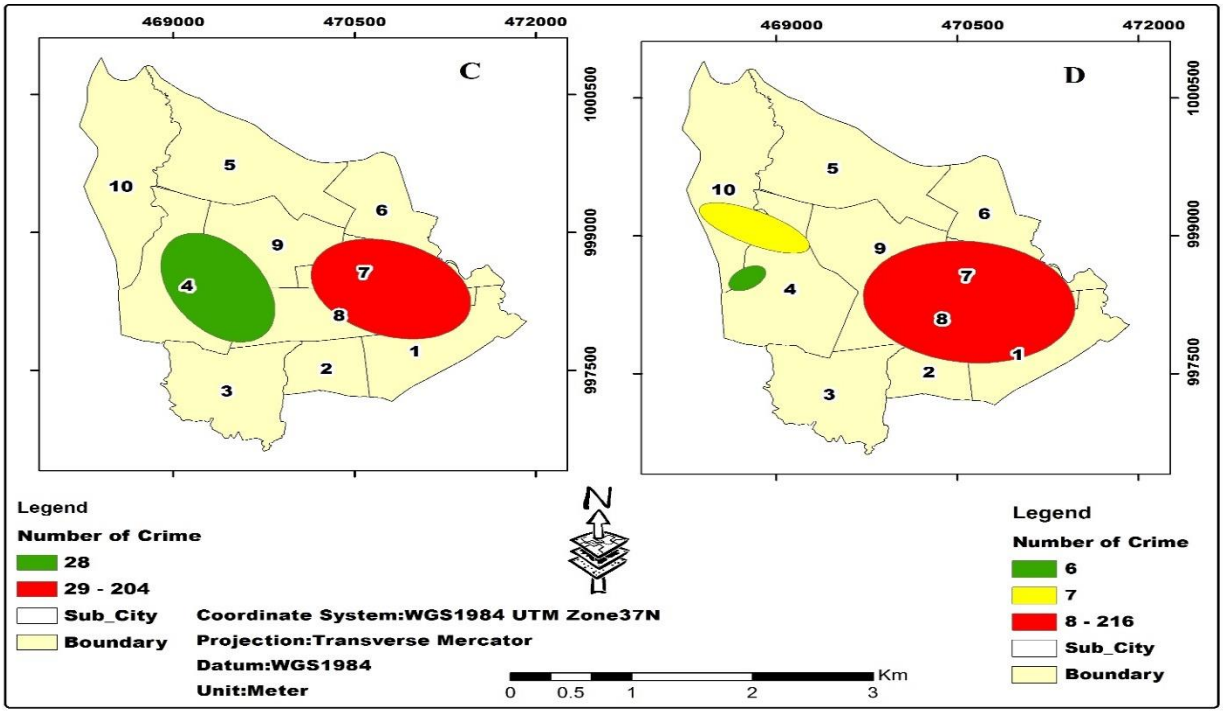


Figure 3.4 (C and D) Spatial Ellipse Map (2008 & 2009)

3.4.2 Thematic mapping of geographic boundary (Area Density)

Thematic mapping incorporates defined borders, such as political boundaries, census tracts, or police beats, with crime data. This method allows for the quick interpretation of information, displaying the intensity of crime events for each border area within the study area. So our case the total number of crime incident committed in each Woreda is filled with the attribute table of ArcGIS, the using conversion tool feature to raster, the city Woreda boundary which is filled with total number of crime incident was converted to raster and reclassified using natural classification techniques. Each area is thematically mapped based on the number of crimes occurring within them. Maps created in this way are quick to produce and require little technical expertise to interpret. Furthermore, this technique enables the user to quickly determine which areas have a high incidence of crime. In addition, census areas can be easily linked with other data sources, such as population, to calculate a crime rate increasing their versatility for analysis. The processed result of each year data shown in fig 3.5 and 3.6 below.

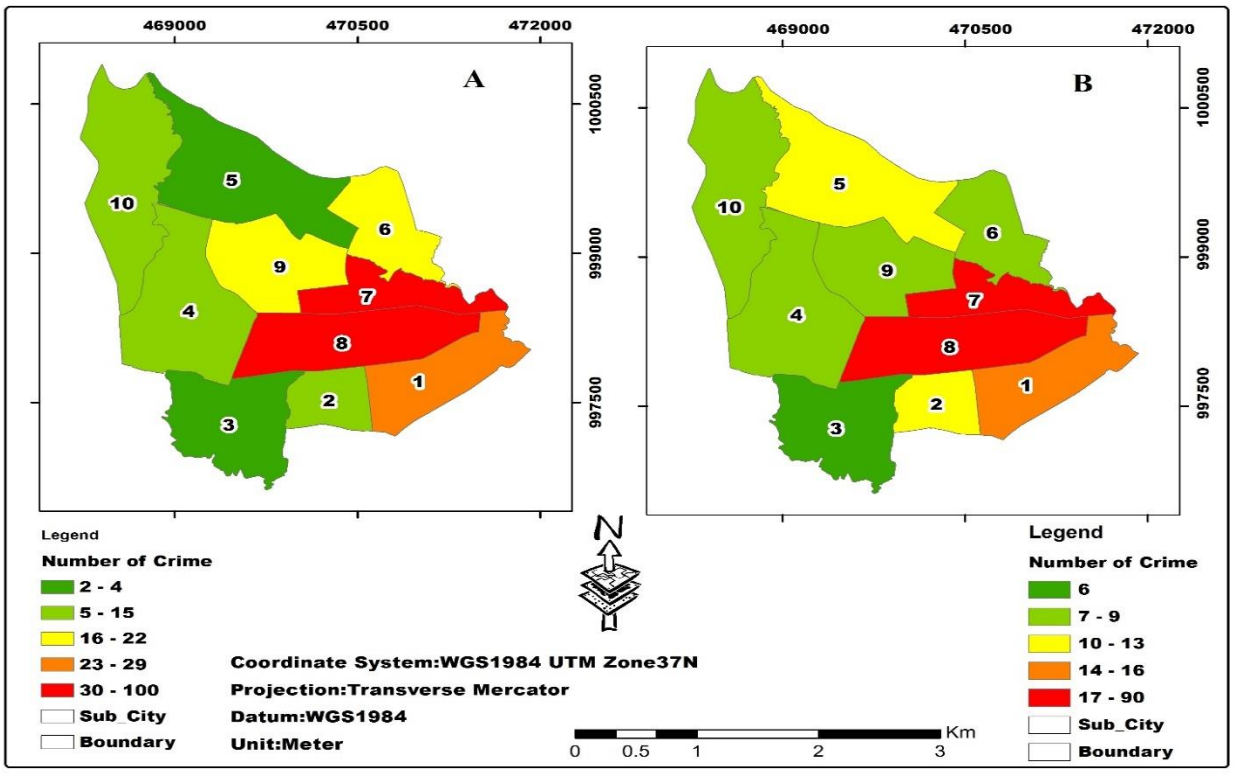


Figure 3.5 (A and B) Choropleth Map in (2006 & 2007)

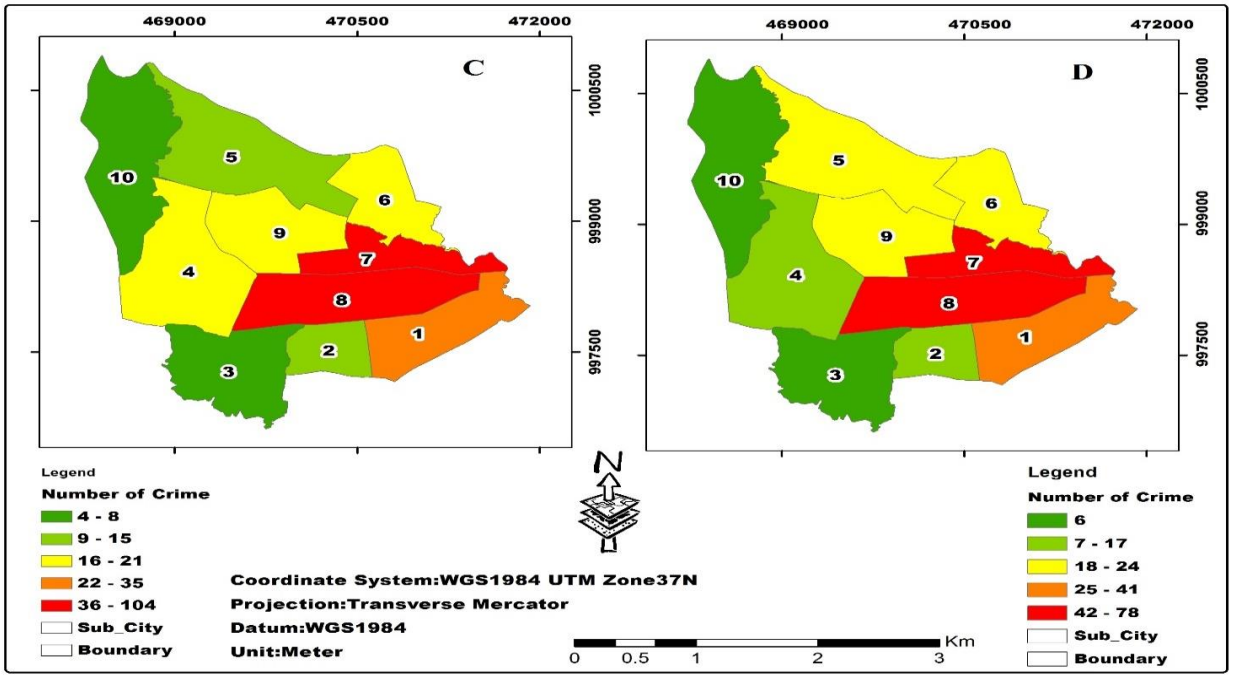


Figure 3.6 (C and D) Choropleth Map in (2008 & 2009)

3.4.3 Grid Thematic Mapping (Quadrat analysis)

Grid thematic mapping is a process of laying a uniform grid with a user-specified cell size over a study area, and each corresponding grid is shaded to represent the level of crime events within each cell. Therefore, all areas used for thematic shading are of consistent dimensions and are comparable, assisting the quick and easy identification of hotspots. The grid mapping technique is able to display the actual crime patterns in greater spatial detail than the jurisdiction-bounded technique if the correct grid cell size is used. Each grid cell can have a crime count associated to it, which can then be thematically mapped. The mapped value could also be a density value calculated from the count and cell area but no universally accepted rule to assign the grid cell value. However, by trial and error mechanism, the cell value can be computed and grid map can be generated depending up on scale of the map .The challenge was determining the best grid cell size. If the grid cells are too large, the resolution on the map will be coarse, making it difficult to identify the hotspots, while grid cells that are too small produce maps that diminish the clarity of the crime patterns and hotspots. In this study, since the scale of map is large and the study area is small as compared to whole city, only 300m grid cell size were used and the result is as shown in fig 3.7 and 3.8 below.

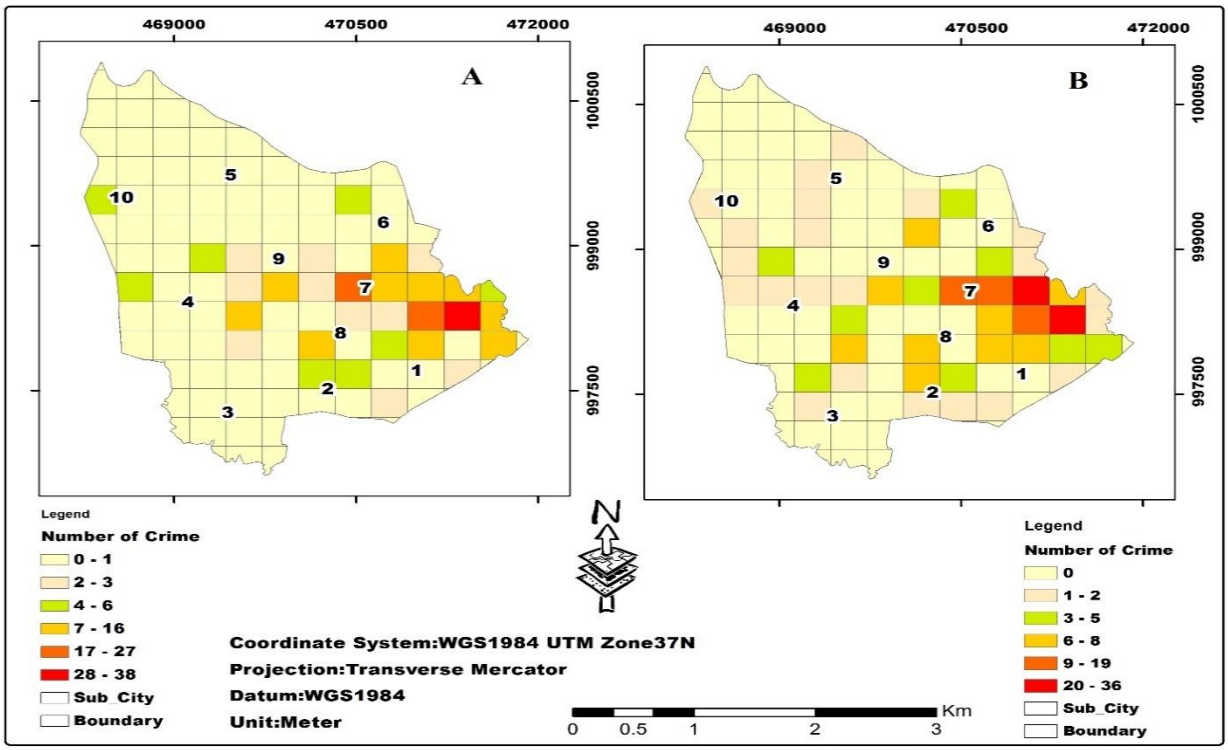


Figure 3.7 (A and B) Grid Thematic Map (2006 & 2007)

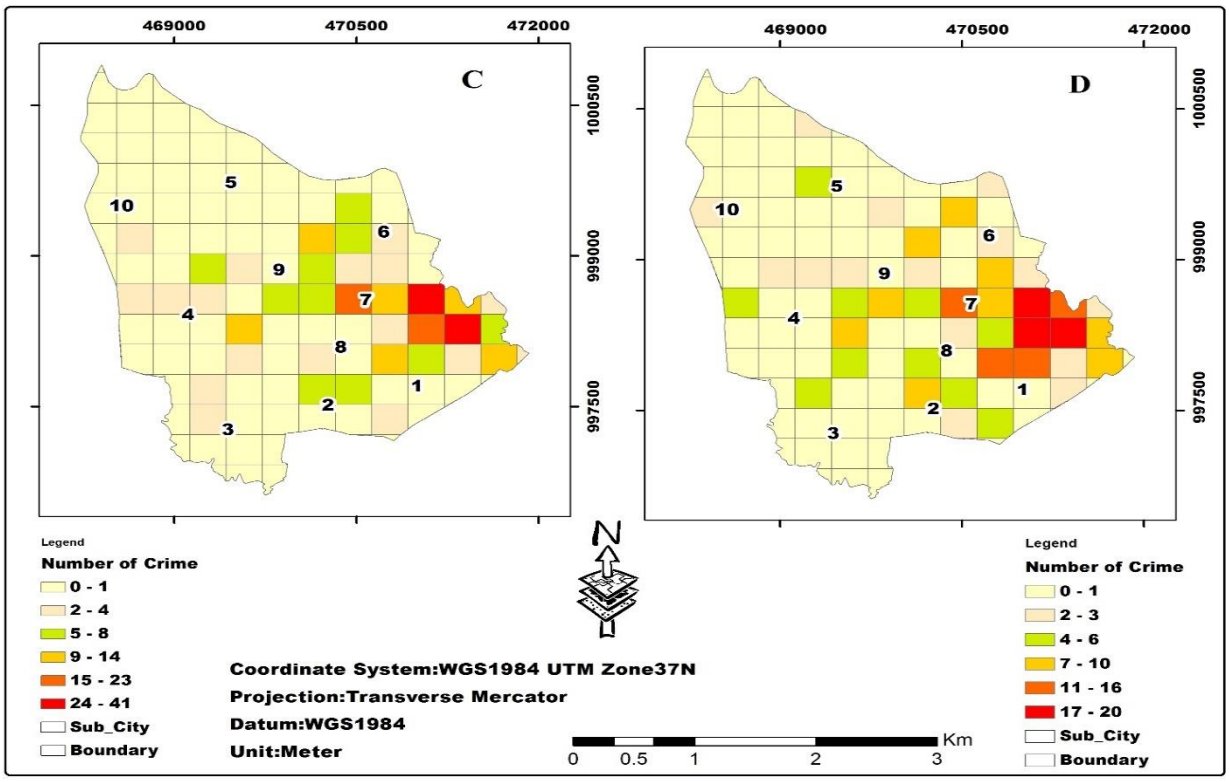


Figure 3.8 (C and D) Grid Thematic Map (2008 & 2009)

3.4.4 Point Density Mapping

The most common approach for displaying geographic patterns of crime is point mapping. In this study, the number of crime committed (frequency of incident happened) were filled in ArcGIS environment. In point density mapping, density of crime incident were identified using cell size of 20m in spatial analysis tool. Then using raster to polygon conversion mechanism, the calculated raster were converted to polygon. From this polygon, the area of hotspot and the number of crime is found. Then, in spatial analysis tool of ArcGIS, the point density of each historical data were obtained using graduate symbol size in natural break classification mechanism. Finally, the result of these point density were shown using different color below. In point mapping, size of symbols were used to reflect the number of crime at location (the size dot is proportional to the number of crime occurring at that place). However, trying to interpret spatial patterns and hot spots in the crime point data can be difficult, particularly if the data sets are large. Hence, the proportional symbol map showing the result is shown in the following fig 3.9 and 3.10 below.

