Crime Mapping and Spatial Analysis

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ABSTRACT

Crime maps are becoming significant tools in crime and justice. Advances in the areas of information technology and Geographic Information Systems (GIS) have opened new opportunities for the use of digital mapping in crime control and prevention programs. Crime maps are also valuable for the study of the ecology and the locational aspects of crime. Maps enable areas of unusually high or low concentration of crime to be visually identified. Maps are however only pictorial representations of the results of more or less complex spatial data analyses.

A hierarchical model dealing with crime analysis is proposed and applied to the regional analysis of crime in Tehran, the model helps to identify spatial concentration of crimes in specific area (area based method). In area-based methods, crime data are aggregated into geographical areas such as blocks, precincts, and for each area, the analyst computes a measure of crime value. Multicriteria evaluation concept has been used to assess the crime rate in various blocks a discrete (part) of Tehran city. In this part we used two methods for crime density assessment:

- **Crime assessment based on crime per block,**
- **Crime assessment based on density of crime per population.**

After determination of hot spots based on two methods mentioned above spatial function is used to find suitable location to establish new police station or direct patrol to the hot spots to reduce of crime.

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1. Introduction

1.1. Introduction of Tehran police

Crime mapping and spatial analysis of crime are recognized as powerful tools for the study and control of crime, because crime maps help police identify problems at the block. The most powerful weapon in law enforcement is information technology.

The application areas of GIS in law enforcement are relatively narrow, because:

- Although police forces are using GIS technology, the penetration of GIS into every application is still relatively limited worldwide.
- In Iran GIS has not yet been viewed as an obligatory technology within the police force, whereas organizations such as the utilities have taken GIS on board, this is due to high cost of GIS tools and lack of GIS experts in the police force.

Law enforcement needs information management, especially location information. Traditional law enforcement for different types of police applications really deals with data collection. However, data collection without data analysis is useless. Not only GIS allows integration and spatial analysis of data to identify, apprehend, and prosecute suspects, it also aids more proactive measures through effective allocation of resources and better policy setting.

Definition of crime mapping, crime analysis and crime prevention:
Crime mapping involves the manipulation and processing of spatially referenced crime data in order to display visually in an output that is informative to the particular user (Alex and Kate 2001). Crime mapping can provide information concerning the location of hotspots or high level of reported crime.

Crime analysis is a set of processes applied on relevant information about crime patterns. Administrative and operational personal can use the result of analysis to prevent and suppress of criminal activities and also for investigation aims.

Crime prevention seeks to reduce the risks of criminal events and related anti-social behaviour by intervening in their causes.

1.2. Problem definition

It is quite obvious that if the police authorities have goals of improving crime management (crime prevention) in the city the manual recordings of crime incidents cannot be the way forward .

The various police stations under the Tehran police office have the responsibility of handling the various crime incidences in the boundary under their jurisdiction but at the moment have problems with their recording system, and aggregation of crimes incidents in all police stations.

All the recordings that are done in the police station are manually written in blotters (police blotter is a record of all arrests, crime events, and charges. see Appendix.1), and it is difficult to do decision making for all of police stations. There are not systems for:

- Crime mapping, incident time and place.
- To inform the targeting of resources for crime prevention
- For police investigations
- To evaluate the effectiveness of crime prevention initiatives.
- Assistance in the prevention and rapid response to crime.

1.3. Research questions

What is the best methodology for crime spatial analysis?
What parameters can be useful for crime mapping and spatial analysis?
Where does the crime tend to concentrate (density)?
How to find the suitable location for establishing a new police station?

1.4. Objectives

General
The main objective of this project is to develop a methodology for crime spatial analysis for Tehran police force.

Details

- Find a method to relocate in current boundary of police station for crime prevention or reduction,
- Identify suitable location for new police station,
- Analysis of factors, which are effective for crime prevention.

1.5. Methods

The procedure used to achieve the aforementioned objectives is as follows:

- Review of the prior works to get knowledge about them.
- Search in blotters of the police station.
- In order to obtain the crime causes several interviews were done with authorities of police stations.
- Data collection (attribute and spatial), and preparation.
- Multi criteria analysis.

Police have learned from experience that there are particular environments that concentration of crimes is larger-than-expected. Sometimes these hot spot areas are defined by particular activities (e.g., burglary), other times by specific concentrations of land uses (e.g., bus station), and sometimes by interactions between activities and land uses, such as shoplifting in commercial areas or pick-pocket in bus or bus stop.

Based on the above-mentioned vector representation will be used for hot spots and multicriteria decision-making is used for detection of hot spots for crime prevention.

- To find Hot Spots (A location where variety of crimes keep occurring over an extended period of time).
- To find Relationship between crime and geographic environment.
- To find suitable location for establishing new police station.

For this research needs access to computer hardware, GIS software, GIS operation for crime analysis, and crime data.

1.6. Case study

Tehran, is the largest and fastest growing city in IRAN has grown from a population of just more than half a million in 1940 to 5.4 million in 1980 and has currently a population of about 9 to 10 million. The physical expansion of the city has also been rapid. Urban growth from the core has been much influenced by the environmental contrasts between north and south. The modern commercial sector together with many of the suburbs where the wealthier section of the population live, have developed northward from the old core, while the poorer suburbs have developed south towards the desert. Tehran consists of 22 census districts (Figure 1.1):

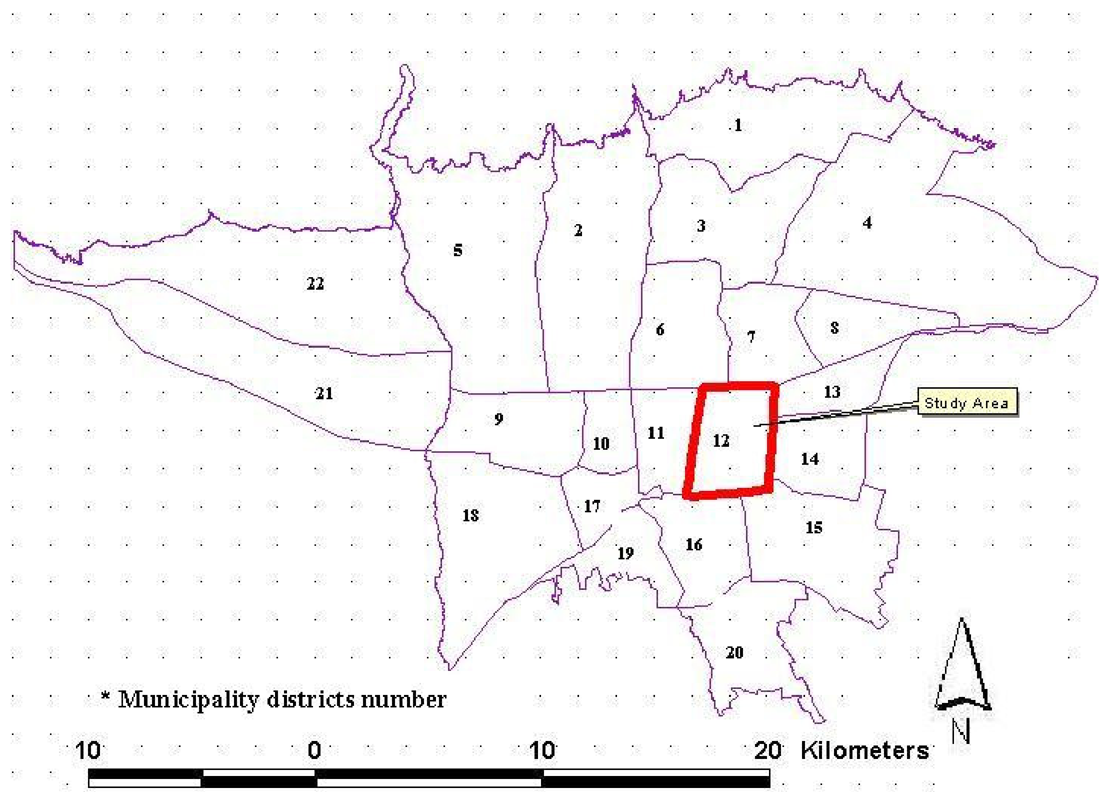


Figure 1.1 Census districts of Tehran

The dataset used in the case study were crime data from Central County (BAZAR) of Tehran (district 12). It covers an area of 11 square kilometres and has a population residential 1.1million, and population non-residential over 3 million, an excellent example of the partitioning of residential, commercial and political urban space. BAZAR of Tehran is a part of the commercial area in Tehran (Figure 1.2). This BAZAR was selected because of the relationship between crime and commercial environment.

Study area

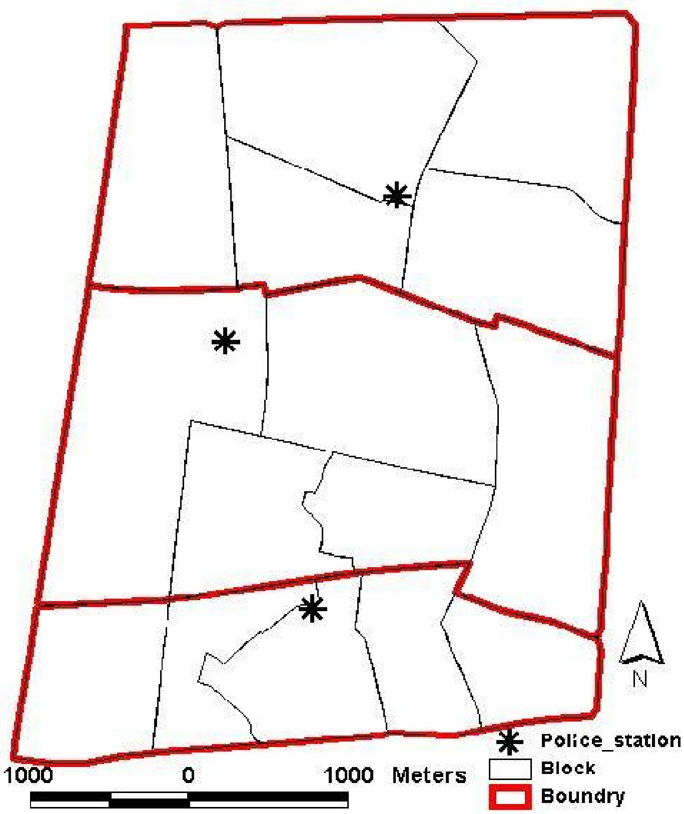


Figure 1.2 Districts 12 (case study)

1.7. Structure of the thesis

The report on the crime mapping and spatial analysis in Tehran city has been arranged in a rather classical set-up. Chapter 1 to 3 provide an introduction to Tehran police, and problem definitions (chapter 1), literature review on crime analysis (chapter 2), data collection and data modelling in GIS (chapter 3).