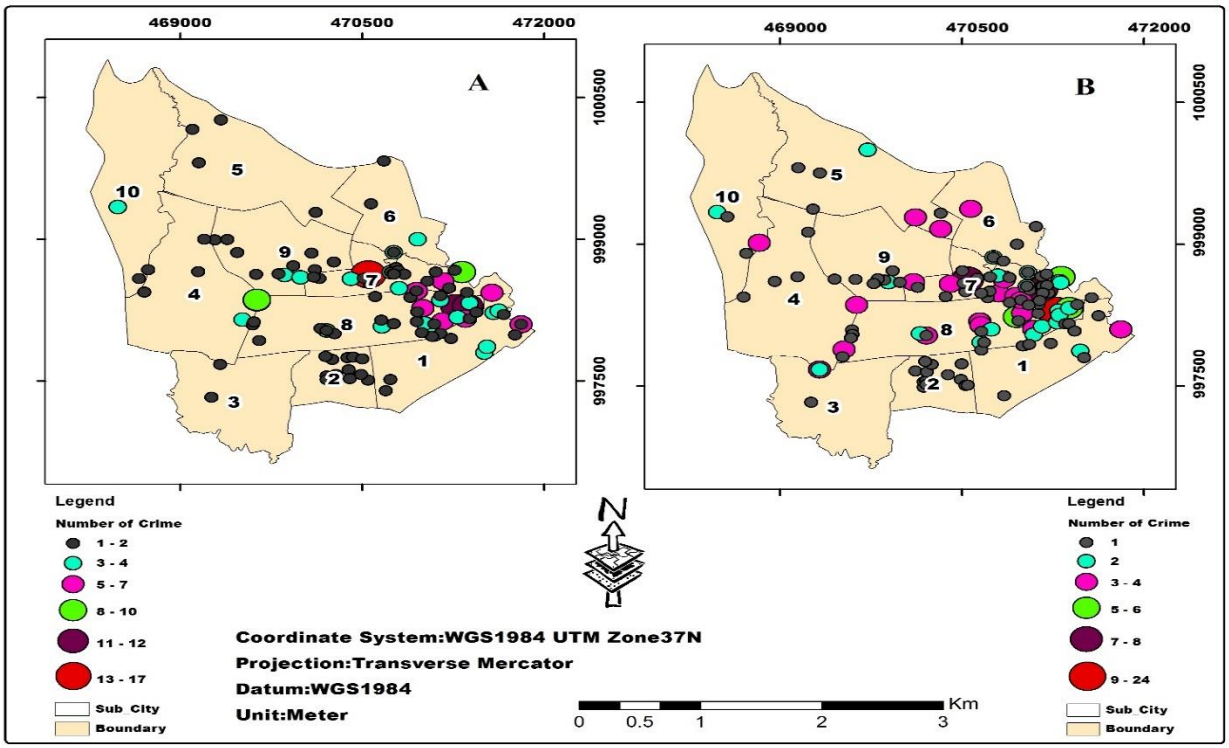


Figure 3.9 (A and B) Point Density Map (2006 &2007)

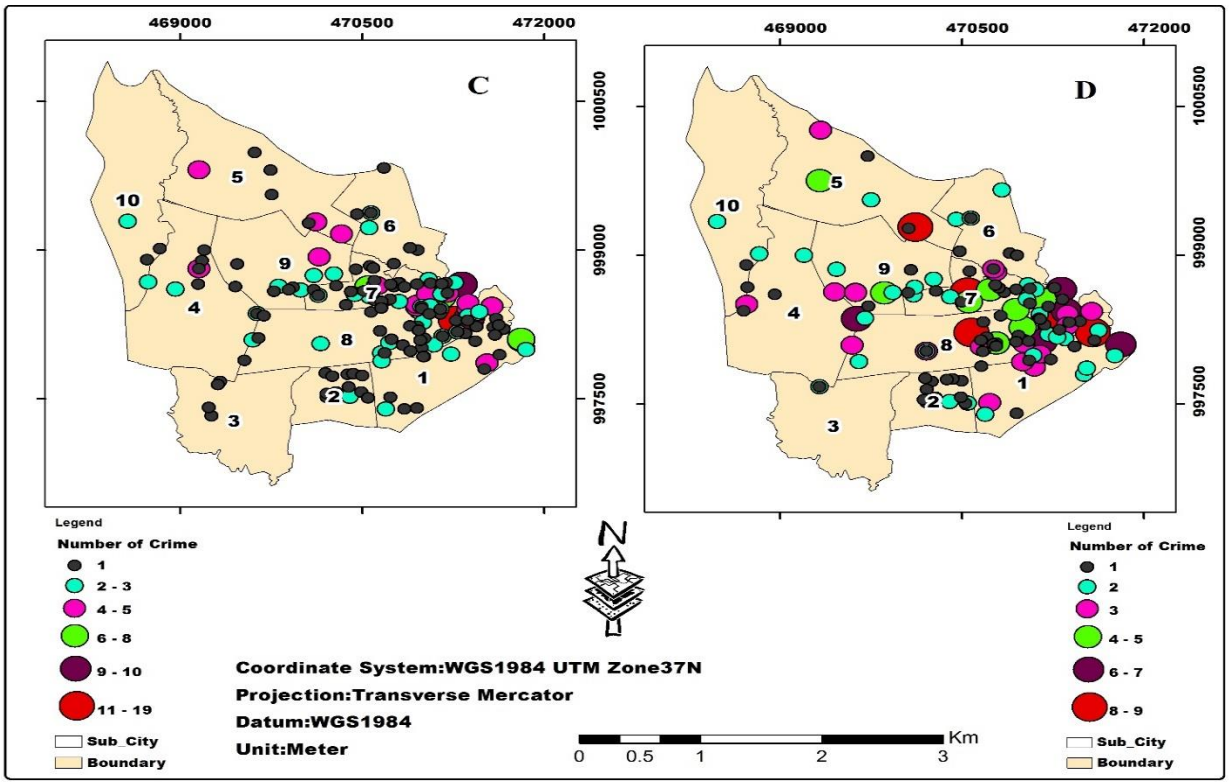


Figure 3.10 (C and D) Point Density Map (2008 & 2009)

3.4.5 Kernel Density Estimation

Kernel Density Estimation (KDE) is regarded as the most suitable spatial analysis technique for visualizing crime data. This technique requires two parameters to be entered by the user – the cell size and the bandwidth (also commonly referred to as the search radius). Decision rules about grid-cell size or the number of columns into which the grid overlay will be divided are usually based the size of the study area. Hotspot detective determines default settings for these parameters after performing an analysis of the input data. Following the default settings is an approach that most analysts take. Parameter selection is critical to the outcome of KDE. Special care should be taken when determining an appropriate bandwidth as this determines the level of smoothing, though despite this, no universal guidance exists. parameter selection will influence the visual appearance of the final map and crime analysts need to have a clear awareness of the impact this can have on the visual output of KDE .The importance of supplying appropriate justification for parameter selection to prevent the statistical strength of any output maps being brought into question. Smaller bandwidths produce hotspot maps, which are better at predicting future patterns of crime across a spatial distribution. As there is no universal guidance for parameter selection for the estimation of kernel density, the search radius and cell size for the processing of kernel density using the historical data were 200m and 20m respectively. The size of study area matter the selection of cell size and search radius. In addition to this, default cell size and search radius were used for the processing of this kernel density estimation. However, the result from this default parameter were not convincing, as it look dispersed in some area and not clearly visible for the identification and visualization of hotspot of crime incident in the study area. Using these cell size 20m and search radius of 200m, the result of kernel density were as clear and visible for visualization, which is shown in the following figure 3.11 and 3.12 below.

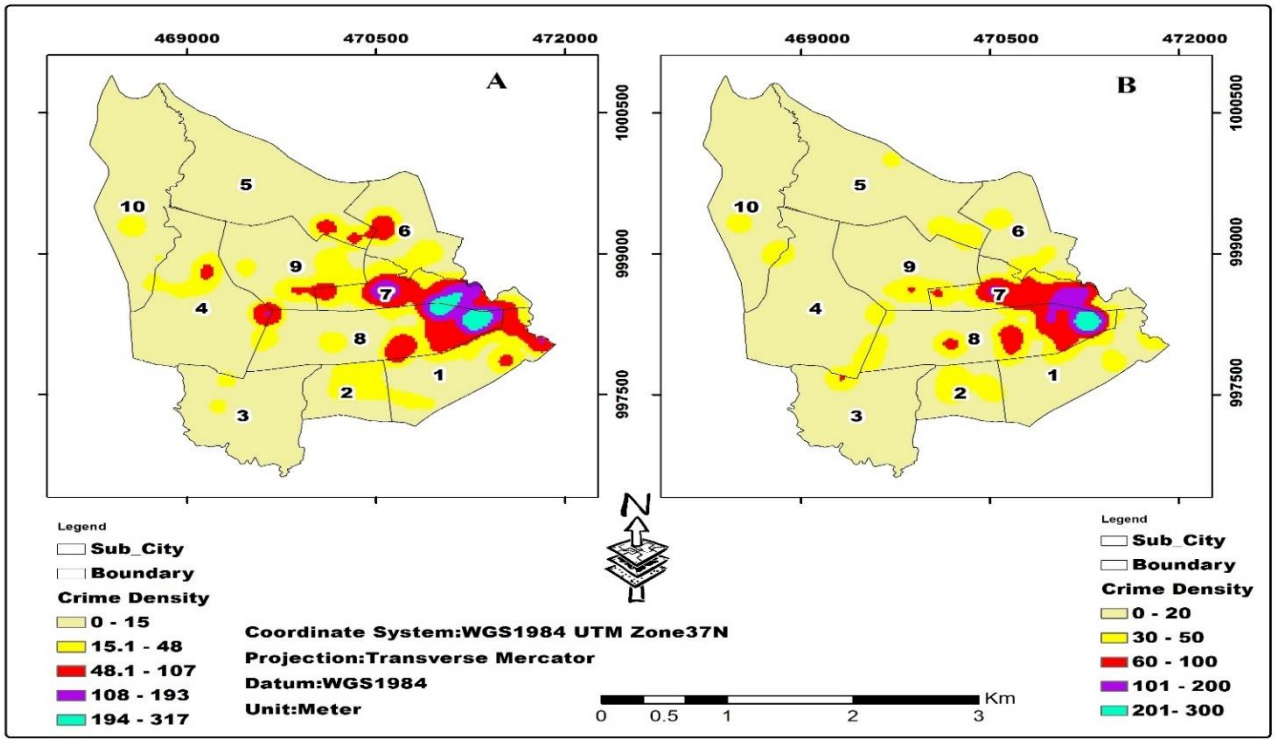


Figure 3.11 (A and B) Kernel Density Estimation Map (2006 & 2007)

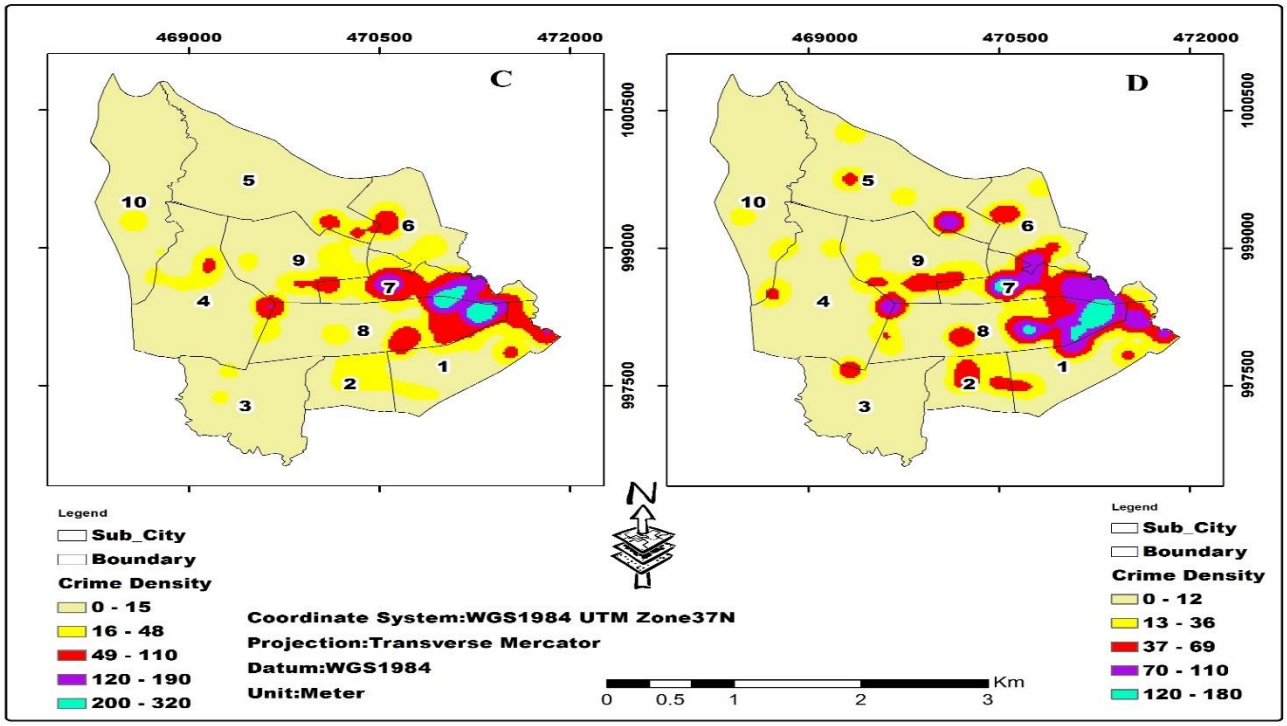


Figure 3.12 (C and D) Kernel Density Estimation Map (2008 & 2009)

Table 3.10 Parameter used in Hotspot Mapping

Methods	Parameters	
	Cell size	Radius
STAC	-	500m
Grid Thematic Mapping	-	300m
Area Mapping	-	-
Point Density	default	default
KDE	20	200m

3.5 Determining Thematic Threshold for Hotspots

Thematic mapping of output areas, grid thematic mapping and KDE produce areal values across a continuous range (example: in grid thematic mapping, each grid cell has a value representing the number of crimes located within the cell). Whereas for spatial ellipses, this is straightforward as it does each ellipse draw simply the area. A threshold value must be determined and any values above this threshold can be classified as an area that is a hotspot .Five thematic classes were used default value generated using quantile method in ArcGIS were applied for thematic mapping of geographical area, Grid thematic mapping , Point density Mapping and KDE. This approach for thematic classification was used because the number of classes falls within the upper and lower settings specified by (Dent, 1999) and (Harries, 1999), and the quantile method was chosen because it distributes the data in an approximately equal balance between the classes, resulting in a visually balanced map pattern. This approach for determining thematic classes is also a common approach that many practitioners apply for generating hotspot maps. The aim of the classification is to approximate the original surface as closely as possible by preserving characteristic patterns of the phenomenon. It is desirable to classify the density values into several categories for visualization. A suitable number of classes should not exceed seven due to limited ability of human eye to discriminate shades. Proposed a method which uses a measure of classification error (sum of absolute deviations about class means) to keep similar data values in the same class. In this way the classification gives in the most accurate and objective overview of the original data. The method is commonly called natural breaks and has been implemented in variety of GIS software.

3.6 Prediction Accuracy Index (PAI)

The PAI technique is used to compare hotspot identification. The method is used to allow the comparison between different hotspot identification techniques or methods. It takes in account that the area might vary from hotspot to hotspot. If hotspot is covering wide area and if all feature crime are in that area of hotspot, it might appear to us as a good outcome .This PAI value calculated by dividing hit rate percentage by the area percentage (area of hotspot in relation to the whole study area). The higher PAI value, the better the hotspot map Techniques for predicting spatial patterns of crime. In the same Manner, the PAI provides a meaningful way to compare the accuracy of hotspot methods, but argues that it should be accompanied by a measure of precision. In this study, the prediction accuracy index of each year Data were determined from the result obtained in hotspot mapping techniques and result were calculated for each techniques and each year data. Finally the prediction accuracy index of hotspot mapping techniques were compared based the value obtained.

The higher the PAI, the better the hotspot map for predicting spatial patterns of crime. The equation to find this PAI is given in the following equation (2) below.

$$\frac{\frac{n}{N}*100}{\frac{a}{A}*100} = prediction\ accuracy\ index(PAI) \quad \text{.....3.2}$$

Where

n: Number of crimes that fall in hotspot areas

N: Number of crimes in study area.

a: Total area of hotspot in study area (e.g. km²)

A: Area of study area (e.g. km²)

Using the above formula, the prediction accuracy index of crime incident data in the 2006 is calculated below as an example and the remaining data of each year is shown in the following table.

Total number of both personal crime and property crime happened in the year 2006 is equal to 280. In addition, total number of crime happened in hotspot of study area was 257.The total area covered by this hotspot from total of 8.53 square kilometer area is 3.68 square kilometer. Moreover, the total number of crime incident for the year 2007 was 242. Here point density mapping technique is selected as a sample for calculation of PAI. Therefore, the calculated PAI for the year 2006 is as follows.

$$\mathrm{PAI} = \frac{\frac{257}{242}*100}{\frac{3.68}{8.53}*100} = \frac{106.198}{43.141} = 2.461$$

In the same manner the remaing PAI for all hotspot-mapping techniques were shown as follows in table format.

Table 3.11 Prediction Accuracy Index of Different Hotspot Techniques.

Point Density	Data	Hotspot	Area	Hit Rate	Hot area	PAI	Avg. PAI
2006	280	257	3.68	106.198	43.141	2.461	
2007	242	210	3.64	66.455	42.672	1.557	
2008	316	288	4.015	100.699	47.069	2.139	
2009	286	255	4.47	-	52.403		2.052
Grid mapping	Data	Hotspot	Area	Hit Rate	Hot area		
2006	280	269	2.59	111.157	30.363	3.660	
2007	242	227	2.597	71.835	30.445	2.359	
2008	316	290	2.574	101.398	30.175	3.360	
2009	286	257	2.521	-	29.554		3.126
Area mapping	Data	Hotspot	Area	Hit Rate	Hot area		
2006	280	237	3.62	97.933	42.438	2.307	
2007	242	207	4	65.506	46.896	1.396	
2008	316	258	4.03	90.209	47.245	1.909	
2009	286	224	3.62	-	42.438		1.870
STAC	Data	Hotspot	Area	Hit Rate	Hot area		
2006	280	236	2.98	97.520	34.935	2.791	
2007	242	166	3.566	52.531	41.805	1.256	
2008	316	232	1.89	81.118	22.157	3.661	
2009	286	229	2.155	-	25.263		2.569
KDE	Data	Hotspot	Area	Hit Rate	Hot area		
2006	280	220	0.8004	90.909	9.383	9.688	
2007	242	223	1.5173	70.569	17.787	3.967	
2008	316	298	1.945	104.195	22.801	4.569	
2009	286	221	1.0998	-	12.893		6.074

3.7 Relationship between Population Density and Addis Ketema Crime incident

Many researcher have argued that the modification of specific features of urban design would reduce crime with their work. This idea attracts environmental criminologist, architect, planners, geographers and psychologist to study of the environment in which incident occur

Crime opportunity takes place when the offender finds a target in suitable situation without a capable guardian in the urban physical environment. Criminal pattern theory reveals that offenders tend to concentrate in areas familiar to them and through their day-to-day activities watch for an easy target and an open space for a quick and easy escape route before committing a crime. Population density and total area are expected to influence the influx of crime incidence in housing scheme.

The spatial relationship and distribution of crime incidents with population density and land use were analyzed in this part of study. The spatial distributions of crime clearly demonstrate that land uses and population characteristics are associated with crime hot spots. From the viewpoint of environmental criminologists, crime is closely related to the society, economy, population, land use and so on. In case of this study, the projected population data of Addis Ketema sub-city in the years 2006-2009, population density were calculated by dividing the population number by area in square kilometer. Then from numerically computed population density and crime number, crime density obtained by dividing the crime number by area in square kilometer. As a result, areas categorized from very low to very high in ascending order based on the result obtained from the crime rate density which is number of crimes per area square kilometers as revealed below in fig 3.13.

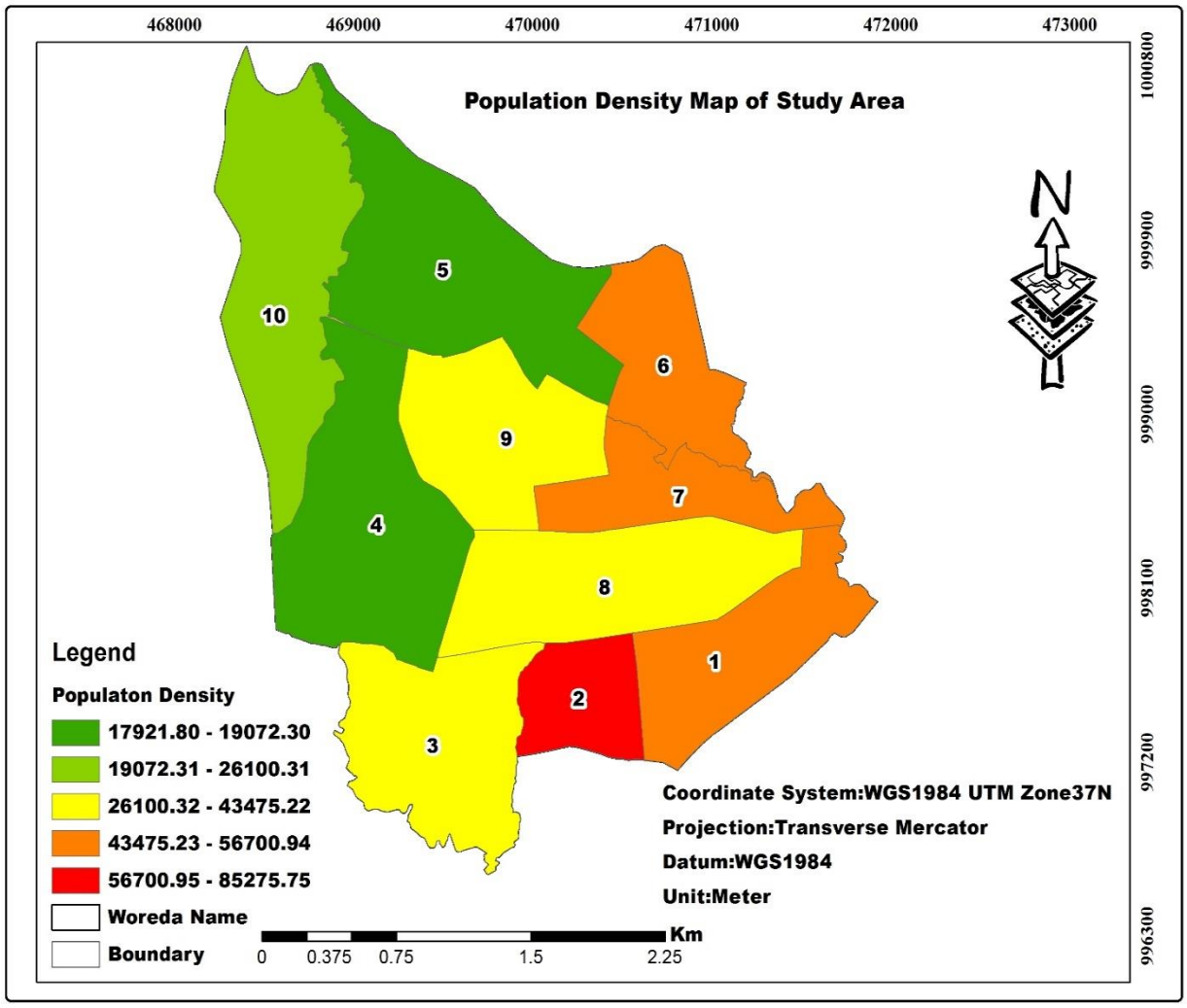


Figure 3.13 Population Density Map

Table 3.12 The Relationship between Population & Crime Incident.