Chapter 4 to 6 analysis and subsequently focus on the processes of using Multicriteria evaluation based on block and density population (chapter 4), the result of analysis and determination of suitable blocks for establishing new police station and discussion about it (chapter 5), conclusion and some suggestion for future work (chapter 6).

2. Literature review on crime analysis

Unfortunately there is no experience about GIS (crime mapping) in the Tehran police organization and it is not possible to find any research or article about this case, not only in my country but also in Asia. Because of these reasons, articles written about the United Kingdom, United state of America, and Australia will be used in the literature review.
This chapter consists of the following parts:
2.1 – Definition of crime, and crime analysis.
2.2 – Methods for automating the geographical analysis of crime incident data.
2.3 – Spatial perspectives on crime.
2.4 – Tools in the spatial analysis of crime.

2.1. Definition of crime and crime analysis

Introduction
As an introduction to crime analysis, this section provides the definition of crime and crime analysis as a general concept as well as definitions of six types of crime analysis. These definitions are meant to enhance the understanding of crime analysis and to help create commonly understood terminology.

2.1.1. Crime definition

Crime is a multifaceted concept that can be defined in legal and non-legal sense. From a legal point of view, it refers to breaches of the criminal laws that govern particular geographic areas (jurisdictions) and are aimed at protecting the lives, property and rights of citizens within those jurisdictions. Most of the crimes with which the criminal justice system is concerned involve breaches of State/Territory legislation that cover most offences relating to persons (for example, murder and sexual assault), property (for example, theft and property damage) and regulation (for example, traffic violations). Commonwealth legislation relates primarily to matters such as trade and commerce, importation/exportation, taxation, defence and external affairs (1).

Non-legal point of view would define crime as acts that violate socially accepted rules of human ethical or moral behaviour. As the moral principles that underpin the notion of crime are subject to gradual change over time, the types of behaviour defined by the legal system as criminal may also change. Examples of behaviours that have been de-criminalized in some jurisdictions include prostitution, abortion, attempted suicide and homosexual intercourse. Other behaviours, such as tax evasion or credit card fraud, have been criminalized over time (1).

The distinction between these two points of view is important. While criminal justice agencies' crime data will be based upon the relevant legal definition of crime, data collected via victimisation surveys may be based upon an individual's interpretation of crime, rather than upon existing legal definitions. This potential disparity is more likely to affect the less serious end of the 'crime' spectrum.

2.1.2. Types of crime analysis

The following are six types of analysis of crime. As you will see, each contains characteristics of crime analysis in general, but each is specific in the type of data and analysis used as well as in its purpose.

Not all law enforcement analysts do the same type of work. There are several different types of policing analysis. Crime analysts spend varying percentages of their time on the following types of analysis (1):

- Tactical Crime Analysis*:*

This is day-to-day crime analysis, looking for series, patterns, sprees, hot spots, and hot dots immediately affecting the jurisdiction. Tactical crime analysis also focuses on specific information about each crime such as method of entry, point of entry, suspects actions, type of victim, type of weapon used, as well as the date, time, location, and type of location. Field information such as suspicious activity calls for service, criminal trespass warnings, and persons with scars, marks, or tattoos collected by officers is also considered in the analysis. Used for:

- Day to day
- For series, patterns, sprees, hot spots
- Used for Deployment & Administration

- Strategic Crime Analysis:

The study of crime and law enforcement information integrated with socio-demographic and spatial factors to determine long term "patterns" of activity, to assist in problem solving, as well as to research and evaluate responses and procedures. Used for:

- Identify unusual activity levels by time or location.
- Forecasting potential crime events/concentration.

- Administrative/Academic Crime Analysis:

The study of crime and law enforcement information integrated with socio-demographic and spatial factors to determine long term "patterns" of activity, to assist in problem solving, as well as to research and evaluate responses and procedures. Used for:

- Reports or statistical summaries for grant funding, commanders & public
- Policy implications beyond law enforcement agency.

- Operations Analysis:

The study of policing practices is regards patrol and resource allocation (e.g., a study of police overtime assignments last year). Operational analysis coupled with Strategic Crime Analysis, helps patrol commanders to make changes that use resources more efficiently. Used for:

- Assess needs (calls for service, population of data & demographics)
- Generate projections for deployment & resource allocation

- Intelligence Analysis:

The study of criminal organizations and enterprises, how they are linked, who the key players are. Helps investigation and prosecution units within police. The purpose of intelligence analysis is to assist sworn personnel in the identification of networks and apprehension of individuals to subsequently prevent criminal activity. Used for:

- Linkage between crime organizations & enterprises
- Relate elements such as companies, agencies, people, times, days, to crimes & places

- Investigative Analysis:

Looks at crime scene, psychological, and forensic analysis used in major crimes. It also helps catch serial killers, arsonists, and similar criminals. The primary purpose of criminal investigative analysis is to develop patterns of serial crimes crossing city, state, and even national boundaries by linking behavior and evidence within and among incidents in order to catch the offender and/or clear cases. Used for:

- Crime scene, psychological & forensic information.
- Link serial or related events.

2.2. Methods for automating the geographical analysis of crime incident data

Introduction

This part considers two ways of automating the geographical analysis of crime locations. Almost all police stations collect crime reports with a form of postcode of the building nearest the incident, it is possible for police organization conjunction with automated analysis technique, and it is possible for police department to discover crime hotspots in data.