Population density (No/ Sq.Km)	property	person	Area in sq.km	Crime Density (no. of crimes per sq.km		Level of Crime Intensity
				Property	Person	
17921.80-19072.30	61	61	2.440052	50.080541	49.999084	Low
19072.31-26100.31	8	15	1.191442	6.714554	12.589788	Very low
26100.32-43475.22	302	155	2.67466	314.9029	166.454658	High
43475.23 -56700.94	265	211	1.848334	478.226283	362.066562	Very High
56700.95 - 85275.75	21	43	0.38026	55.225301	60.484853	Moderate

The level of crime intensity shown in above table 3.12 were determined from the numerically computed population density and historically recorded crime incident over the study area.

3.8 Relationship between Land use and Addis Ketema Crime incident

Different study suggested that, there is a relationship between land use, urban form, routine activities and crime (Suryavanshi, 2005). As land use change with new development and redevelopment, the structure of urban form will change as well (Brantinghams 1981; Felson 1987). Urban forms are dynamics; any change in land use may bring about other changes to nearby areas. For instance, the development of a new community facility may change the routine activities of the community involved. According to (Felson, 1987), routine activities would create crime opportunities for the offender. Property crimes are higher at places where there are dispersed shopping and strip commercial developments. Commercial areas in cities have been found to be prone to burglaries and thefts while residential areas are conducive to crimes such personal crime (Suryavanshi, 2005). In the case of this study, the land use types were obtained by digitizing Addis Ketema sub city structural plan, which was prepared in 2006 according to Ethiopian calendar. From this structural plan, land use categories such as: Mixed, Commercial, Open space, Environment, Manufacturing and Storage, Service And Residential area were digitized and reclassified according to color coding principle of ministry of Urban Development and Housing. Finally, the number of crime against person and property in each land use and area coverage in square kilometers were calculated and shown in fig3.14 below for both types of crimes. In addition to this, the total number of crime recorded from 2006 – 2009 were also reclassified in to both personal and property which is overlaid in land use type as shown in fig 3.15 (a) below. In the same manner, total number of crime incident was also overlaid in the reclassified population density of the study area and is as shown in fig 3.15 (b) below.

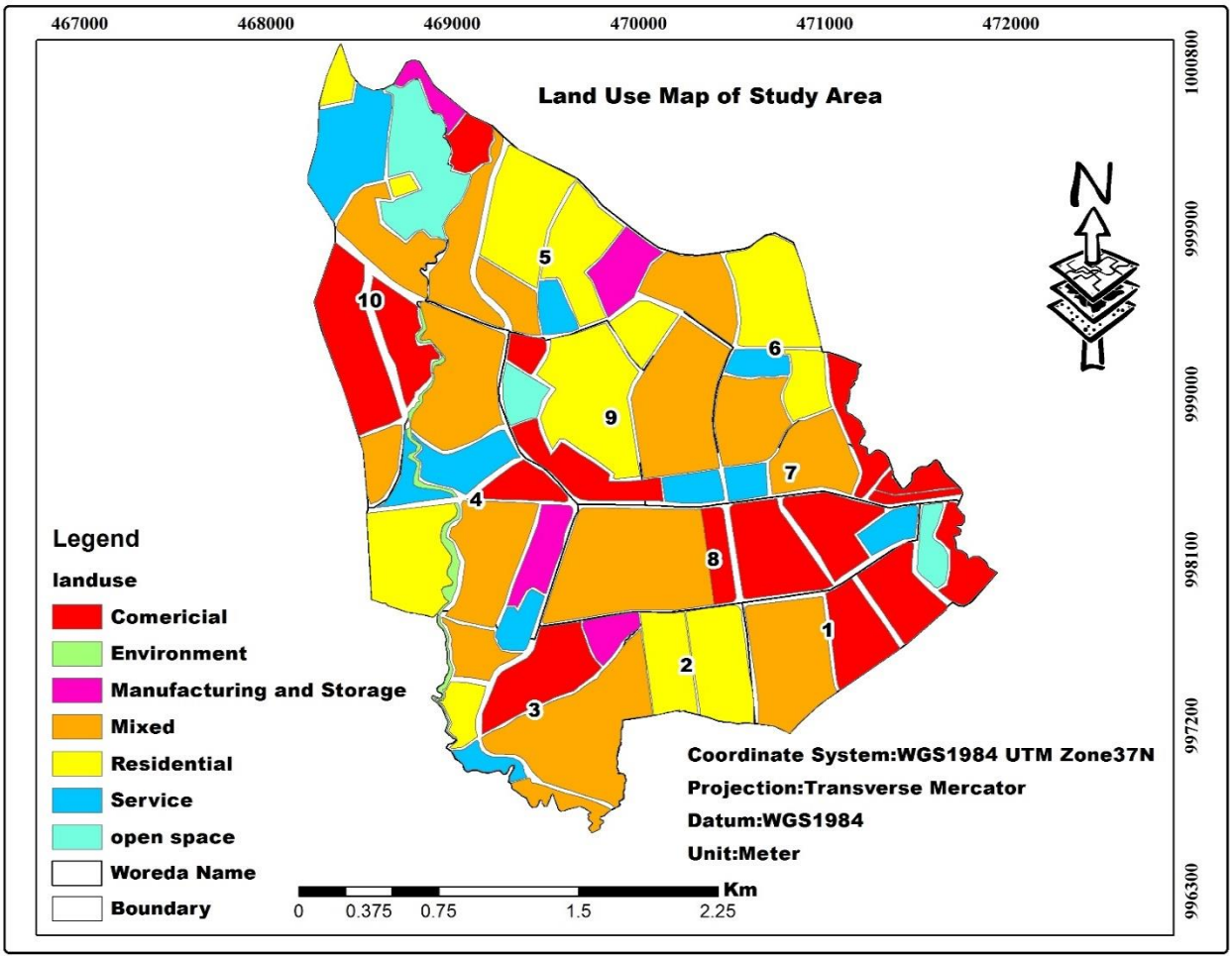


Figure 3.14 Land Use Map

Table 3.13 Relationship between Land Use & Crime Incident

Land use Type	Person crime	Property crime	Area (sq.Km)
Mixed	142	150	2.90
Commercial	120	226	1.66
Open Space	8	12	0.33
Environment	56	48	0.1
Manufacturing and storage	7	25	0.27
Service	59	138	0.66
Residential	73	59	1.70
Total	466	658	7.62

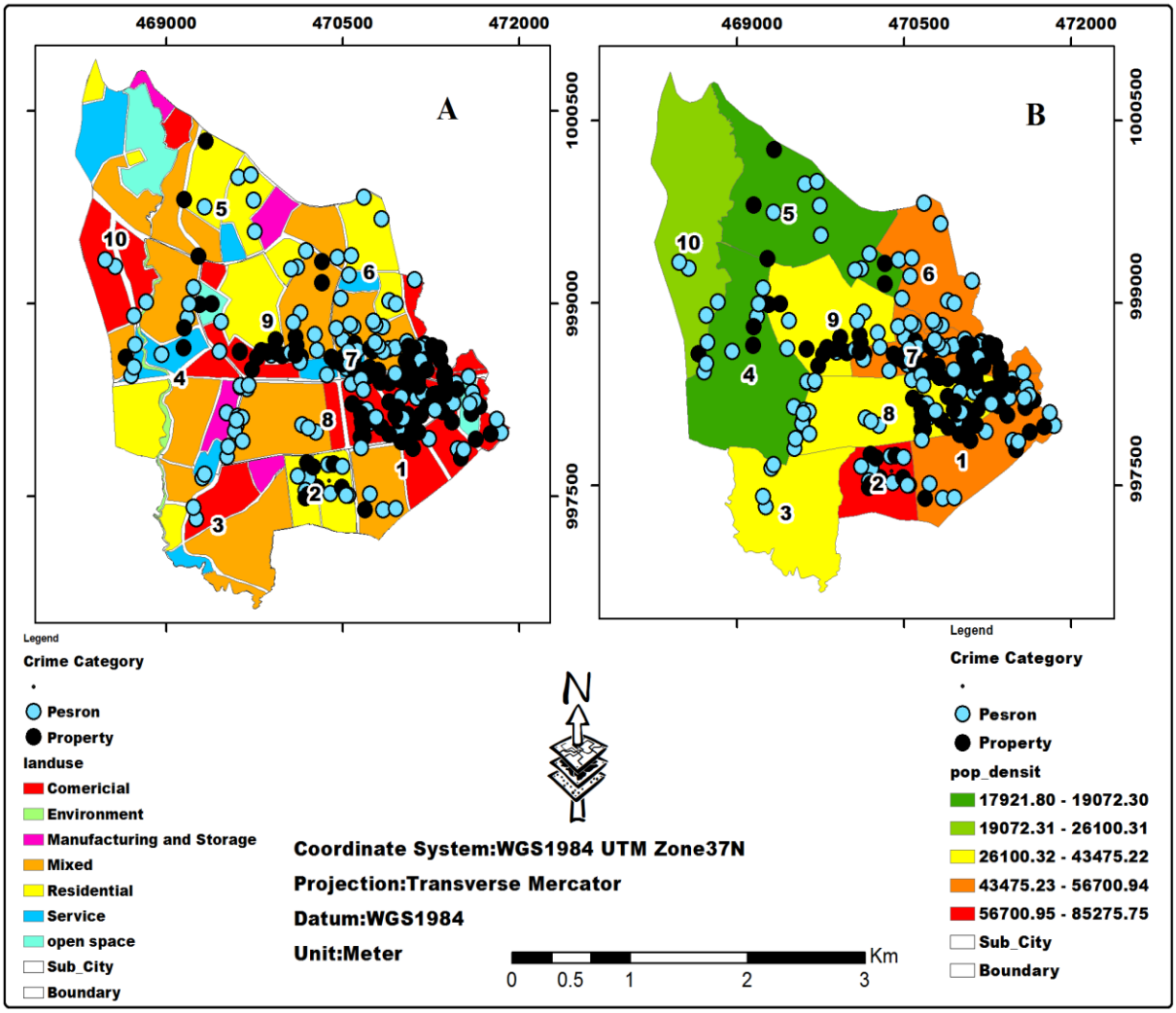


Figure 3.15 Relationship between Populations, Land Use &Crime Incident

Here in fig3.15 above (A and B), the crime against person and crime against property were overlaid in both land use map and population density map. Crime against person shown by cyan color and that crime against property shown by black color were more repeated around central part of sub city.

CHATER FOUR

4 RESULT AND DISCUSSION

4.1 Rate of Crime against Person and Property in Addis Ketema in 2006 -2009

The rate of crime against person and property were computed per1000 person in Addis Ketema sub city using the crime incident data in the years 2006 -2009 .Then, the result from these data were compared to each Woreda and to each year to get which Woreda have highest crime rate and lowest crime rate. The result also compared in which year the crime rate was highest. As shown in the figure 4.1 below, rate of crime against person is highest in Woreda 8 and 7 and lowest in Woreda 3, 5, and Woreda 6 . During the study year 2006, there are 0.68 and 0.67 rate of crime against person respectively in Woreda 8 and 7. Whereas the rate of crime against property in Woreda 8 and 7 respectively are, 1.94 and 1.84. From these result, the rate of crime against person and property accounts 8.11% and 7.90 % and 23.08 % and 21.51 % in Woreda 8 and 7 respectively.

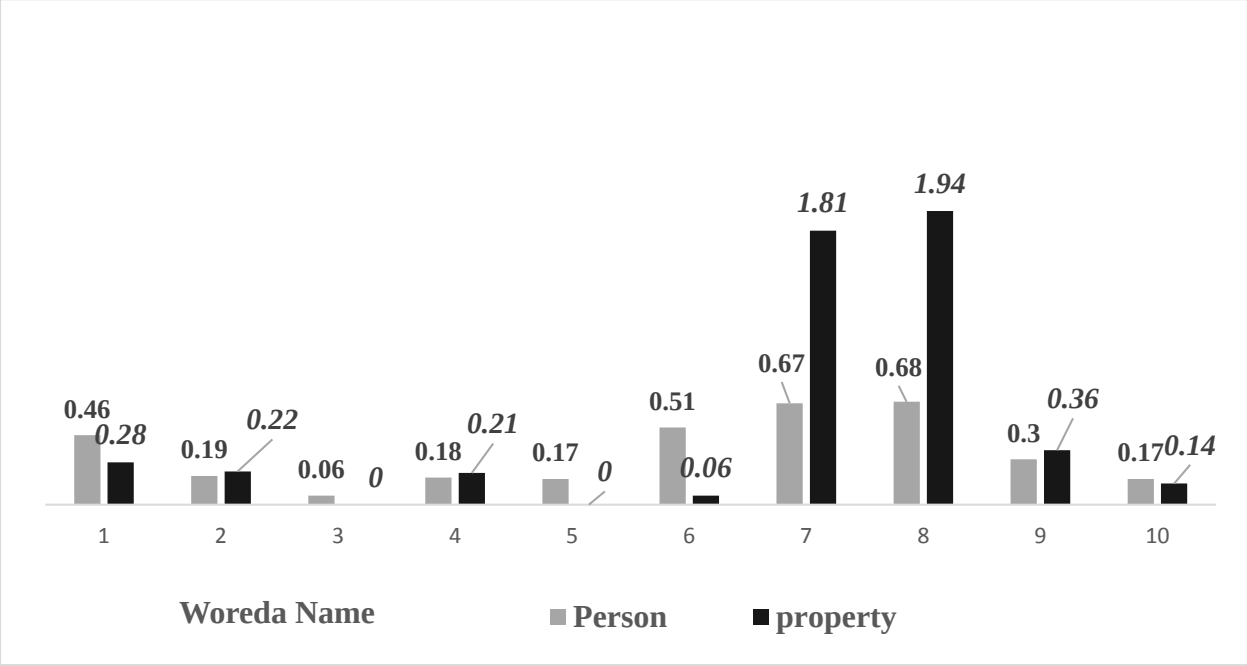


Figure 4.1 Rate of Crime against Person & Property (2006)

As shown in above figure 4.1, there is 0, 0, and 0.06 rate of crime against property in Woreda 3.5, and 6 respectively during the year 2006. Whereas the rate of crime against, property in these Woreda during 2006 were 0.06, 0.016, and 0.51 respectively .From these result, rate of crime against person and property accounts 8.82 % and 0.71 % respectively in those Woredas.

As shown in fig4.2 below, there are 1.64 and 1.62 rate of crime against property and 0.67 and 0.9 rate of crime against person in Woreda 8 and 7 per 1000 person respectively in 2007.In this year, rate of crime against property accounts 21.84 % 21.62% in Woreda 8 and 7 respectively. Whereas the rate of crime against person accounts 8.87 % and 12.01 % in Woreda 8 and 7 respectively. On the other hand, the rate of crime against property and person in the year 2007 were lowest in Woreda 3, 6, 2, and Woreda 1 respectively. In these Woreda, the rate of crime against person covers 8.03 % from total. Whereas the rate of crime against person accounts 8.45 % from total.

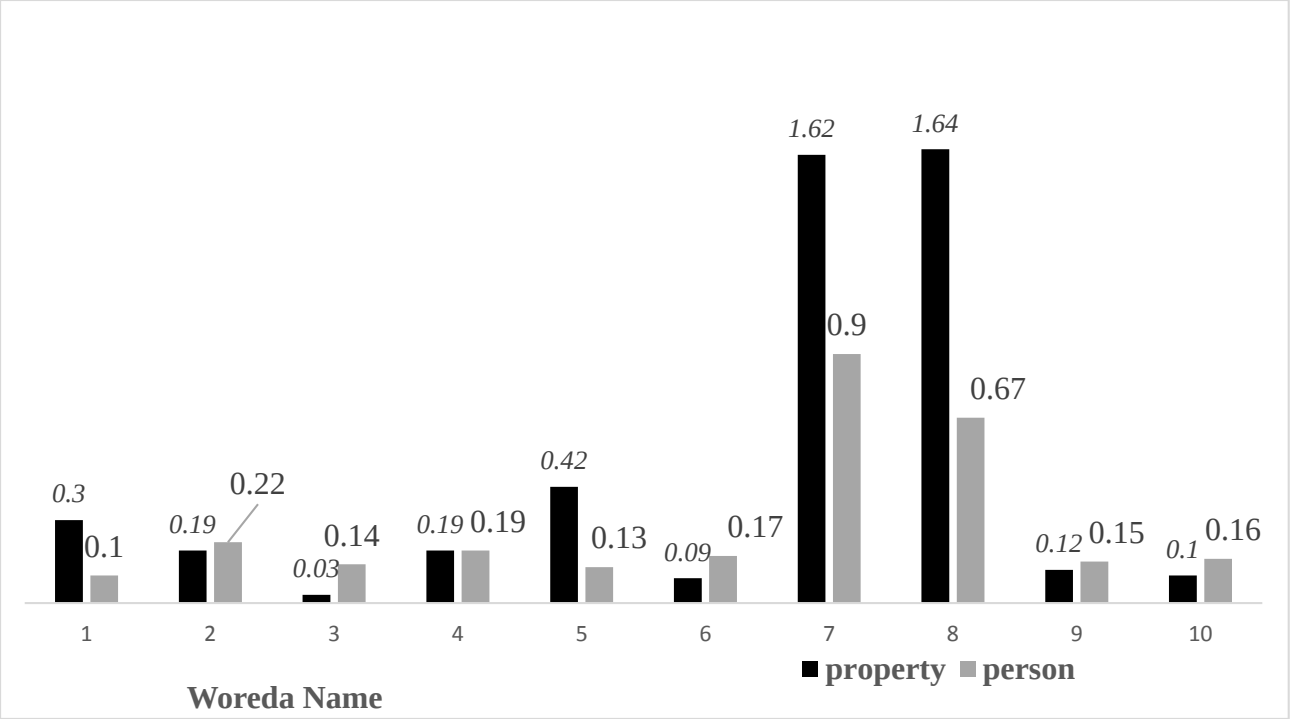


Figure 4.2 Rate of Crime against Person & Property (2007)

In the year 2008, there are 2.03 and 1.87 rate of crime against property in Woreda 8 and 7 respectively. However, rate of crime against person in these Woreda in the year 2008 were 0.58 and 0.92 respectively as shown in fig. 4.3 below. In addition to this, the rate of crime against

property per 1000 person in Woreda 8 and 7 accounts 22.06 % and 20.32 % respectively from total.

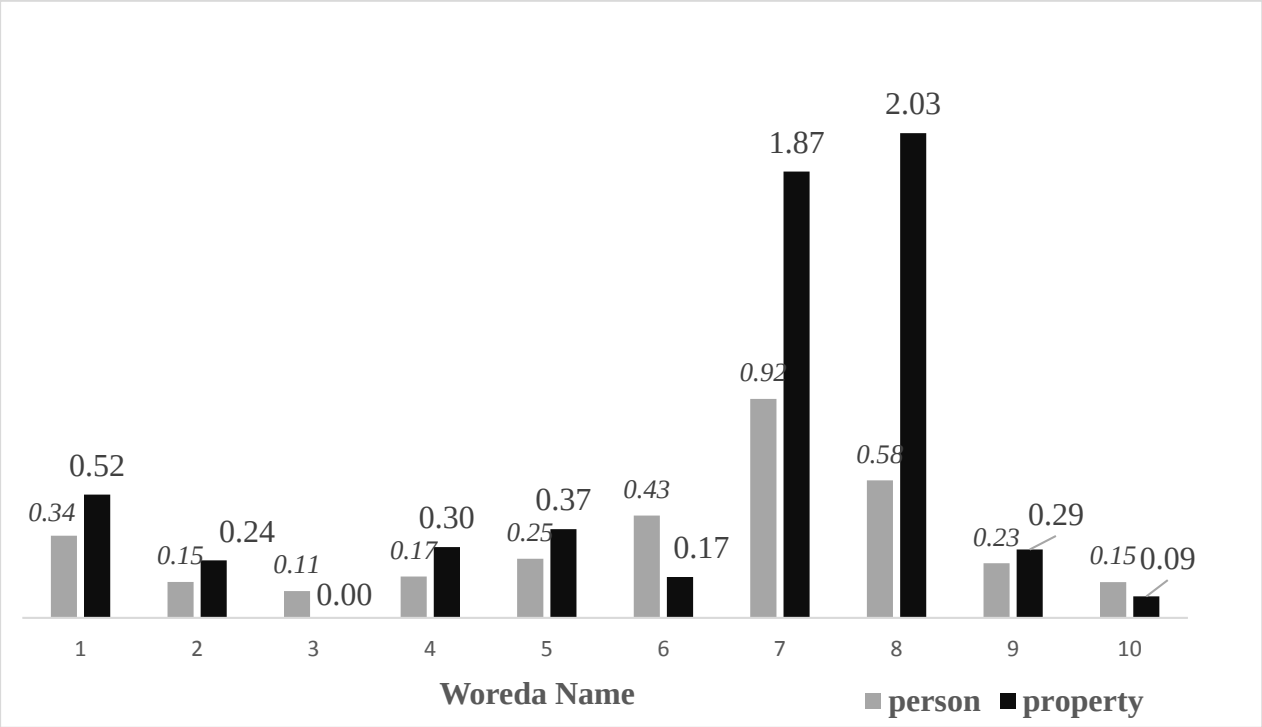


Figure 4.3 Rate of Crime against Person & Property (2008)

However, both crime rate are lowest in Woreda 3, 10 (0, 0.11) and (0.09, 0.15) respectively. From these result, crime against property accounts 0.98 % in both Woreda and that of crime against person covers 2.85 %.

On the other hand, there are 1.24 and 1.05 rate of crime against property and person respectively in Woreda 7 and 8 in the year 2009 as indicated in fig4.4 below. The rate of crime against property accounts 15.19 % and that crime against person accounts 12.89 %.

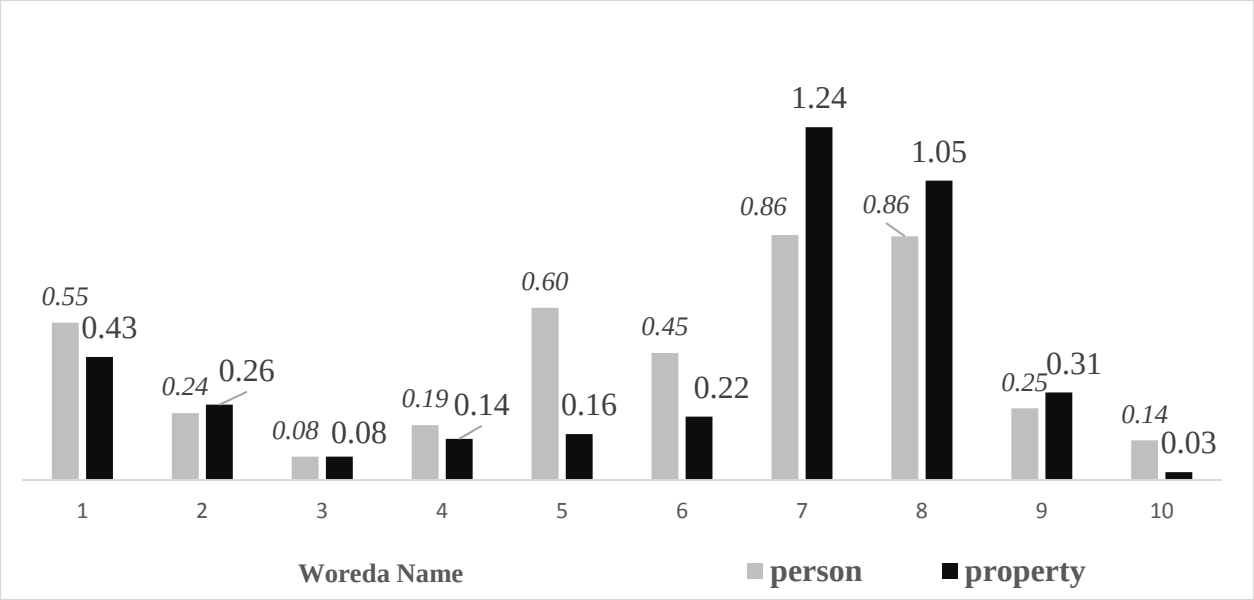


Figure 4.4 Rate of Crime against Person & Property (2009)

As shown in above fig4.4, there are 0.03, 0.08 and 0.14 rate of crime against property per 1000 person in Woreda 10, 3 and 4 respectively. Moreover, that of crime against person committed were, 0.14, 0.08 and 0.19 respectively. From these result, rate of crime against property accounts 3.13 % and that of crime against person accounts 5.09 %.

In general, from the calculated rate of crime against person and property in year 2006 -2009, the rate of crime against person was minimum (0.0102, 0.0109) which covers (1.24, 1.33) percentage in Woreda 3 and 10 respectively. In the same manner, the rate crime against person was maximum (0.079, 0.071) which accounts (9.71, 8.73) percentage in Woreda 8 and 7 respectively. On the other hand, the rate of crime against property was minimum (0.005, 0.002) which covers (0.26, 0.71) percentage in Woreda 3 and 10 respectively. Whereas the rate crime against property was maximum (0.193, 0.134) which covers (23.4, 16.4) percentage in Woreda 8 and 7 respectively. Thus, fig 4.5 given below shows changes of both crime rate in percentage from 2006 -2009.

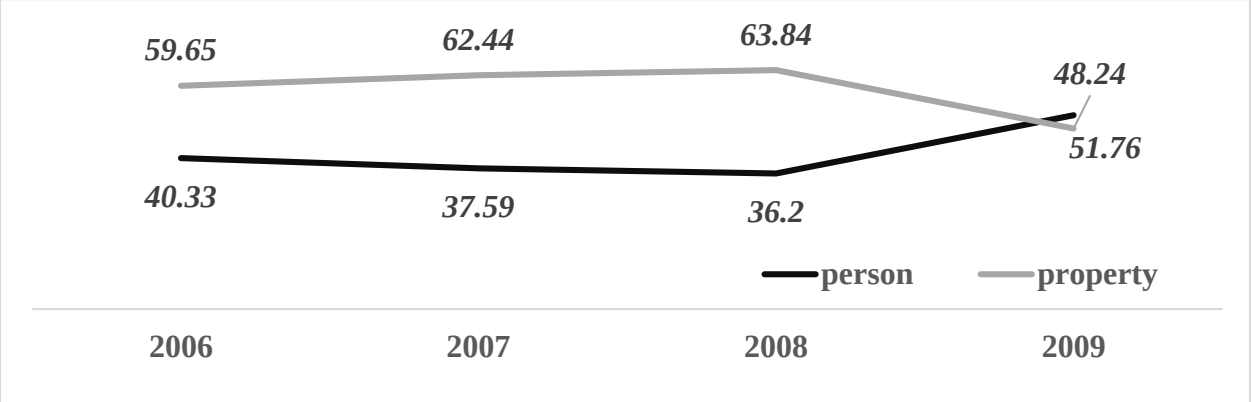


Figure 4.5 Crime Rate (Percentage) From 2006 -2009

As depicted in the above Fig 4.5, the rate of crime against person decrease from 40.33 to 37.59% in the year 2006 - 2007.Then from 37.59% to 36.2% from 2007 to 2008-year. Finally, it increased from 36.2% to 48.24% in the year 2008 - 2009%. In addition to this, personal crime rate decreased by 4.13% in the year 2006 - 2008 and increased by 12.04% in the year 2008 -2009 On the other hand, the rate of crime against property increased from 59.65 % to 62.44 % in the year 2006 - 2007. Besides, it increased from 62.44% to 63.84% in the year 2007 -2008.Finally, in the year 2008 and 2009, property crime rate decreased from 63.84 % to 51.76%.Generally, the rate of crime against property increased by 4.19 % in the year 2006 - 2008 and decreased by 12.08 % in the year 2008 – 2009.the relation between crime against person and crime against property shown in fig 4.5 above is negatively correlated because of if more precaution is needed in crime against person, the offender may turn to crime against property and vice versa.

4.2 Result From Different Hotspot Mapping Techniques

This study examined five commonly used crime hotspot-mapping techniques to generate hotspot maps and determine if difference between each techniques exist and compare which techniques identify more hotspot area. As shown in above figure from 3.3 -3.12, the generated hotspot map of each techniques from 2006 - 2009 is shown.

4.2.1 Result of Spatial Ellipse in the Year from 2006-2009

CrimeStat III program (Levine, 2010) was used for generating STAC (standard deviational spatial ellipses). Search radius of 500m and minimum point per cluster are taken as five for the study area. Circle is repeatedly laid over grid and the number of point within the circle is counted in hierarchical techniques. The results are visualized as standard deviational ellipse computed for the point identified as "Hotspot".

The result of hotspot map using STAC in the year 2006 show that six standard deviation ellipse were created as shown in fig 3.3(a) above. These standard deviation ellipses indicate the positions and the directions toward which crimes have a tendency to be patterned. In the year 2006, more number of crime were concentrated around southeastern part of the sub city. The crime incident patterned more in Woreda 7, 8 and 1 (38 -163) as shown in red color. However, less crime incident happened in Woreda 4, 10 and some part of Woreda 9 (5-9), which is shown by green, light green and light yellow respectively in fig 3.3(a) above. In the same manner to data used in 2006, using data in 2007 also generated six ellipse that show hotspot area. As indicated in fig 3.3(b) above, More number of crime(39 - 103) incident were concentrated around Eastern and Southeastern part of sub city which include Woreda 7 and some part of Woreda 1 shown by red color. Whereas lowest number of crime (6 - 10) incident sparsely occurred around Western, and Southwestern part of sub city as shown in green and yellow color respectively. In both year (2006 and 2007), center of sub city accounts average number of crime incident occurred (17 -37 and 11 -38) respectively.

In the year 2008, the generated hotspot area using CrimeStat software are of two. These areas are densest place in which crime incident evenly occurred. As depicted in fig 3.4(c) above, two ellipse were generated. Highest number of crime (29 -204) were concentrated in Woreda 7,and some part of Woreda 8,1 and 6 as shown by red color. However, around Western part of sub city, lowest number of crime (24) incident occurred shown by green color**.** However, three standard deviational ellipse were created in 2009 crime incident data. The resulting hotspot map shown in fig3.4 (d) above indicate that More number of crime (8 -216) incident were concentrated around central, eastern and southeastern part of sub city. These areas include Woreda 7 in total, and some part of 1,2,6,8 and Woreda 9 as shown by red color. Whereas crime incidents were sparse around Western part of sub city, which include Woreda 10and, 4 as shown in green and yellow color respectively.

In general, the combined data from 2006 - 2009 were processed in CrimeStat program, and the result were analyzed in ArcGIS. As a result, two standard deviation ellipse were generated that show the number of hotspot in study area and it is shown in fig 4.6 below.

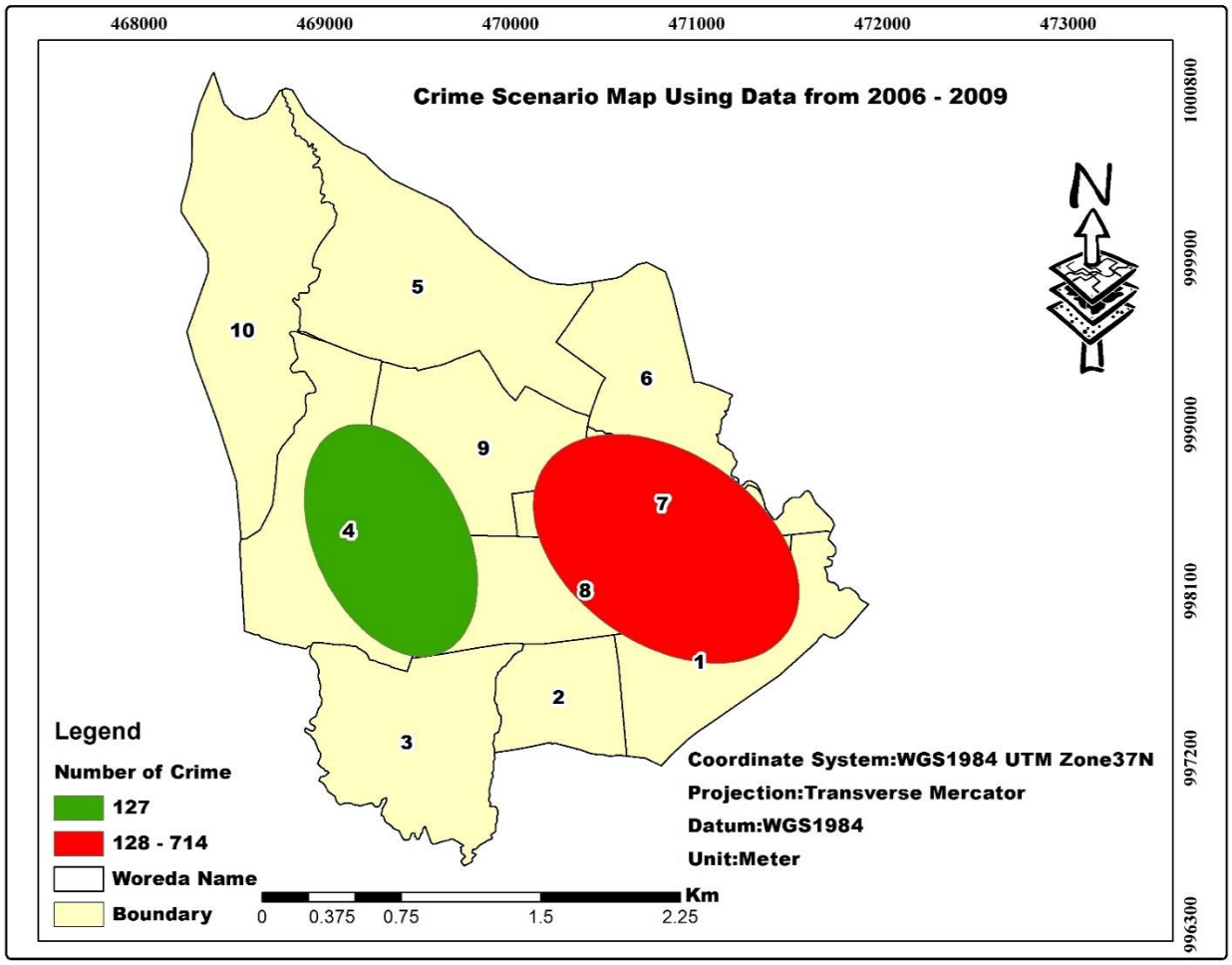


Figure 4.6 Spatial Ellipse Map (2006 – 2009)

From the fig4.6 above, hotspot area of crime incident are near center, eastern part and at the downtown of sub city. In these areas, highest number of crime (128 - 724) incident shown by red color occurred repeatedly. On the other hand, Western and Southwestern part of sub city are less prone to crime incident (127) shown by red color.

4.2.2 Results from Area (Choropleth) Mapping from 2006 - 2009

This technique requires crime point data to be aggregated to polygonal census output areas to generate a count of crime for each output area (output areas are the smallest unit of census geography in Addis Ketema Sub city Woredas). In ArcGIS environment, crime incident location (X and Y) coordinate of point were filled and these point were directly linked with each Woreda boundary. Then the number of crime incident falling these boundaries were counted and filled in attribute of ArcGIS. As a result, Hot spots produced by this study were consistently located in the same areas throughout the entire study area as indicated in fig 3.5 and 3.6 above. Highest number of crime (30 -100) incident concentrated around near Center and Southeastern part of sub city as indicated by red color in fig3.5 (a) above. However, the North east and southwest part of sub city were the lowest number of crime (2 - 4) incident committed area. In addition to this, central and some part of Northeastern, part of sub city also shared less number of crime incident in 2006-year data. Moreover, in the 2007, most of crime incident were repeated in Woreda 7 and 8 as shown in fig 3.5(b) above. From this result, central (17 -90), Southeastern (14 -16) and Northeastern (10 -13) part of sub city were also repeatedly crime offense area. Nevertheless, in Northern and Southwestern part of sub city, crime were incident sparse. The result of data in the year 2008 and 2009 indicated in fig 3.6 (c) and (d) above shows hotspot area around down town of sub city. Whereas crime incidents were less around Northern and Northwestern part of sub city. In both year, Woreda 7 and 8 were hotspot area (36 -104) and (42 -78) fig3.6 (c and d) respectively as shown by red color. In short, using the four-year (2006 -2009) data, the data also processed in ArcGIS .Total of 1124 crime incident data were used. In the same manner to above, all crime incident falling in each Woreda boundary were filled in ArcGIS environment. The results shows that, 121 - 372-crime incidents were repeatedly committed in Woreda 7 and 8(shown by red color) 33.09 % of incidents repeatedly occurred in these area in fig 4.7 below. On the other hand, in Woreda 4, 5, 6 and Woreda 9, between 46 -73 crime incidents (6.49 %) (Shown by yellow color) were committed. However, Woreda 2, 3 and Woreda 10, less number of crime incident has been committed (2.04 %).