2.2.1. The Geographic Analysis Machine

The Geographical Analysis Machine (GAM) system (Alex and Kate 2001) considers way in which crime analysis can be automated. This system allows crime analysts without detailed geographical knowledge to perform geographically sound and rigorous analysis of their data. Two methods are introduced: the Geographical Analysis Machine (GAM) which shows the user where there are clusters or hotspots in their data, and the Geographical Explanations Machine (GEM) which points to geographical data sets that may explain the clusters found by the GAM. Almost all law enforcement agencies collect crime reports with a form of geocode attached; in the UK this is usually the postcode of the building nearest the incident. By making use of this locational data in conjunction with automated analysis techniques, it is possible for agencies to discover crime hotspots in their data, allowing the targeting of resources to these areas. At first this matter to introduces the geographical analysis machine (GAM) and then discusses the geographical explanation machine (GEM), which makes use of related geographical variables to attempt to explain the pattern found by GAM, and GEM can be used to investigate crime data.

The geographical analysis machine (Openshaw, Charlton et al. 1987) was an early attempt at automated exploratory spatial data analysis that was easy to understand. The GAM sought to answer a simple practical question: namely given some point referenced data of something interesting where might there be evidence of localized clustering if you do not know in advance where to look due to lack of knowledge of a possible casual mechanism or if prior knowledge of the data precluded testing hypotheses on the database? More simply put, here is a geographically referenced database, now tell me if there are any crime clusters or hotspots and if so where are they located? It offers a solution to those researchers and users of GIS who want to perform a fast exploratory geographical analysis of their data with minimum of effort. It is an automated procedure that is designed to yield safe results that are largely self-evident (Alex and Kate 2001).

GAM reflects the view that useful spatial tools have to be able to cope with both the spatial data and end users who do not have degrees in statistics. The results have also to be easily understood and self-evident so that they can be readily communicated to other non-experts.
How does GAM work? The GAM algorithm involves the following steps:

1. Read in X, Y data for population at risk and a variable of interest (crime) from a GIS.
2. Identify the rectangle containing the data; identify starting circle radius and degree of overlap.
3. Generate a grid covering this rectangle so those circles of current radius overlap by the desired amount.
4. For each grid intersection generate a circle of radius.
5. Retrieve two counts for the population at risk and the variable of interest.
6. Apply some 'significance' test procedure.
7. Keep the result if significant.
8. Repeat steps 5 to 7 until all circle have been processed.
9. Increase circle radius and return to step 3 or else go step 10.
10. Create a smoothed density surface of excess incidence for the significant circle using a kernel smoothing procedure and aggregating the result for all circles.
11. Maps this surface.

The choice of significance test is not considered as being too critical. The aim is not to test conventional hypotheses, but merely to determine whether or not an observed positive excess incidence is sufficiently large to be unusual and hence of interest. It is more a measure of unusualness or surprise than a formal statistical significance test. A number of different measures of 'unusualness' can be applied depending on the rarity of incidence of interest, e.g. Poisson, bootstrapped z-scores, and Monte Carlo test based on rates. The aim here is not a formal test of significance, instead; significance' is being used only as a descriptive filter employed to reject circles. It is map created by the overall distribution of significant circles that is of most interest.

2.2.2. The Geographical Explanations Machine

GAM is purely a pattern detector and no explanation is provided that can help the user understand what variables may be geographically correlated with any clusters it may find. The search for explanation using a GIS reduces to multiple spatial queries to find out what appears to be geographically associated with the clusters. There is nothing wrong with this approach but it would be better if the procedure could be automated so that it could be made far more comprehensive and thus rigorous.
It is also possible that the apparent patterns being uncovered by GAM merely reflect confounding variables and those they are, therefore, of no real consequence. There is also a risk that a good understanding of what the patterns of cluster mean will be greatly hindered by missing information. Indeed, there are many different possible variables that may be considered important. Some of these could well be related more to individual behaviour, others to geographical location, and some to both (Alex and Kate 2001).

How does GEM (Alex and Kate 2001) work? The GEM algorithm involves the following steps:

1. Read X, Y data for population at risk and a variable of interest from a GIS. Also read in the X, Y data classified by value for each of overages.
2. Identify the rectangle containing the data set a starting circle radius, and the degree of circle overlap.
3. Generate a grid covering this rectangular map area so that circles of current radius overlap by the desired amount.
4. For each grid intersection generate a circle of radius.
5. Retrieve two counts for the population at risk and the variable of interest.
6. Apply some significance test procedure.
7. If the result is not significant go to step 5 and investigate another location, or store summary of results to permit later identification of recurrent or important coverage permutations.
8. Repeat step 5 to 7 until all circle have been processed.
9. Increase circle radius and return to step 3 or else go to step 10.
10. Create smoothed density surface of excess incidence for the significant circle for selected combinations of coverage permutations using a kernel smoothing procedure and aggregating the result for all circle.
11. Map this surface.

This system has demonstrated that with a little effort and very little GIS know-how it is possible for an analyst to produce maps of crime hotspots in their area using the geographical analysis machine. The discussion of GEM has show how with a little more data from their GIS it is possible to start to look for explanatory geographic variables that may assist police officers on the ground to deal with the hotspots found.