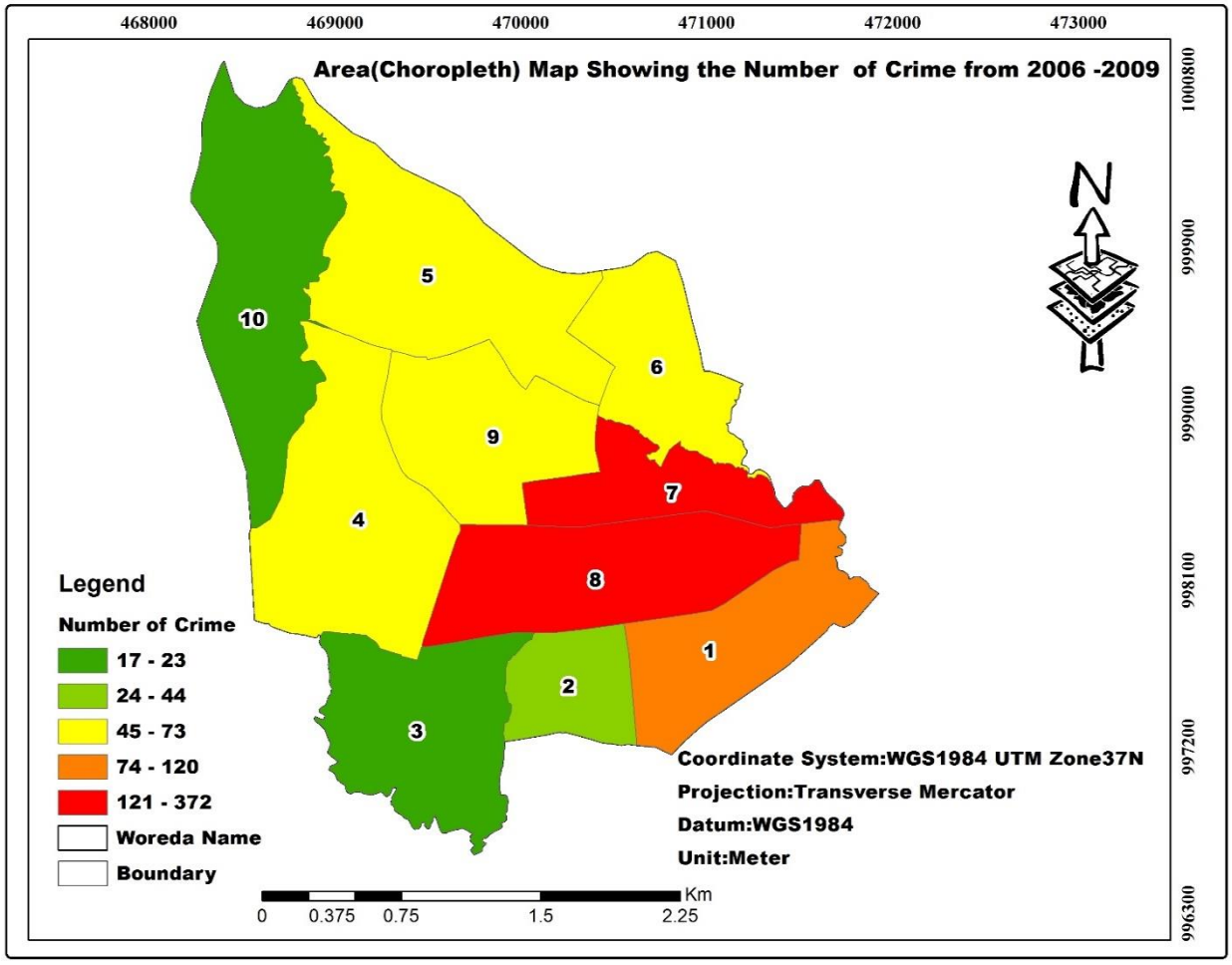


Figure 4.7 Choropleth Map (2006 – 2009)

From the fig 4.7 above, hotspot area of crime incidents located south central and southeastern part of sub city. However, southwestern and northwestern part of sub city were spares crime incident distributed.

In general, Choropleth map show hotspot in boundary wise. In this case, detailed crime pattern cannot be considered. Choropleth maps often distort the cartographic appearance of the actual crime patterns because the crimes are aggregated to polygons with arbitrary boundaries. This may result in producing misleading hotspot maps because it ". . . shades the whole of a region and can often be too coarse to represent the detailed spatial patterns of actual crime events" (Spencer Chainey and Ratcliffe, 2005).

4.2.3 Results of Grid Mapping from 2006 – 2009

ArcGIS software enables analysts to specify grid lattice that can be positioned across the study area. The parameter the user must decide is the size of each square grid cell. There is little guidance on which cell size to select, if the cells are too large, the resulting hotspot map will only show coarse geographic patterns of crime, and if too small, it can be difficult to discern any spatial patterns from the hotspot map (Chainey and Ratcliffe, 2005). Accordingly, for the processing of hotspot map of this study, 300m cell size was used which produce most reasonable result as compared to the trial error method. As indicated in fig 3.7 and 3.8 above, using the historical crime incident data, most of the hotspot area convers toward the southeastern part of sub city. However, in 2006-year crime incident data, hotspot area appeared more (28 - 38) in Woreda 8 as shown by red color as shown in fig 3.7(a) above. Besides, Woreda 7 and some part of Woreda 9 were prone to the crime incident. However, most of the northern part and southwestern part of the study area were less prone. Fig3.7 (b) also revealed the result of 2007-year crime data. In this year 242-crime incident were recorded. From these number, more number of incident (20 -36) were repeatedly happened in Woreda 7 and some part of Woreda 8. However, the western and northern part of the sub city were less prone crime incident by the result of this Grid mapping. In similar fashion, most of Woreda 7 and 8 were highest hotspot area by the result of 2008-year crime data. In this year, police recorded 318 crime incidents. From these record, Woreda 8 and 7 were repeatedly crime incident prone area (hotspot area) (24 -41) as indicated by red color in fig 3.8(c) above. Northern and western part of sub city were less hotspot area. The result of crime incident data in the year 2009 indicate that, Woreda 8 and some part of Woreda 7 were the hotspot area as shown by red color(17-20) in fig 3.8(d) above. Besides, some part of Woreda 1 and Woreda 6 also hotspot area. The result of this grid map also reveals that, majorly the northern part of sub city were non-hotspot area as shown in fig 3.8(d) above.

The grid thematic mapping analysis of combined data sets produced more number of hot spot locations within southeastern part of sub city compared to One-Year data sets. Even if the size of cell used for processing of grid mapping was same, hotspot area identified by combined data. As shown in fig 4.8 below, Woreda 8, 7, 6 and Woreda 1(47 -135) were hotspot location of crime incident. However, Northern part of sub city resides in non-hotspot area.

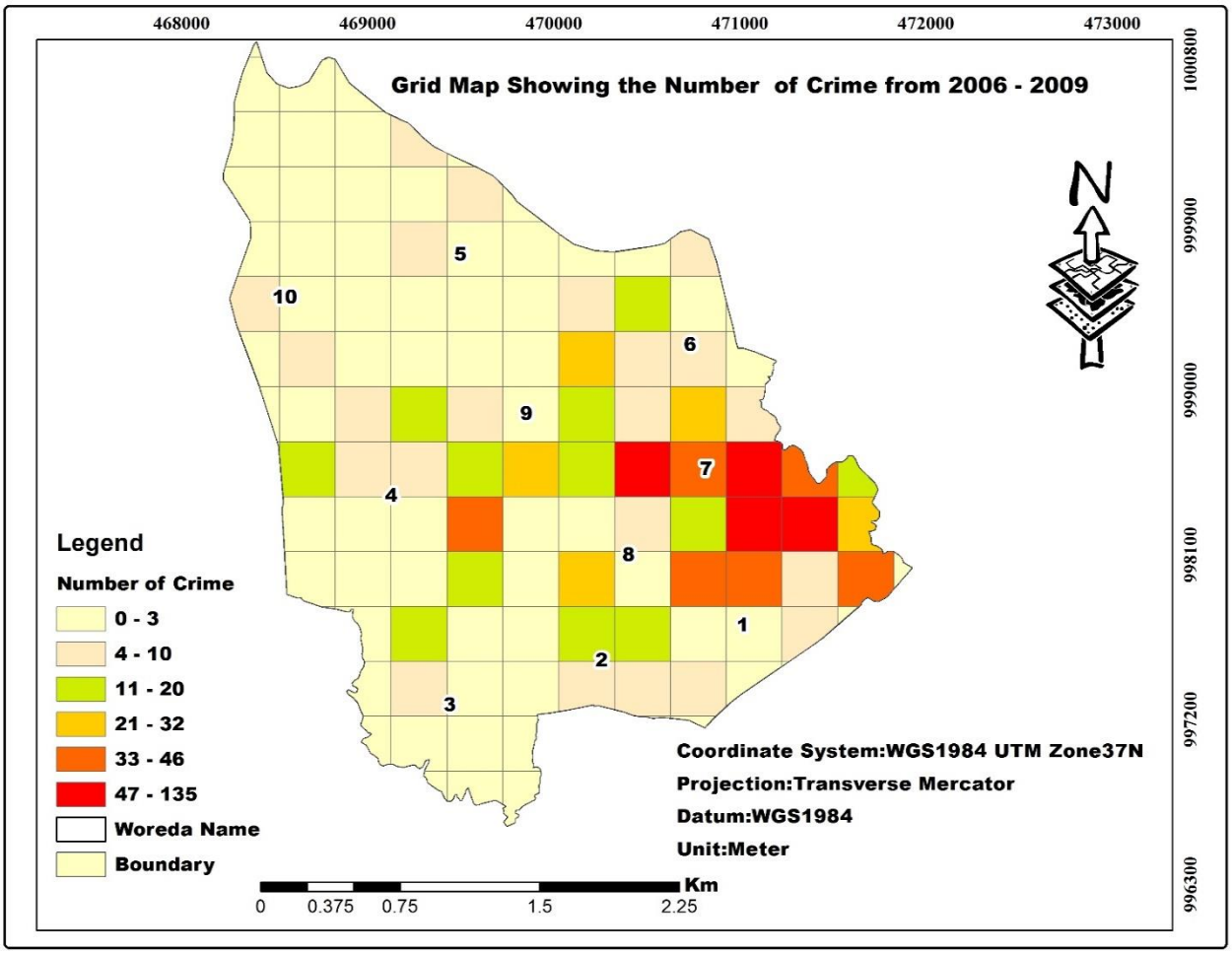


Figure 4.8 Grid Map (2006 – 2009)

Although the grid mapping (Quadrat) method is simple way of visualization, the results are too sharpened and much of the spatial details are thrown away as noticed in the above figure. When quadrats are too small they may contain zero crime incident point to couple of point. But if they are too large, they may contain too many crime incident point and the distribution become more clustered.so the results are completely based on size of the grids.

4.2.4 Results of Point Density Map from 2006 -2009

Based on the hotspot analysis of point density (graduate symbol) mapping of recorded crime incident data, hotspot area identified in some party the study area. In order to analyze the spatial distribution of crime incident by point density technique, the frequency of crime incident filled in ArcGIS environment were classified in to six from lowest to highest using natural break classification. As a result, highly concentrated crime incident location were shown by large size, which represent hotspot area. The result of crime incident data of 2006 year shows that Hotspot incident were around the central part of Woreda 7 as shown in the fig 3.9(a) above. Total of 280-crime incident were recorded in the year 2006 in Addis Ketema sub city. From these, 13-17 were in Woreda 7 shown by red color. Following these, Woreda 8 was the next prone area of crime incident (11-12) shown by purple color. During this year Woreda 2, 3, 4, 5, and 10 are non-hotspot area as point density result showed in fig 3.9(a) above. While in 2007, Eastern part of Woreda 8 was highly (9 - 24) prone area of crime incident as shown in fig 3.6(b) above by red color. In addition to this, Major part of Woreda 7 which is designated by purple color belongs to hotspot location. However, Northern part of sub city were non-hotspot area in fig 3.9(b). In the same manner, the result of crime incident data in the year 2008 shows that Eastern part of Woreda 8 was hotspot location as shown by red color (11 -19) in fig 3.10(c) above. However, in the year 2009 , Woreda 1, 6,7 and most part of Woreda 8 were the hotspot area as shown in fig 3.10(d) above by red color(8 -9). In addition to this, the southeastern part of Woreda 8 and Woreda 1 were also hotspot location.

A further hotspot analysis was executed based on combined (overall) crime incident data over four year data in Addis Ketema sub city to identify the hotspot location Fig 4.9 below. Total of 1124 crime incident data was analyzed using point density technique. As a result, southeastern part of sub city was hotspot location. Especially eastern border of Woreda 8 were more prone area.

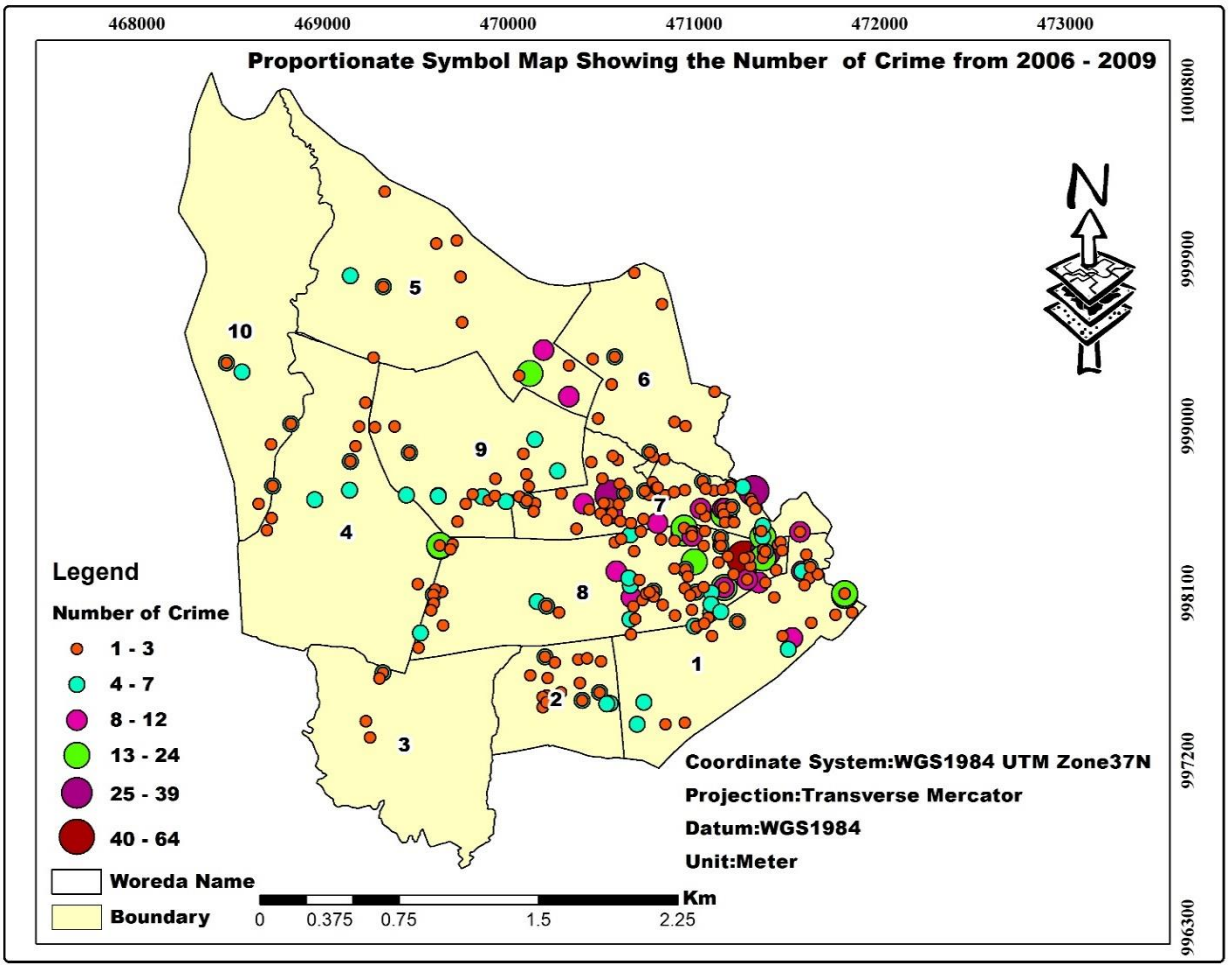


Figure 4.9 Proportionate Symbol Map (2006 – 2009)

As depicted in fig4.9 above, major part of Woreda 7 is also hotspot area as designated by purple color (25 -39).Moreover, Central, Northern and South western part of sub city were non hotspot location as point density map depicted.

4.2.5 Result of Kernel Density Estimation from 2006 -2009

KDE Map were created in ArcGIS of spatial analyst toolbox using recorded crime incident data. Even if there is no universal, doctrine on how to set the search radius and cell size to process the kernel density and in what circumstances; the cell size of 20m and search radius of 200m was used to process the KDE. However, the user's role is to specify search radius and cell size for estimation, which play a decisive role. When the bandwidth set is too large, important information may be lost. In case of a small bandwidth, local data information has a more significant impact on the result. Depending up on this parameter assigned, three-hotspot site were identified using entire one-year data (2006) as shown in the fig 3.11 (a) above. From this result, Total of 220-crime incident in 0.8004 square kilometer area were repeatedly occurred in these three site or location. The hotspot area generally include down town of sub city including major part of Woreda 7 and 8 as shown by cyan color and some part of Woreda 6 and Woreda 1 as shown by red color. However, the northern and western part of sub city were almost non-hotspot depending up this kernel density result.

On the other hand, the result of KDE in the year 2007 depicted hotspot area in southeastern part of Woreda 8 as indicated by cyan color in fig 3.11(b) above. In addition to this, the central part of Woreda 7 and 8 indicated by purple and red color were highly concentrated crime incident location. During this year, 223-crime incident recoded which cover total hotspot area of 1.5173 square kilometer area. However, the result of this KDE in the year 2007 indicate that majorly Northern, Central and Western part of sub city were non-hotspot area.

The KDE result of entire 2008 year data also indicate that eastern part of Woreda 7 and 8 were hotspot area as shown in the fig 3.12(c) above. The entire 2009-year crime shows that 221-crime incidents recorded in hotspot area of 1.0998 square kilometer area as shown in fig 3.12 (d) above. This result also suggest that, eastern part of Woreda 8 and central part of Woreda 7 were hotspot area as shown by cyan and purple color. In addition to this, the central and southeastern part of sub city also highly concentrated crime incident area.

In the same manner to other hotspot mapping techniques, using entire four year (combined) data KDE also processed in ArcGIS. The KDE analysis of these entire data set produced hotspot area majorly in Woreda 8 and some part of Woreda 7.However, from these data set, 819-crime incident were recorded in hotspot area of 1.242 square kilometer. The KDE analysis of the entire

data set also revealed some part of Woreda 1, Woreda 6 and 9 were hotspot area. As shown in fig 4.10 below, hotspot area are generally located in central and southeastern part of sub city. Whereas, the northern and some part of southwestern of sub city were less prone (almost non-hotspot area).

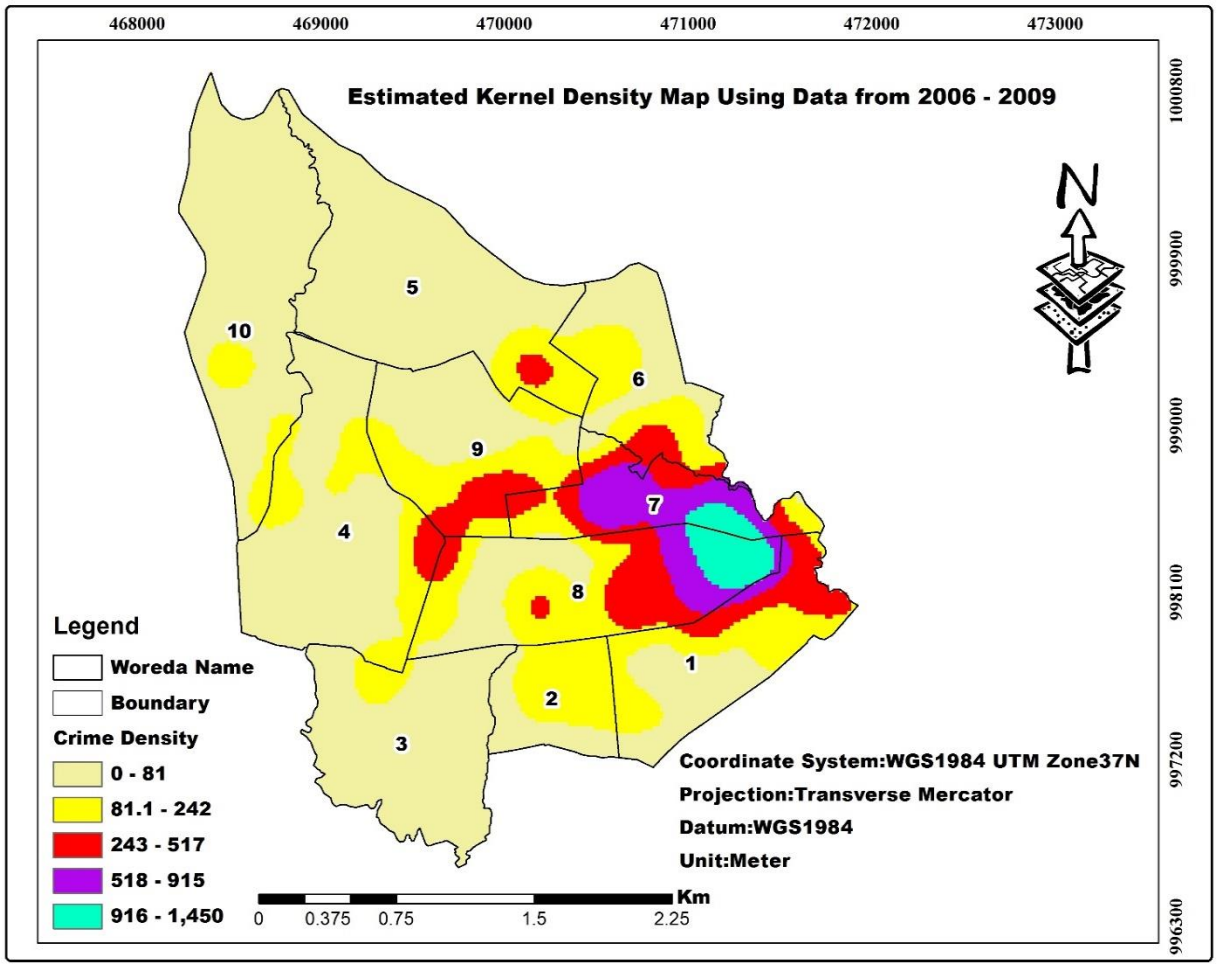


Figure 4.10 Estimated Kernel Density Map (2006 - 2009)

4.3 Result of Prediction Accuracy Index of Different Hotspot Mapping Techniques.

Hotspot mapping techniques differ in the output they generate (Jefferis, 1999; Eck *et al*., 2005). In this research, we have explored each of the common hotspot mapping techniques to determine whether differences exist in their ability to predict future patterns of crime. Since different techniques are based on different theories, concepts, and set of parameters, their Resulting outputs, namely, the hotspot maps, are thus somewhat different from each other. The Statistically significant hotspot area produced using one technique maybe lacking statistical Significance using another method.

The study area for all methods is the same, namely, Addis Ketema sub city. The hotspots produced by spatial and temporal analysis of crime mainly spatial ellipse produce the result in the form of ellipse. Grid thematic mapping results in the form of a regular grid. Whereas choropleth (area) mapping produce the hotspot area in form of census tract or some political boundary. However, point density produce the hotspot in the form dot or proportional symbol. Finally, KDE generalizes or "smooths" discrete data points so that a continuous surface area is produced and visualized (Bailey and Gatrell, 1995).

After having compiled all hotspot-mapping techniques, the prediction accuracy index was calculated for each techniques as shown in Table 3.11 above. As the result, 15 PAI value calculated for each techniques. From this, 5 average PAI value were generated as shown in the following fig 4.11 below. This figure shows the average PAI results for the five-hotspot mapping techniques. These results show that there are differences between hotspot mapping techniques in their ability to predict future patterns of crime. KDE proved to be the best hotspot mapping technique producing an average PAI (6.074) value well above the other mapping techniques, followed by Grid thematic Mapping (3.126). Then, STAC produced good result (2.569) next to grid thematic mapping. Area mapping appeared to be the worst (1.87). However, the result of point density (2.052) shows intermediate between area mapping and STAC.

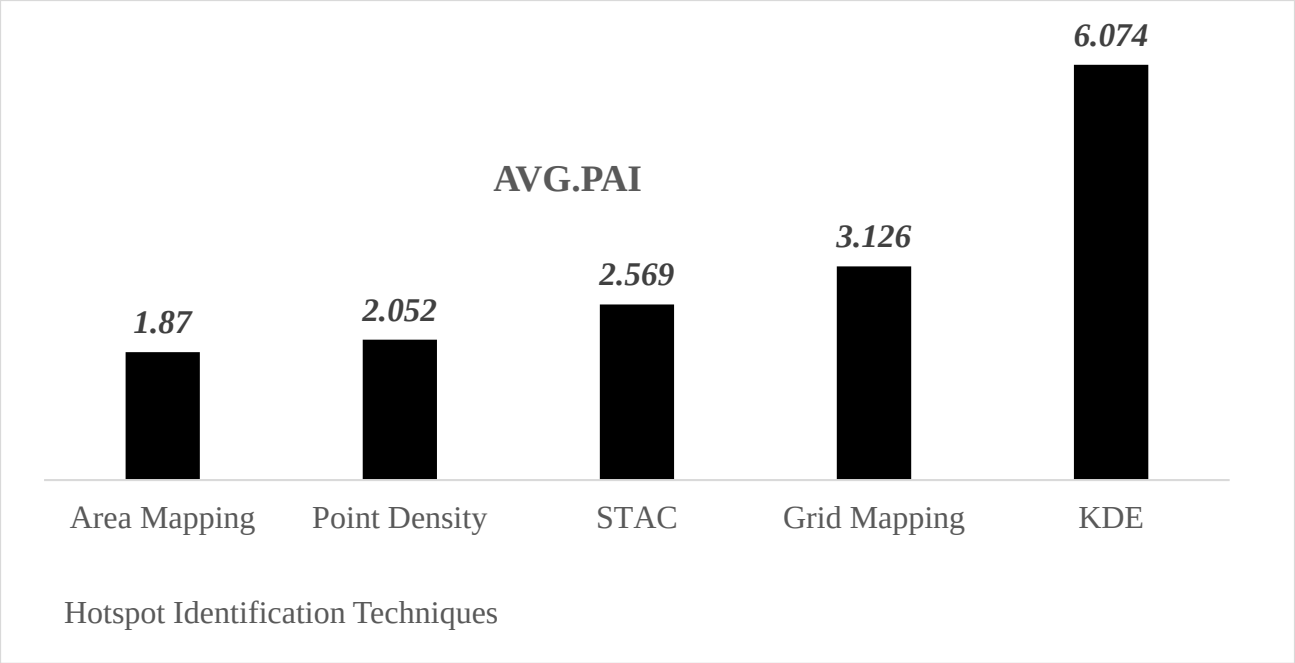


Figure 4.11 Average (PAI) Using Different Hotspot Techniques

The PAI value for each data set in this comparison is shown in Table 3.11 above. The highest PAI value was in the data set of 2006 entire year data. In range of this data, KDE resulted the highest PAI value (9.688) whereas lowest value reveals in spatial ellipse technique used in 2007 entire year data (1.256). The highest average PAI value of the study resulted from the total number of 298-crime incident happened in hotspot area. In another word, PAI Value of 6.074 resulted from total number of hotspot crime of 298 and hotspot area coverage of 1.945 square kilometer. In this PAI analysis, the average PAI for one-year 2009 data set was not calculated, as there were no future crime data to apply to this data set.

4.4 Result of Land use and Crime Rate

The study area land use map was prepared from the structural plan of Addis Ketema sub city by digitation process as mentioned in analysis part above. Hence, the rate of crime against person and property calculated for each land use type. As a result, commercial area covered 20.93 % of property crime and 11.11 % of personal crime as shown in fig 4.12 below. In addition to this, mixed land use were the next highest percentage of both personal and property crime rate repeatedly happened (13.89 and13.15) percentage respectively.

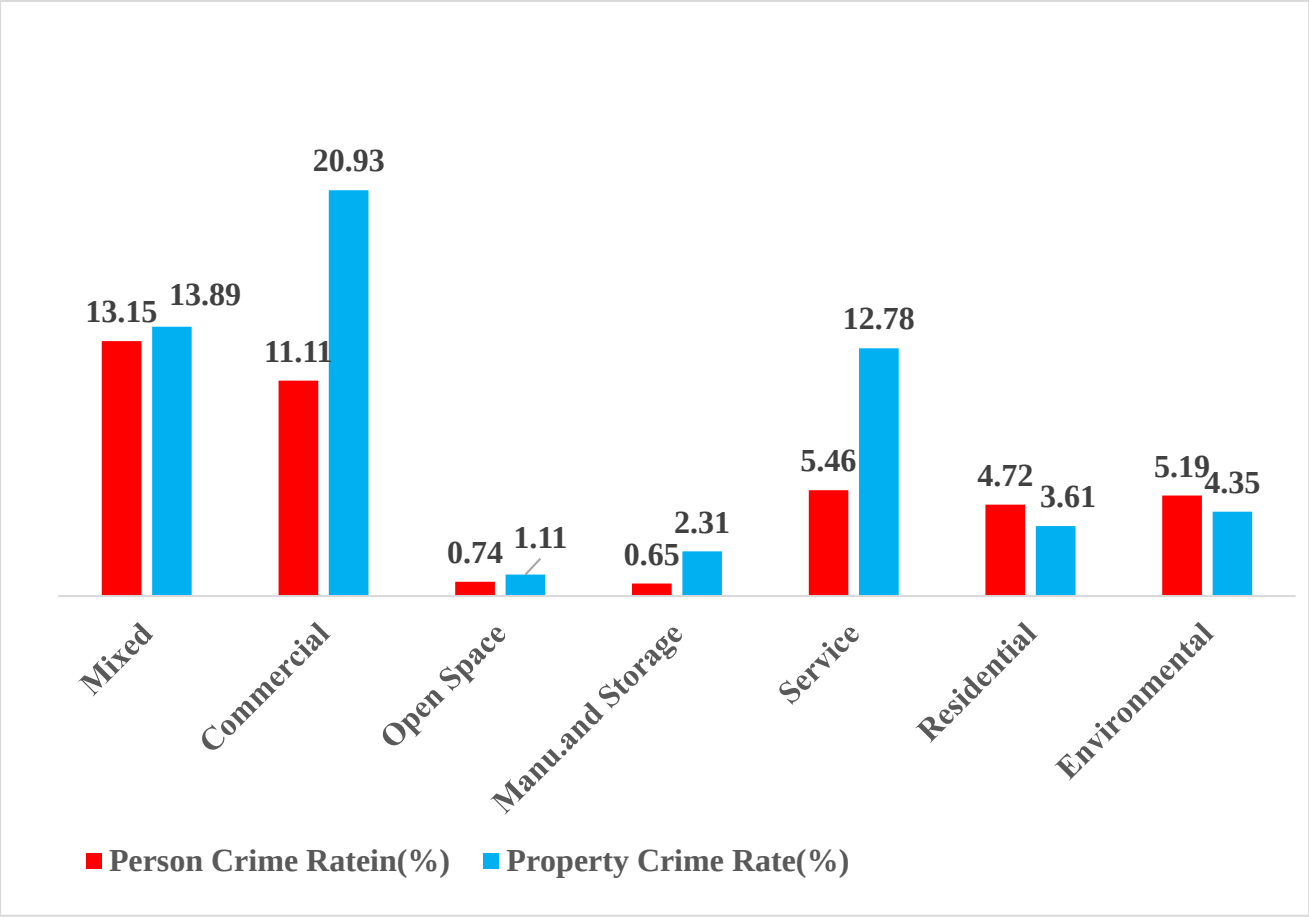


Figure 4.12 Crime Rate on Different Land Use

However, the rate of crime against person and property were lowest in open space (0.74 %), manufacturing, and storage (0.65 %) respectively. Besides, both crime against person and property were lowest in open space (0.74 and 1.11) percentage respectively.

Relationship between Land use, Population and Crime Hotspot Result

The kernel density estimation is the best hotspot mapping techniques (Chainey, 2008) so that the result of this study revealed also KDE as good techniques for its predicting ability. As a result, hotspot map KDE generated using combined data is used for the comparison of land use with hotspot and population density result. As shown in fig 3.13, fig 3.15 (A and B) and crime density result of Table 3.12 above, Population density, Crime category (person and property) and Land use are related. Crime against property and person was highest (478.226 and 362.066) respectively in population density range of 43475.23 -56700.94 which covers 1.848 square kilometer from the total study area. Whereas the crime density is lowest (6.714 and 12.589) person and property respectively in the population density range of 17921.80 -19072.23 that covers 2.440 square kilometer from the total study area. In addition to this, map showing the relationship between land use and hotspot area of crime incident is shown in fig 4.13 below. As a result, hotspot area of crime incident is highest in central and southeastern part of sub city shown by cyan and purple color in fig 4.13 (b). In the same manner, land use map shown in left hand side of fig 4.13(a) revealed that commercial area are the highest prone area to crime incident. As discussed in the result section part of crime against person and property on land use above, the commercial area are more prone to both crime against person and property. Moreover, fig4.13 also demonstrate the distribution of crime incident is highest majorly in Woreda 8 and 7 and some part of Woreda 1, 6 and Woreda 9.Whereas Woreda 2,4,5 and Woreda 10 area non hotspot area.

In general, the result of population density map shown in fig3.13 above, land use map and hotspot map of KDE using combined data as shown fig 4.13 below revealed that, Woreda 8, 7 and some part of Woreda 1 are the highest crime incident area (hotspot). Nevertheless, in these areas, the population density result indicate that highest population was there. However, area where very high population density resides in Woreda 2.moreover, the hotspot area are covered majorly by commercial and mixed land use type.

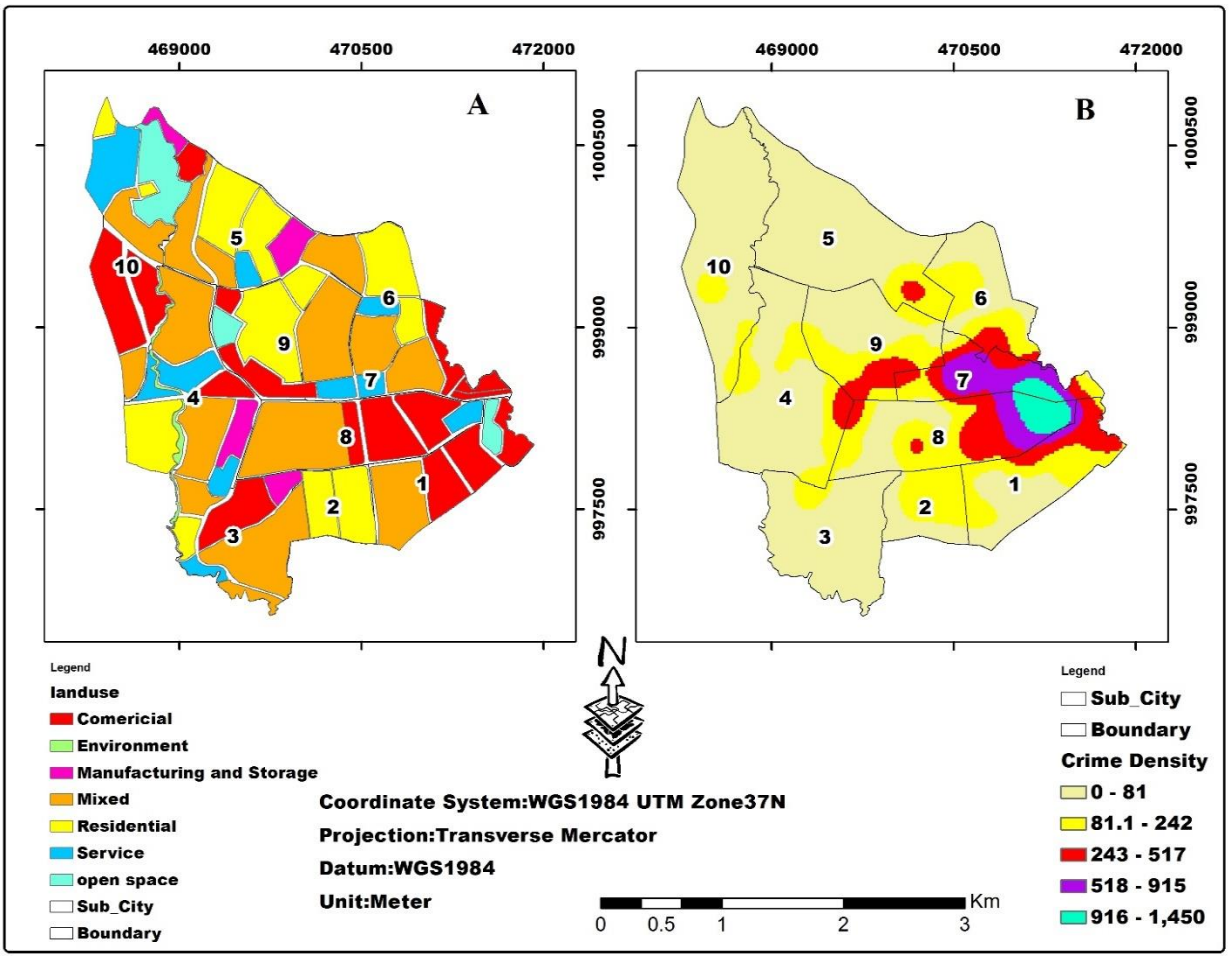


Figure 4.13 (A and B) Map of Land Use & Hotspot Area

CHAPTER FIVE

5 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

The result of this research shows that not all hotspot Mapping techniques produce the same hotspot area across the study area. The result also shows that there is measurable link between crime activities, population and land use. Thus, status of occurred incidents and population were related in terms of crime rate. In this case, the computed rate of crime was highest in the central and southeastern part of sub city, which include Woreda 7 and 8.while it was lowest in northern and western part of sub city. Further, the study has shown that there are places which experience high criminal activities even if there are other places in the City which offer similar land uses but experience lesser crime. In general, the rate of personal crime property varies from 2006 -2009. Further, several hotspot identification techniques are carried out within the study area by making use of GIS and CrimeStat. Hence, the hotspot area identified by using these techniques revealed that majorly the southeastern part and central part of sub city were hotspot area.

In addition, the prediction accuracy index of each hotspot identification techniques are carried out and it is found that Kernel Density Estimation techniques result predict more. Further, the relationship between land use, population density and crime incidents in the study area is determined and it is found that incidents generally prefer commercial, mixed and service area respectively. In addition to this, the highest population area were more prone to crime incidents.

In this thesis, it is observed that the abilities of GIS such as Managing data, organizing in different spatial units, providing quick and objective results and the spatial and other kind of information satisfy the better results for incident analysis. The finding of this study showed that GIS is compatible with statistical tool like crime stat, which is generated for incident analysis.

5.2 Recommendation

Urban Planners may plan cities not only by considering the direction of cities' growing but also the function of crime. When they determine the location and the usage of a facility, they take in to account its security and its effect on the safety of its near surrounding. The short-term and long-term measure can be taken by the planers that will reduce the likelihood of crime. For example, increase lighting, use of surveillance equipment, alarms and warning sign in potential target area of crime incident area identified such as Commercial and Mixed area.

Police officers should collect the incident information with their Geographic coordinates and should keep it in digital format.

The police force can quickly reach the place where the crime activities are reported if the patrol units equipped with GPS, so that their locations could be known.

More researches will be done further to obtain a better design of the spatial-temporal predictive accuracy measures. For example, the Area factor, Time constraint in terms of recording the happened crime whether it is in day or night, correct location of incident happened

Further researches could also be focused on the validation of these newly designed measures. To accomplish this, more spatial-temporal hotspot mapping methods and comparative study areas are needed.

In general, the Ethiopian government should make GIS related resources available to the Ethiopian Police Force (EPF) to incorporate geo-spatial technology into crime control and public safety operations and; acquire technical knowledge on how to apply geo-spatial technology for developing predictive crime models and resources deployment.

6 REFERENCES

Ackerman, W. V. (2004). Assessing Spatial Patterns of Crime in Lima, Ohio Cities. (pp. 423 - 437). ohio city,USA: Elsevier Ltd.

Adler, F. M. (2007). Criminology and the Criminal Justice System:6th.ed. Mc Graw-Hill Companies.inc.