Several standard types of crime analyses have proven helpful to patrol officers: automated pin mapping, hotspot analysis, and radial analysis are a few of the most extensively used. Automated pin mapping is the most rudimentary and in some ways the most flexible of these uses. Law enforcement practitioners have begun to realize the advantages of maps over printouts in enabling officers to visualize spatial patterns of criminal events.

Mapping provides the capability of displaying any subset of events on a map. Not only can use the user specify the time period they want to examine, they can also display events of a certain type or that meet specific criteria. By enabling the visualization of subsets of information, mapping provides an invaluable tool for revealing clusters and patterns of crime that are not readily apparent from a list of crime events in a report. Another important function that mapping enable, is the visualization of the concentration of events at a single address. This is accomplished by tying the size of the symbol at a location to the number of events occurring there: the more events, the larger the symbol. This method for identifying report events at a single address supports problem-oriented policing efforts by making locations with several calls easily identifiable.

Conclusion

This part has demonstrated with a little effort and very little GIS Know-how it is possible for an analyst to produce maps of crime hotspots in their area using the GAM.

GEM has shown how with a little more data from their GIS it is possible to start to look for explanatory geographic variables that may well assist police officers on the ground to deal with the hotspots found.

The GAM looks for evidence of clustering in crime data, whereas the GEM goes a step further and investigates information, such as census data. The advantage of using these tools is that they include statistical testing which can assess the significance of any clusters of crime or relationships with other geographical information.

2.3. Spatial perspectives on crime

"Although criminological research reaches back over some two centuries, professional geographers have not been directly involved until the recent past"(Herbert 1982).

The study of crime has, not surprisingly, been dominated by research in criminology, sociology and law, but spatial and ecological perspectives on crime by mostly criminologists, did precede the 'recent past' after which professional geographers entered the crime research arena. Lawman (1986) identifies four major stages, which the spatial and ecological perspectives on crime underwent during the past 150 years. First, there was the cartographic school of criminology, which started in France, and spread to other European countries, most notably England, from 1830 t0 1880. The second stage was the Chicago ecological school of the 1920s and 1930s, followed by a third stage, the factor analytic school of the 1950s. The final and current stage is the geography of crime and environmental criminology (Lawman 1982).

The cartographic school was called that because of the frequent use of maps to depict regional and seasonal variations in pattern of crime. One of the French exponents of the cartographic school was Guerry, cited in Herbert (1982), who mostly concentrated on the urban-rural differences in crime occurrence. Guerry also identified different seasonal patterns, concluding that crimes against property were more frequent during winter in the north of France, whilst the south had more incidence of crime s against the person during summer. Followers of the nineteenth century cartographic school in England, such as Tobias and Mayhew, were the first to isolate cities as the focus of their studies. They concluded that there were different source areas of criminals, and that areas exist within cities where more crime occur than in other areas (Herbert 1982).

The spatial ecology of crime was developed at the Chicago school of criminology through the work of Shaw and McKay ((Herbert 1982); Dun 1980). Shaw and McKay used data collected on crime in Chicago to map the homes of juvenile offenders through the use of dot maps, to show actual distributions, and crime rate maps, to show aerial variations in delinquency residences (Herbert 1982). These maps indicated a regular change from the centre to the periphery of the city, in terms of the number of offender residences, prompting the conclusion that delinquents are concentrated near the city centre.

These "delinquency areas" (Dun 1980) were correlated with variables related to its physical and social environments such as "substandard housing, poverty, foreign-born population and mobility" (Herbert 1982). This ecological analysis of areas with a large number of delinquents, in terms of the above variables, showed that the communities within these areas "tended to function least efficiently as an agent of social control" (Dunn 1980). This explanation led to the social disorganization theory

(Bottoms and Wiles 1995), which proved to become either the source of constant debate or central principle within all disciplines, geography included, dealing with crime.
Both Herbert (1982) and Lawman (1986) argued that the social disorganization theory was not based on a biotic model of ecology. Instead, it interprets delinquency only in terms of social, cultural and economic factors, and not an ecological adaptation to different areas (Herbert 1982). This severe criticism of the social disorganization theory caused the ecological approach to crime to wane within criminology.

Lawman (1986) cited the factor analytic school as the third stage in the development of spatial perspective on crime, but Herbert (1982) viewed factor analysis only as an extension to the methodology of the spatial ecologists. The factor analytic stage represented the resource of spatial perspective on crime after sever criticism of ecological theory, and therefore is an important contribution to the study of crime. Herbert (1982) cites the work of Lander and Schmid who used factor analysis in the study of crime in Baltimore and Seattle, respectively**.**

Both studies produced dimensions of crime, but in fact drew similar conclusions to that of the ecological approach. High proportion of ‘non whites’ that rent their accommodation, for example, provides a dimension of anomie to crime, according to Lander. Broken families with a low economic status, on the other hand, is also a dimension, according to Schmid (Herbert 1982).

The final, and current stage of spatial perspective on crime according to Lawman (1986) is that of the complementary fields of the geography of crime and environmental criminology. The geography of crime represented the first attempts by geographers to enter the crime research in arena. This mainly involved engaging in a “modern form research in aerial and ecological traditions” which forms the initial links with the geography of crime (Herbert 1982). The majority of this work emerged in the USA, although British research is also well documented.

2.4. Tools in the spatial analysis of crime

This part examines four statistical mapping techniques that are useful for the spatial analysis of crime: block aggregation, voronoi diagrams, kernel smoothing and animation. Each technique is discussed in terms of its application to crime analysis, its utility for displaying crime patterns, and its ability to monitor changes in crime patterns over time. Used by analysts at the New York City Police Department (NYPD), and illustrates the application of the methods in a GIS environment and the strengths and limitations of the methods when linked with broader crime reduction policies.