Anselin, L. C. (2000). Spatial Analyses of Crime.In Duffee, D. (ed.) Criminal Justice 2000. In *Measurement and Analysis of Crime and Justice* (pp. 213–262). Washington ,DC: National Institute of Justice.

Argun, M. D. (2016). Crime Mapping and Geographical Information Systems inCrime Analysis. *international journal of human science*.

Atkinson, P. a. (2000). Geographical analysis of communicable disease data", in P. Elliot, J. Wakefield, N. Best and D. Briggs (Eds). *Spatial epidemiology: methods and applications.* Oxford: Oxford University Press.

Bala, A. B. (2015). Geospatial Information System for Crime Analysis and Crime Zone Identification-Case Study of Katsina, Nigeria. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*.

Block, R. .. (1993). *Illinois Criminal Justice Information Authority: Statistical.* Baltimore: STAC News.

Block, R. a. (1993). *STAC News Vol. 1, No. 1.* Chicago: Illinois Criminal Justice Information Authority - Statistical Analysis Center.

Block, R. a. (1995). "Space, Place and Crime: Hot Spot Areas and Hot Place of Liquor- Related Crime."In J.E. Eck and D. Weisburd (eds.),. *Crime and Places* (pp. 145–184). Monsey, NY: Criminal Justice Press.

Block, R. a. (2000). The Bronx and Chicago – Street Robbery and the Environs of Rapid Transit Stations. In Goldsmith, V., McGuire, P.G., Mollenkopf, J.H. and Ross, T.A. (Eds.). *Analysing Crime Patterns: Frontiers and Practice* (pp. 137-152). Thousand Oaks (CA): Sage.

Boba, R. (2009). Crime Analysis with Crime Mapping. In R. Boba. Thousand Oaks, CA: Sage Publications.

Bowers, K. .. (1999). Exploring Links Between Crime and Disadavantage in North-West England – An Analysis Using Geographical Information Systems. *International Journal of Geographic Information Science*, 159 -184.

Bowers, K. .. (2001). A GIS-linked Database for Monitoring Repeat Domestic Burglary .In Hirschfi eld, A. and Bowers, K. (eds) Mapping and Analysing Crime Data – Lessons from Research and Practice . London. *Taylor & Francis*.

Bowers, K. N. (2001). A GIS-linked Database for Monitoring Repeat Domestic Burglary", in A. Hirschfield and K. Bowers (Eds.) Mapping and Analysing Crime Data. *Lessons from Research and Practice.* London: Taylor and Francis.

Braga, A. (2007). Effects of Hot Spots Policing on Crime . *A Campbell Collaboration Systematic Review .http://www.aic.gov.au/campbellcj/reviews/titles.html*.

Brantingham, P. .. (1984). Patterns In Crime. New York: Macmilan.

Brantingham, P. a. (1999). A Theoretical Model of Crime Hotspot Generation. *Studies on Crime and Crime Prevention*, 7 - 26.

Brantingham, P. J. (1981). Environmental Criminology, London. *Sage publication.*

Brantingham, P. J. (1991). Environmental Criminology. Beverly Hills, CA: Sage Publication.

Brimicombe, A. (2005). Cluster Detection in Point Event Data having Tendency Towards Spatially Repetitive Events." In Geocomputation. *8th International Conference on GeoComputation* (pp. 1 -11). michigan : michigan university.

Bruce, C. (2004). Fundamental of Crime Analysis in exploring crime analysis. *The international Association of Crime Analysis*, 11 - 36.

Chainey, S. .. (2002). When is a Hotspot a Hotspot? A Procedure for Creating Statistically Robust Hotspot Maps of Crime . In Higgs, G. (ed.). *Innovations in GIS 9 Socio-economic Applications of Geographic Information Science ,London:Taylor and Francis*.

Chainey, S. .. (2005). GIS and Crime Mapping. *London: Wiley*.

Chainey, S. (2012). Improving the explanatory content of analysis products using hypothesis testing, Policing. *A Journal of Policy and Practice*, 108 - 121.

Chainey, S. (2013). Examining the infl uence of cell size and bandwidth size on kernel density estimation crime hotspot maps for predicting spatial patterns of crime. *BSGLg*, 7- 19.

Chainey, S. a. (2005). GIS and Crime Mapping. London: Willey.

Chainey, S. a. (2013). A problem-oriented approach to the production of Strategic Intelligence Assessments, Policing. *An International Journal of Strategies and Management*, 474 - 490.

Chainey, S. P. (2005). *GIS and Crime Mapping.* London: Wiley.

Chainey, S. T. (2008a). The Utility of Hotspot Mapping for Predicting the Pattern of Crime. *Seciurity Journal* , V 21 No.1,4 - 28.

Chainey, S. T. (2008b). Response to Pezzuchi. *Secuirity Journal*, V 21,4.

Chainey, S. T. (2008c). Response to to Levine. . *security Journal*, V 21,4.

Cohen, L. .. (1979). Social Change and Crime Rate Trends: A Routine Activity Approach. *American Sociological Review*, Vol. 4 : 588 – 065.

Cornish, D. .. (1986). The Reasoning Criminal. *Rational Choice Perspectives on Offending.* new york: Springer-Verlag.

Costello, A. a. (2001). GIS and the journey to crime in A. Hirschfield and K. Bowers (Eds.) . *Mapping and Analysing Crime Data* (pp. 27 - 60). London: Taylor and Francis.

Cotton, J. (1986). Ambient Temperature and Violent Crime. *Journal of Applied Social Psychology*, 18 -30.

Dent, B. (1999). *Cartography – Thematic Map Design.* London: McGraw-Hill.

Donna R. Tabangin, J. C. (2008). Investigating Crime Hotspot Places and their Implication to Urban Environmental Design : A Geographic Visualization and Data Mining Approach. *International Journal of Civil and Architectural Engineering*.

Donna R. Tabangin, J. C. (2008). Investigating Crime Hotspot Places and their Implication to Urban Environmental Design: A Geographic Visualization and Data Mining Approach. *World Academy of Science, Engineering and TechnologyInternational Journal of Civil and Architectural Engineering*, 404 -4012.

Eck, J. (1998). What Do Those Dots Mean? Mapping Theories With Data." In D. Weisburd and T. McEwen (eds.),. *Crime Mapping and Crime Prevention* (pp. 379–406). Monsey, NY: Criminal Justice Press.

Eck, J. a. (1995). Crime Places in Crime Theory." In J. E. Eck and D. Weisburd (eds.),. *Crime and Place* (pp. 1–33). Monsey, NY:: Criminal Justice Press.

Felson, M. (1987). Routine activities and crime prevention in the developing metropolis. *Criminology*, 911 -932.

Felson, M. (1998). Crime and everyday life. *Impact and implications for society.* Thousand Oaks, CA: Pine Forge Press.

Field, S. (1992). The effect of temperature on crime. *British Journal of Criminology*, 32,340.

Fitsum Meseret Legesse, K. D. (2016). The Impelementation of Community Policing in Slum Neighborhood of Addis Ababa,Ethiopia. *International Journal of Current Research*, pp.35358-35366.

Gilmartin, P. a. (1989). Choropleth maps on high resolution CRTs: the effects of number of classes and hue on communication. *Cartographica*, 40 -52.

Goldsmith, V. M. (2000). Analysing Crime Patterns. *Frontiers of Practice.* New York: Altamira Press.

Gymfi, J. A. (2002). An Analysis of the Broad Crime Trends and Patterns in Ghana. *Journal of Criminal Justice*, 229-243.

Hagan, F. E. (2008). Introduction to Criminology: Theories,Methods, and Criminal Behavior. (p. 6th ed). Sage publications.inc.

Haining, R. (2009). Spatial methodologies to support local policing in the UK :glimpsing the future Twenty-First Century:. *Journal of the Academy of Social Sciences*, 161 -174.

Harries, K. (1999). *Mapping Crime: Principle and Practice.* Washinton DC: United States National Institute of Justice.

Harrsies, K. (2006). Extreme Spatial Variations in Crime Density in Baltimore County,MD. *Geoforum 37*, (pp. 404–416).

Heikkila, E. J. (1998). GIS is dead; long live GIS! American Planning Association. *Journal of the American Planning Association*, 350.

Hipp, J. R. (2003). Crimes of Opportunity or Crimes of Emotion-Testing Two Explanations of Seasonal Change in Crime. *British Journal of Criminology*, 82,1333.

Hough, M. a. (1998). Getting the Grease to the Squeak: Research Lessons for Crime Prevention. *Crime Prevention and Detection Paper 85.* London : Home Office.

Jefferis, E. (1999). *A Multi-Method Exploration of Crime Hot-spots: A Summary of Findings Crime Mapping Research Centre Intramural project.* Washington, DC: National Institute of Justice.

Jenks, G.-F. (1967). The Data Model Concept in Statistical Mapping. *International Yearbook of Cartography*, 186 -190.

Jian Feng, Y. D. (2015). A spatio-temporal analysis of urban crime in Beijing: Based on data for property crime. *Urban Studies Journal Limited*, 23 -45.

John E. Eck, S. J. (2005). *Mapping Crime :Understanding Hotspot.* Washington ,DC: U.S Department of Justice Office of Justice Programs National Institution of Justice.

Johnson SD, B. K. (2009). Predictive mapping of crime by ProMap: accuracy, units of analysisand the environmental backcloth. In:Weisburd D, Bernasco W, Bruinsma G (eds). *Putting crime in its place: units of analysis in spatial crime research* (pp. 65–192). New York: springer.

Johnson, C. (2000). Crime Mapping and Analysis Using GIS. *Conference on Geomatics in Electronic Governance.* Pune: Geomatics Group, C-DAC.

Johnson, C. (2000). Crime Mapping and Analysis Using GIS. *Conference on Geomatics in Electronic Governance.* pune: pune university campus.

Kennedy, D. (2009). Deterrence and Crime Prevention. *Reconsidering the prospect of Sanction.* New York,NY: Routledge.

Klinkenberg, B. (2008). GIS snd Crime. *Available also at http://www.geog.ubc.ca/courses/geob479/notes/crime/Crime_intro.pdf. [Accessed on August 4, 2010]*.

Krisp J.-M. and Špatenková, O. (2009). Kernel density estimations and their application in visualizing mission density for fire & rescue services. *Proceedings on Cartography and Geoinformatics for Early Warning and Emergency Management: Towards Better Solutions*.

Langworthy, R. .. (2000). The Utility of Standard Deviation Ellipses for Evaluating Hotspots Goldsmith, V., McGuire, P.G., Mollenkopf, J.H. and Ross, T.A. (eds). *Analysing Crime Patterns: Frontiers and Pracrice*. Thousand Oaks, CA: Sage.

LaVigne, E. R. (2002). Forcasting the Future of Predictive Crime Mapping. *Crime Prevention Studies*, 29-57.

LaVigne, N. a. (1998). Crime Mapping Case Studies: Successes in the Field Vol. 1. *Washington, DC: Police Executive Research Forum.*

LaVigne, N. a. (1999). Crime Mapping Case Studies: Successes in the Field, Vol. 2,. *Washington, DC: Police Executive Research Forum*.

LeBeau, J. .. (2001). Mapping Out Hazardous Space for Police Work . In Bowers, K. and Hirschfi eld, A (eds) Mapping and Analysing Crime Data – Lessons from Research and Practice . London. *Taylor & Francis*.

Leitner, N. S.-D. (2017). Land Use Influencing the Spatial Distribution of Urban Crime: A Case Study of Szczecin, Poland. *International Journal of Geo -Information*.

Levine, N. (2008). The Hottest Part of a Hotspot: comments on The Utility of Hotspot Mapping for Predicting Spatial Patterns of Crime. *Secuirity Journal*, 295-302.

Levine, N. (2010). *CrimeStat III: A Spatial Statistics Program for the Analysis of Crime Incident Locations*. Washington, DC: Houston, TX: Ned Levine and Associates.

Liu, L. (2012). The GIS-based Reseach on Criminal Cases Hotspot Identifying. *International Conference on Environmental Science and Engineering*, (pp. 57 - 63).

M.Vijaya Kumar, C. (2011). GIS Technologies in Crime Analysis and Crime Mapping. *International Journal of Soft Computing and Engineering (IJSCE).*

M.Vijaya Kumar, C. (2011). *GIS Technology in Crime Mapping and Analysis: volume -1 issue - 5.*

Martin, D. .. (1998). The Multiple Impacts of Mapping it Out; Police, Geographic Information System (GIS) and Community Mobilization During Devil's Night in Detroit, Michigan. *Crime Mapping Case Studies: Successes in the Field*.

Mashford, T. (2008). Methods for implementing crime mapping within a large law enforcement agency: experiences from Victoria, Australia", in S.P. Chainey and L .Tompson (Eds.). *Crime Mapping Case Studies: Practice and Research, Chichester: Wiley*.

McDonald, P. (2002). Managing Police Operations. *Implementing the New York Crime Model – CompStat.* Belmont, CA: Waldsworth.

McLafferty, W. (2000). Identifying Crime Hotspot UsingKernel Smoothing. *Analyzing crime Pattern:frontier of Practice* (pp. 77 - 85). Thousands Oaks,CA: Sage.

Monmonier, M. (1996). How to Lie with Maps. In M. Monmonier. Chicago: University of Chicago Press.

Murray, A. M. (2001). Exploratory Spatial Data Analysis Techniques for Examining Urban Crime Implications for Evaluating Treatment. *British Journal of Criminology*, 309–329.

N, L. (2008). The hottest part of a hotspot: comments on 'the utility of hotspot mapping forpredicting spatial patters of crime. *secuirity journal*, 295 -302.

N.L, L. (2002). *CrimeStat: A Spatial Statistics Program for the Analysis of Crime Incident Locations.* Washington, DC: Ned Levine & Associates, Houston, TX, and the National Institute of Justice.

Office, H. (2001). Crime Reduction Toolkits Focus Area and Hotspots. London: Home Office Crime Reduction Unit.

Office, H. (2005). Crime Mapping: Improving Performance . *A Good Practice Guide for Front Line Officers.* London: Home Office.

Osborne, D. a. (2003). Introduction to Crime Analysis. *Basic Resources for Criminal Justice Practice.* New York: Haworth Press.

Otokiti, M. A. (2017). Spatial Distribution of Crime in Akure, Nigeria: The GIS Perspectives. *SCIREA Journal of Geosciences*.

P, B. A. (2002). *Environmental criminology in M. Maguire, R.Morgan, R. Reiner (eds), The Oxford Handbook of Criminology 3rd edition.* Oxford: Oxford University Press.

Pezzuchi, G. (2008). A brief commentary on The Utility of Hotspot Mapping for Predicting Spatial Patterns of Crime. *Security Journal*, v 21,4.

Pukhtoon Yar1, J. N. (7,2016). GIS Based Spatial and Temporal Analysis of Crimes, a Case Study of Mardan City,Pakistan. *International Journal of Geosciences*, 325 -334.

Rachel Boba, P. (2001). *INTRODUCTORY GUIDETO CRIME ANALYSIS AND MAPPING.* U.S: COPS,U.S department of justice.

Ratcliffe, J. .. (2001). Crime, Repeat Victimisation and GIS . In Bowers, K. and Hirschfi eld, A (eds) Mapping and Analysing Crime Data – Lessons from Research and PracticeLondon. *Taylor & Francis*, 61 -92.

Ratcliffe, J. (2008). Intelligence-led Policing. Cullompton: Willian Publishing.

Ratcliffe, J. a. (1999). Hotbeds of Crime and the Search for Spatial Accuracy. *Journal of Geographical Systems*, 385-398.

Ratcliffe, J. H. (2004). Crime mapping and the training needs of law enforcement. *European Journal on Criminal Policy and Research*, 65 -83.

Ratcliffe, J. H. (2004). Geocoding crime and a first estimate of a minimum acceptable hit Rate. *International Journal of Geographical Information Science*, 61 -72.

Ratcliffe, J. H. (2010). The spatial dependency of crime increase dispersion. *Security Journal*, 18 -36.

Ratcliffe, J. T. (2011). The Philadelphia Foot Patrol Experiment: A randomized controlled trial of police patrol effectiveness in violent crime hotspots. *Criminology*, 795 -831.

Rengert, G. F. (1996). The Geography of Illegal Drugs. Boulder, CO: Westview press.

Roncek, D. a. (1991). Bars, Blocks, and Crime Revisited: Linking the Theory of Routine Activities to the Empirical of Hotspots. *Criminology*, 725–753.

Schick, W. (2004). CompStat in the Los Angeles Police Department. *Police Chief*, (pp. 17 -23).

Shahebaz M. Ansari1, D. K. (2014). Mapping and Analysis of Crime in Aurangabad City using GIS. *IOSR Journal of Computer Engineering (IOSR-JCE)*, 67 -76.

Sherman, L. (2009). Hot spots. In Wakefi eld, A. and Fleming, J. *The SAGE Dictionary of Policing.* London: Sage Publication.

Sherman, L. G. (1989). Hot spots of predatory crime :Routine activities and the criminology of place. *Criminology*, 27 - 55.

Sherman, L. P. (1989). Hot Spots of Predatory Crime: Routine Activities and the Criminology of Place. *Criminology*, 27(1), 27–55.

Siegel, L. J. (2012). Criminology. (p. 11th ed). Belmont, CA Wadsworth : Cengage Learning.

Smith, C. W. (2011). *Spatial Statistics in Crime Analysis:Using CrimeStat III®*. international association of crime analysis.

Spencer Chainey a, L. S. (2008). The Utility of Hots Mapping for Predicting Spatial Pattern Crime. *Secuirity Journal*, V 21,4 - 28.

Tabagin, D. F. (2008). Investigating Crime Hotspot Places and their Implication to Urban Environmental Design:A geographic Visualization and Data Mining Approach. *World Academy of Sciences, Engineering and Technology*, 48, 16-24.

Tahani Almanie, R. M. (2015). Crime Prediction based on Crime Types and Using Spatial and Temporal Criminal Hotspots. *International Journal of Data Mining & Knowledge Management Process (IJDKP)*.

Taylor, R. S. (1984). Block Crime and Fear: Defensible Space, Local Social Ties, and Territorial Functioning. *Journal of Research in Crime and Delinquency*, 21, 303–31.

Timothy, H. (2014). Kernel Density Esstimation and Hotspot Mapping Examining the influence of Interpolation Method ,Grid cell Size and Bandwidth on Crime Forcasting. *International Journal of Police Stratagies and Management*, V 37 ,305 - 323.

Tompson, L. a. (2010). Looking Back to the Future: using space-time patterns to better predict the location of street crime. *International Journal of Police Science & Management*, 23 - 40.

Townsley, M. (2008). Visualizing Space Time Patterns in Crime: The Hotspot Plot. *Crime Patterns and Analysis*, 61 - 74.

Vijaya-Kumar, M. K. (2013). The Day-to-Day Crime Forecasting Analysis of Using Spatial-Temporal Clustering Simulation. *International Journal of Scientific & Engineering Research*, 1 - 6.

Walsh, W. (2001). Compstat: An Analysis of an Emerging Police Paradigm, Policing. *An International Journal of Police Strategies and Management*, 347 - 363.

Weisburd, D. a. (1994). Defining the Street Level Drug Market In D.L. MacKenzie and C Uchida (eds.),Drugs and Crime. *Evaluating Public Policy Initiatives.* Thousand Oaks, CA: Sage Publication.

Weisburd, D. a. (2004). What Can Police Do to Reduce Crime, Disorder and Fear ? *The Annals of the American Academy of Political and Social Science*, 42 - 65.

Weisburd, D. a. (2006). Hot spots policing as a model for police innovation in D.L. Weisburd and A.A. Braga (Eds.) Police Innovation:. *Contrasting Perspectives.* New York: Cambridge University Press.

Williamson, D. .. (2001). Tools in the Spatial Analysis of Crime . In Hirschfi eld, A. and Bowers, K. (eds) Mapping and Analysing Crime Data: Lessons from Research and Practice. *Taylor & Francis*, 187 -202.