Crime Mapping and Analysis Application (CMAA) that incorporates both area and point based methods in a user-friendly tool for mapping and analysis crime patterns. The application allows users to query crime data and perform four different types of mapping and spatial analysis. Specifically, the application:

1. Performs ‘block aggregation’ to generate chloropleth maps (maps with colour varying according to the scale of the problem) of incidents aggregated to several types of geographic units (census blocks, police sectors, police precincts, etc.);
2. Creates smoothed density maps of crime incidence using kernel estimation;

3. Prepares voronoi diagrams (Theissen polygon) of individual crimes and performs a coverage analysis based on the areas of voronoi regions; and
4. Creates map animations to show changes in crime patterns over time.

Although the CMAA incorporates several complex methods, the goal was to create tools for rigorous display of distribution and change in crime patterns within an easy to use system aimed at no specialists. The CMAA was designed to facilitate the query, mapping and exploration of spatial and temporal crime data(Alex and Kate 2001).

The first tool, block aggregation, involves aggregating crime incidents into geographical areas and generating a chloropleth map in which those areal units are shaded based on the number of incidents within them. This type of analysis enables the user to determine quickly which areas have a high incidence of crime and allows them to ‘zero in’ on those areas and perform further analysis. It is also useful for creating tables that show counts of crime by area and change in crime incidence over time.
The block aggregation technique has several advantages. First, it is easy to calculate. Other than acquisition of a digital census block map, there is no additional cost to employing the method. In addition, the output is easy to explain. Whether the audience is executive staff, beat cops, or community groups, block aggregation maps are easily understood, and do not require technical expertise to interpret. The technique is precise yet flexible. While many cluster identification techniques incorporate non-hotspot areas into their hotspots, the block aggregation technique precisely identifies which blocks have large amounts of crime and which do not.

Despite its ease of use and intuitive appeal, the block aggregation technique has several limitations. First, the technique does not handle small amounts of data (Diehr 1984). The data for each block have a large random variability from month to month, so that the map depicting those values may be misleading and inaccurate. On the block level chloropleth maps, increasing the cut-off point by one additional crime may drastically reduce the number of blocks identified in the highest crime category and vice versa.
The block aggregation technique was included in the CMAA because the advantages outweighed the shortcomings. Block aggregation is a useful tool for studying historic crime patterns, and provides an easy first cut at the data before additional analysis using more sophisticated techniques. It also creates a direct link to demographic and housing data from the census and thus provides a valuable foundation for exploring the associations between crime and socio-economic conditions (Alex and Kate 2001).

The second tool, Kernel density estimation, is a statistical method for determining the density of crime or other point events at different locations (Bailey and Gutrell 1995). The method is used to generate a continuous crime density surface from crime point data. The analyst begins with a dot map of crime events. Kernel smoothing results in a continuous weather map that shows geographic variation in the density or intensity of crime. Peaks on the map represent areas of high crime (crime hotspots) and valleys represent areas of low crime. Increasingly, crime analysts are employing kernel smoothing to visualize and analyse crime patterns (Williamson, McLafferty et al. 1999);(Brown and Dalton 1998). A particular benefit of the method is that unlike in block aggregation, the analysis is not limited to some patterns than on a complex point map.

Geographical variation in crime density is clearly visible on the smooth density map. In addition to its ease of interpretation, kernel smoothing, unlike other traditional methods for identifying crime hotspots, such as STAC (Spatial and Temporal Analysis of Crime), is that the hotspots can be irregularly shaped and need not follow regular geometric shapes like circles or ellipses (Block 1995).

The third tool, voronoi diagram, is technique of spatial analysis that has seen wide application across many disciplines. Voronoi diagrams or Theissen polygons, divide a mapped area, into a number of polygons. The voronoi diagram associated with a crime incident map may be quite helpful to police analysts and managers who are confronted with the problem of choosing the geographical areas to be assigned some special patrol resources. Specifically we present a method for performing what we have termed coverage analysis. Coverage analysis relates the percentage of the total map area covered by the sum of the corresponding voronoi polygons.

The relationship between the percentage of incidents and percentage of area is based upon two factors. First, each voronoi polygon is associated with one and only one crime incident, and second the voronoi polygons are associated with clustered crime incidents. Given this, we can create a voronoi diagram that shows the trade-off between the number of crime incidents and the total area that lies within the voronoi polygons associated with those incidents.

The final tool incorporated in the CMAA is an animated map, characterized by continuous or dynamic change (Slocum 1999). The maps are displayed dynamically in sequence, forming a constantly changing image or animation. The field of animation has advanced rapidly in recent years, stimulated by developments in computer hardware and graphics. These advances are fuelling changes in map-making as cartographers gain access to one of the first effective tools for representing continuous change through space and time. Analysts are just beginning to explore the use of animation in crime mapping (Openshaw, Waugh et al. 1994).

The animation component of the CMAA is designed to provide flexibility in defining duration and rate of change for a particular animated sequence. The crime analyst first selects the time interval for maps in the sequence and then defines the degree of overlap among the maps. In this way one can control the smoothness or roughness of change in the animation and the time periods to be displayed. The animation works with crime density maps generated by kernel smoothing, because they are visually appealing and easy to comprehend in the short time interval of the animation (Alex and Kate 2001).