Xie, Z. a. (2008). Kernel Density Estimation of Traffic Accidents in a Network Space. *Computers, Environment, and Urban Systems*, 396 - 406.

Internet sources

Wikipedia

https://datasf.org/opendata/

http://pro.arcgis.com/en/pro-app/tool

http://digitalcommons.wku.edu/geog_fac_pub/3

scholar.waset.org/1307-6892/3617

Klinkenberg.,(2008).GISandCrime.http://www.geog.ubc.ca/courses/geob479/notes/crime/Crime_intro.pdf. [Accessed on August 4, 2010].

7 APPENDICES

Appendix A Original Data Samples

Types of Crime	Location
Attempt(kill)	32 kebele mezinagna
Attempt(kill)	adisu michael
auto theft	teklehaymanot
check fraud	idget building
Attempt(kill)	anuar mosque
check froaud	dir tera
beating	Shawul dema school
beating	abinet akebabi
check fraud	amede gebeya
pick pocket	ayele hotel
check fraud	tasa tera
Attempt(kill)	sinemaras
check fraud	gojam berenda
check fraud	amede gebeya
auto theft	afric clinic
check fraud	tasa tera
Attempt(kill)	abadir school
Attempt(kill)	ehil berenda
check fraud	ayele hotel
snach	autobus tera
check fraud	mesalemia akebabi
pick pocket	autobus tera
pick pocket	Chaka meda
barecheck	tasa tera
pick pocket	adds ketema school
check fraud	mehal adarash
pick pocket	selam baltina
beating	American gibi
Attempt(kill)	alga tera
check fraud	nesiru megazin
check fraud	tasa tera
Attempt(kill)	atana tera
Attempt(kill)	keetema tera
Attempt(kill)	mesalemia hibrent bank
beating	gesho gibi
pick pocket	shawul dama

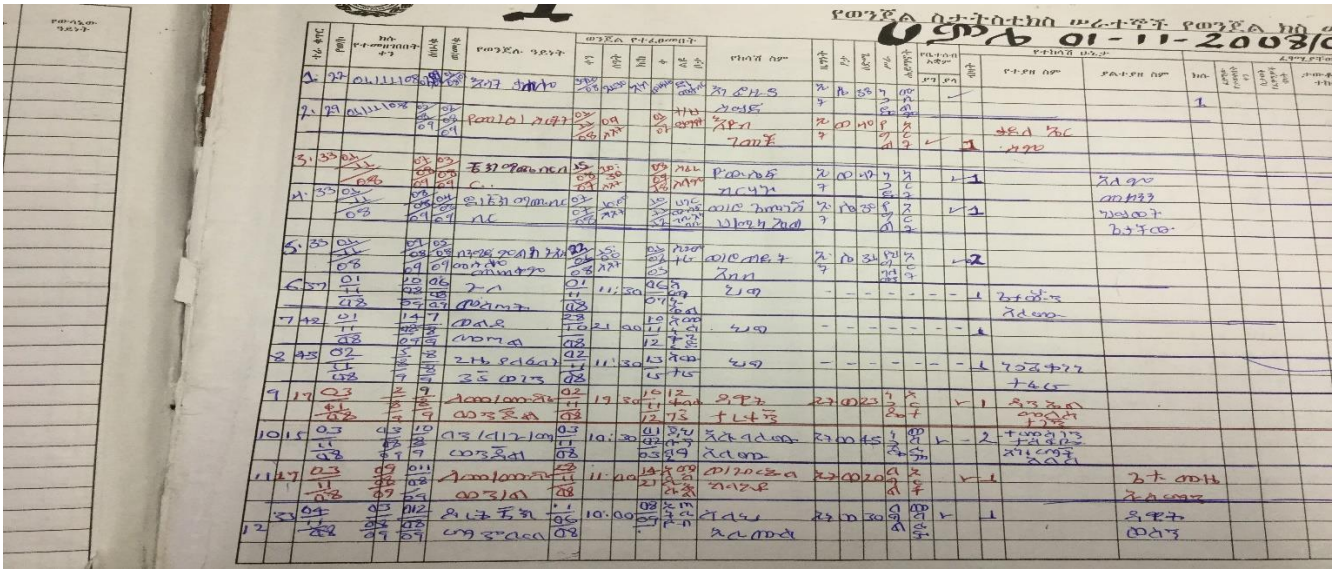
Appendix B Collected Sample Data

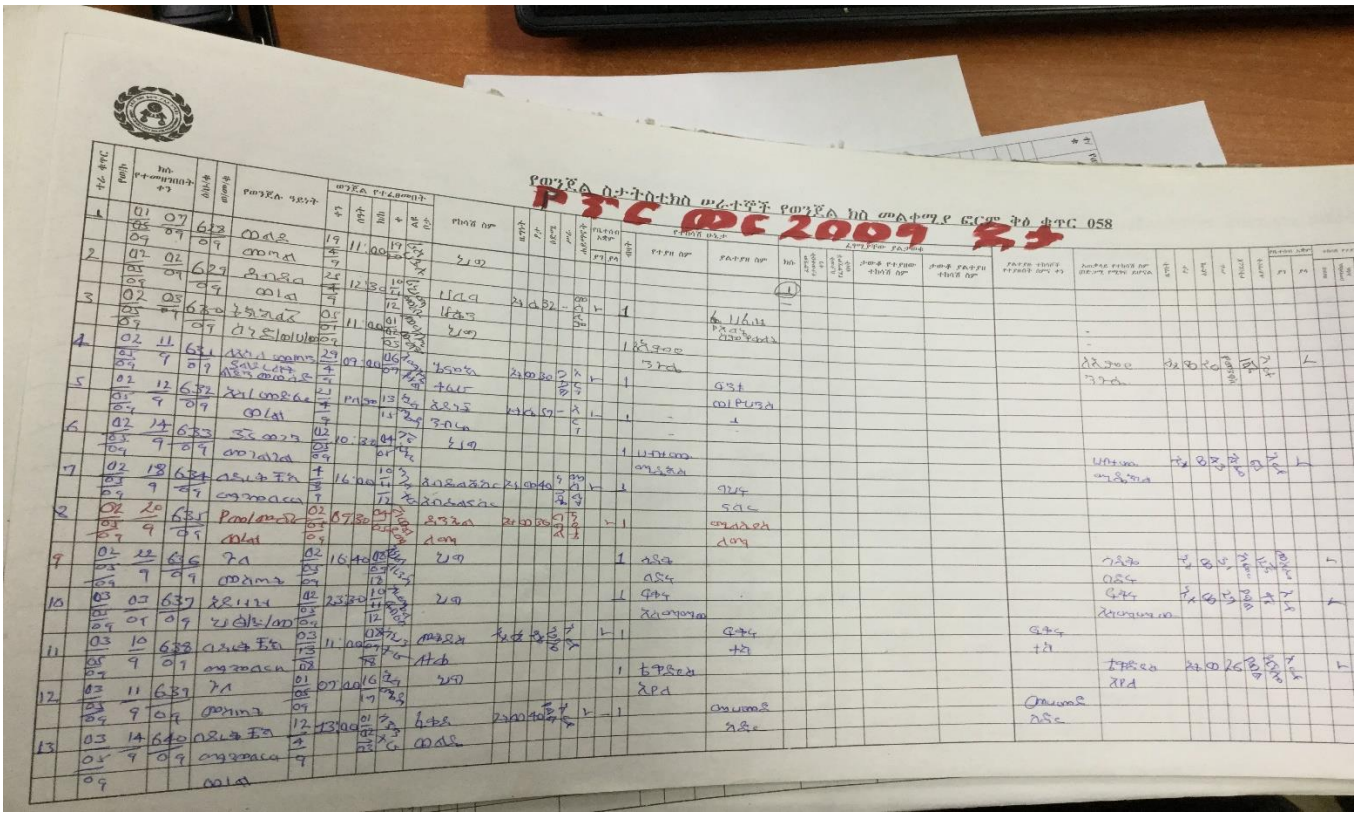
Types of Crime	Location	Latitude	Longitude	Elevation
Attempt(kill)	32 kebele mezinagna	470759	998860	2472
Attempt(kill)	adisu michael	470572	999374	2475
auto theft	teklehaymanot	471760	997985	2424
check fraud	idget building	471214	998482	2457
Attempt(kill)	anuar mosque	471569	998432	2435
check froaud	dir tera	471285	998174	2430
beating	Shawul dema school	470206	998032	2418
beating	abinet akebabi	470692	997395	2414
check fraud	amede gebeya	470946	998452	2446
pick pocket	ayele hotel	470405	998581	2459
check fraud	tasa tera	471270	998289	2446
Attempt(kill)	sinemaras	471580	998219	2440
check fraud	gojam berenda	471321	998651	2444
check fraud	amede gebeya	470946	998452	2446
auto theft	afric clinic	471471	998653	2436
check fraud	tasa tera	471270	998289	2446
Attempt(kill)	abadir school	471232	997948	2394
Attempt(kill)	ehil berenda	469631	998353	2460
check fraud	ayele hotel	470405	998581	2459
snach	autobus tera	470548	998627	2459
check fraud	mesalemia akebabi	469807	998633	2472
pick pocket	autobus tera	470548	998627	2459
pick pocket	Chaka meda	470954	999000	2459
barecheck	tasa tera	471270	998289	2446
pick pocket	adds ketema school	470733	998651	2476
check fraud	mehal adarash	471144	998355	2444
pick pocket	selam baltina	471087	997990	2427
beating	American gibi	471809	998098	2423
Attempt(kill)	alga tera	471665	998202	2437
check fraud	nesiru megazin	470953	998230	2452
check fraud	tasa tera	471270	998289	2446
Attempt(kill)	atana tera	468482	999340	2472
Attempt(kill)	keetema tera	471284	998786	2456
Attempt(kill)	mesalemia hibrent bank	469807	998633	2472
beating	gesho gibi	471625	998242	2435
pick pocket	shawul dama	470206	998032	2418
beating	shankila wonz	469145	998656	2420
check fraud	tasa tera	471270	998289	2446
Attempt(kill)	american gibi	471809	998098	2423

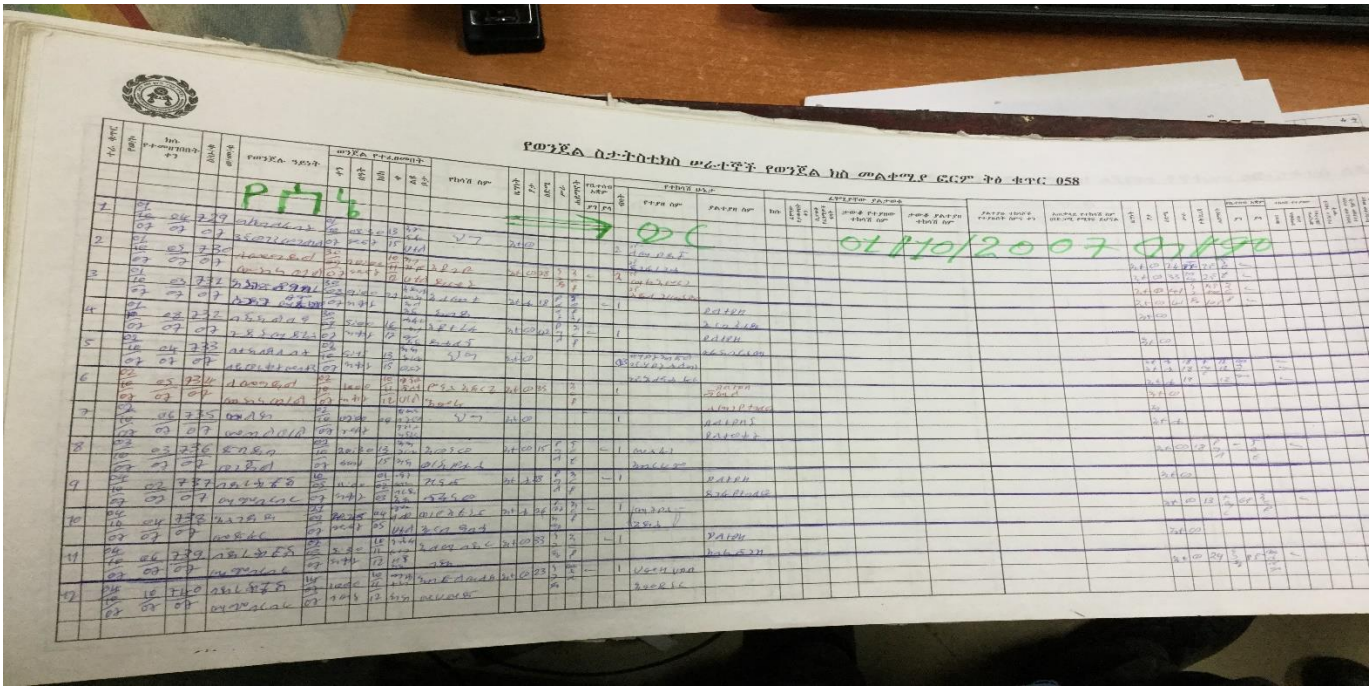
check fraud	mirab hotel	471161	998131	2446
check fraud	atana tera	468482	999340	2472
barecheck	sine alem hotel	469929	998717	2467
Attempt(kill)	ehil berenda	469631	998358	2460
auto theft	A.A gebeya center	471384	998325	2493
snach	sefere selam awash bank	469387	998997	2449
pick pocket	Amide gebeya	470946	998452	2446
Attempt(kill)	goma tera	471528	997861	2415
auto theft	mirab hotel	471161	998131	2446
check fraud	mirab hotel	471161	998131	2446
beating	mehal adarash	471144	998355	2444
Attempt(kill)	32 mezinagna	470759	998860	2472
beating	Shawul dema school	470206	998032	2418
Attempt(kill)	chew berenda	471189	999034	2454
Attempt(kill)	shawul dema akebabi	470155	998055	2422
Attempt(kill)	somali tera	471724	998613	2438
check fraud	ehil berenda	469631	998358	2460
check fraud	wolega hotel	471262	998672	2453
beating	Addisu michael	470572	999374	2475
beating	sebategna	470661	998078	2445
check fraud	gojam berenda	471321	998651	2444
Attempt(kill)	mesalemia	469859	998621	2465
pick pocket	autobus tera	470548	998627	2459
Attempt(kill)	anuar mosque	471569	998432	2435
check fraud	gojam berenda	471321	998651	2444
check fraud	sinemaras	471580	998219	2440
pick pocket	autobus tera	470548	998627	2459
Attempt(kill)	bilen hotel	470730	997514	2417
pick pocket	autobus tera	470548	998627	2459
pick pocket	ayele hotel	470405	998581	2459
check fraud	ethio tebib	469282	998993	2471
Attempt(kill)	gojam berenda	471321	998651	2444
pick pocket	mesalemia	469859	998621	2465
pick pocket	autobus tera	470548	998627	2459
check fraud	4 police tabiya	471165	998555	2391
Attempt(kill)	alga tera	471665	998202	2437
barecheck	mirab hotel	471161	998131	2446
pick pocket	shenkora berenda	470656	998141	2443
Attempt(kill)	Chaka meda	470954	999000	2459
check fraud	mehal adarash	471144	998355	2444
check fraud	dir tera	471285	998174	2430
check fraud	metebaber hotel	470537	998583	2455
Attempt(kill)	32 kebele mezinagna	470759	998860	2472

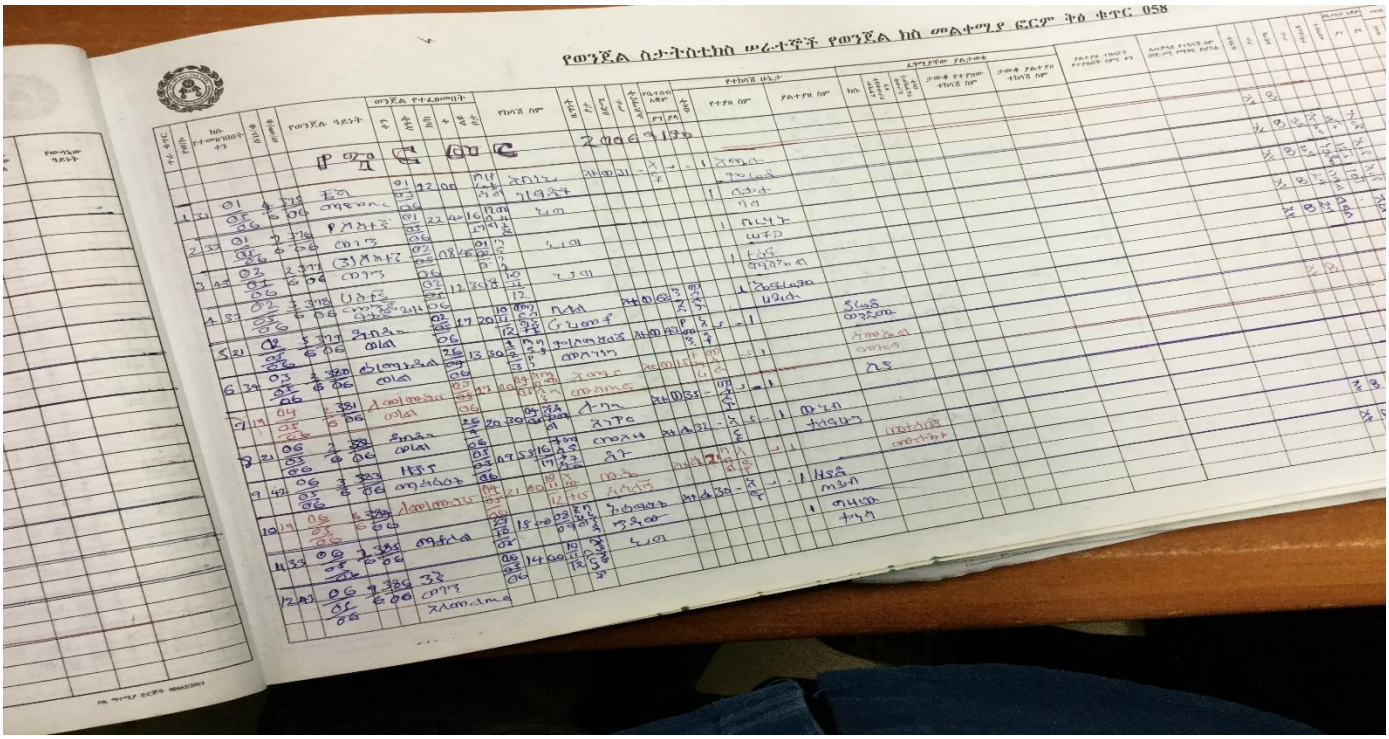
check fraud	ehil berenda	469631	998358	2460
check fraud	misir tera	471075	997969	2424
Attempt(kill)	buna tera	471143	998000	2426
check fraud	misir tera	471075	997969	2424
check fraud	ehil berenda	469631	998358	2460
check fraud	ehil berenda	469631	998358	2460
Attempt(kill)	berbere berenda	471506	997799	2430
beating	yirga haile	471383	998596	2449
check fraud	tasa tera	471270	998289	2446
check fraud	tana gebeya	471369	998290	2393
check fraud	tana gebeya	471369	998290	2393
check fraud	autobus tera	470548	998627	2459
snach	autobus tera	470548	998627	2459
Attempt(kill)	Autobus tera CBE	470606	998392	2453
check fraud	shera tera	471000	998271	2444
check fraud	shera tera	471000	998271	2444
Attempt(kill)	woreda 2 wotat	470272	997997	2427
snach	yekatit 23 school	469988	998594	2464
check fraud	dir tera	471285	998174	2430
pick pocket	felege birhan school	470990	999305	2479
Attempt(kill)	32 mezinagna	470759	998860	2472

Appendix C Hard copy data samples






የወንጀል ስታ-ትስቲክስ ሠራተኞች የወንጀል ክስ መልተማያ ፎርም ቅፅ ቁጥር 058


የወንጀል ስታ-ትስቲክስ ሠራተኞች የወንጀል ክስ መልተማያ ፎርም ቅፅ ቁጥር 058