Animation is an effective way of displaying changes in crime through time and space; however, it is primarily a visual tool. Animated maps clearly show regular patterns, but if events move or vary in intensity unpredictably over time, the animation will be difficult to comprehend. Viewers often have trouble comprehending information on animated maps. The images move by quickly and are difficult to compare. Therefore we expect that the animation tool in the CMAA will primarily be used for visualization and display, for ‘gee-whiz’ presentations, and to give the viewer a sense of general space-time trends (Alex and Kate 2001).

Conclusion

The Crime Mapping and Analysis Application moves beyond the creation of computerized pin maps to assist decision makers with visualizing, analysing and uncovering patterns in the large spatial database that law enforcement organizations work with on a daily basis. The application offers a series of technically sophisticated in space, how those clusters change over time, and how a given level of resources might be allocated to cover the largest amount of crime.

Although the CMAA was designed for using by decision makers with little or no training in spatial analysis, it is unclear how these non-specialists will respond to the system and which of its components they will find of greatest value.

3. Data collection and preparation

3.1. Data modelling in GIS

A data model is a set of constructs for describing and representing selected aspects of the real world in a computer. According to Longley (2001), when representing the real world in computer, it is helpful to think in terms of four different levels of abstraction (figure 3.1).

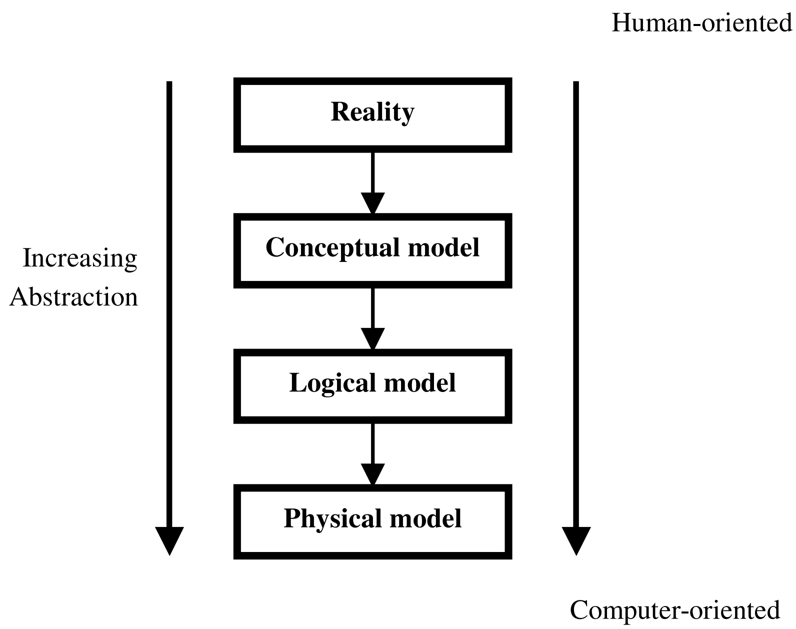


Figure 3.1 Levels of GIS data modelling (Longley 2001)

First, reality is made up of real-world phenomena, and includes all aspects that may not perceive by individuals, or deemed relevant to particular application. Second, the conceptual model is a human oriented, often partially structured, model of selected objects and processes that are thought relevant to a particular problem domain. Third, the logical model is an implementation-oriented representation of reality that is often expressed in the form of diagrams and lists. Forth, the physical model portrays the actual application in a GIS, and often comprises tables stored as files or databases.

There are two important components of geographic data:

- The spatial data:

  Geographic position specifics the location of a feature or phenomenon by using a coordinate system, which are used for representing geographical places: cities, rivers, lakes, etc.

- The attribute data

  Attribute data refer to the properties of spatial entities, which describe the characteristics of the geographic features: population, length, and area.

Spatial features in a GIS database are stored in either vector or raster form:

Vector data

GIS data structure adhering to a vector format store the position of map features as pairs X, Y (and sometimes Z) coordinates. A point is described by a single X-Y coordinate pair and by its name or label. A line is described by a set of coordinate pairs and by its name or label. Therefore, a line is built up of straight-line segments. An area, also called polygon, is described by a set of coordinate pair and by its name or label with the difference that the coordinate pairs at the beginning and end are the same.

A vector format represents the location and shape of features and boundaries precisely. Only the accuracy and scale of the map compilation process, the resolution of input devices and the skill of the data-in putter limit precision.

Raster data

The raster or grid-based format generalizes map features as cell or pixels in a grid matrix. The space is defined by matrix of points or cells organized into rows and columns. If the rows and columns are numbered, using column number and row number can specify the position of each element. There are advantages to the raster format for storing and processing some types of data in GIS.

Comparison of raster and vector data formats is depicted in Table 3.1. In this project vector data are used.

Table 3.1 Comparison of raster and vector data

	Raster data	Vector data
Shape description	Not precise	Precise
Data volume	Large	Small
Processing speed	Fast	Slow
Complexity	Simple	Complex
Construction cost	Low	High
Data updating	Easy	Not easy
Data analysis	Easy	Difficult

In this project object-oriented relational and Geodatabase are used. More recently United Modelling Language (UML) has been adopted in more and more object-oriented data modelling activities. Object oriented GIS data model, is the most significant advancement in GIS technology in 10 years. Unlike traditional GIS data models, which involve a myriad of linkages between data tables and

graphic and attribute data stored in different locations, the object oriented GIS data model can accommodate vector and raster data.
Advantages of object oriented:

- The object oriented design more closely mirrors the real world, because it features a series of intelligent objects.
- The object oriented GIS data model handles these intelligent objects with precise rules and relationships embedded up front in the database design, because these business rules are inside the object oriented GIS data model itself, the number and complexity of custom programming routines that need to be written and run in the background are reduced.
- An object oriented GIS data model can be planned and designed using computer-aided software engineering tools and Unified Modelling Language (UML).
- Object oriented GIS data model is seamless data, is not separated into tiles or grids and any user can edit any feature in the object oriented at any time. Since areas and features are not locked out during editing, multiple users can complete updates faster.
- The object oriented GIS data model can exist inside a standard corporate relational database, and that is good news for IT departments in local governments that might have struggled with operating and maintaining proprietary in the past.

Geodatabase model supports an object-oriented vector, data model that is a kind of physical data model in ArcGIS 8.2. The defining purpose of this new data model is to make the features in GIS dataset smart by endowing them with natural behaviours, and to allow any sort of relationship to be defined among features. In this model, entities are represented as objects with properties, behaviour, and relationships. Support for a variety of different geographic object types is built into the system. These object types include simple objects, geographic features (objects with location), network features (objects with geometric integration with other features), annotation features, and other more specialized feature types. The model allows the user to define relationships between objects, besides rules for maintaining the referential integrity between objects.

3.2. Data collection

Data used in GIS comes from many sources, are of many types and are stored in different ways. A GIS provides tools and methods for the integration of data into a format so that data can be compared and analysed. A small part of Tehran was selected and relative attribute data and spatial data were collected.

The police organization in Tehran has the following hierarchy: one police command at the top that includes a number of peace officer, each peace officer includes several police stations, each police station contains one precinct (jurisdiction), which is divided into five blocks for better administration and response to the area (figure 3.1).

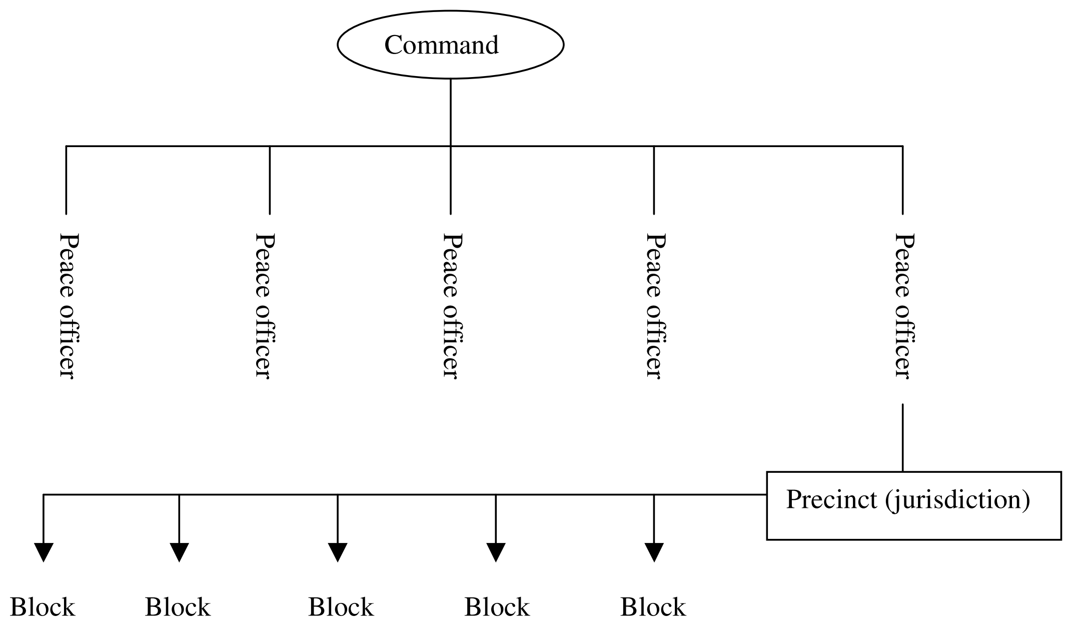


Figure 3.2 Police organization in Tehran

The needed of information can be extracted based on the following procedure:
Required attribute data for this research was collected from central district (peace officer) of Tehran, for duration of one season from Farvardin (April) to Khordad (June) 2002, which were based on the offences statistic at the various blocks that was reported and recorded by police service. The following are some of the crime incidents:

- Burglary
- Shoplifting
- Auto theft
- Fraud
- Theft from vehicle
- Robbery
- Addiction
- Pick pocket
- Hold up
- Motor theft
- Abuse of confidence

An example:
Table 3.2 depicts type of crime and number of crime in different blocks on the police station number 109.

Table 3.2 Census types of crimes in the Police station, number 109

	Type of crime	Block1	Block2	Block3	Block4	Block5	Total
1	Burglary	8	3	0	4	2	17
2	Shoplifting	1	3	7	6	1	18
3	Auto theft	6	5	5	2	6	24
4	Fraud	25	18	20	22	15	100
5	Theft from vehicle	27	16	10	18	7	78
6	Robbery	3	0	1	0	1	5
7	Addiction	17	15	14	23	12	81
8	Pick pocket	20	18	14	18	10	80
9	Hold up	1	0	1	0	0	2
10	Abuse of confidence	30	32	55	50	37	204

- Spatial data contains 31 digital map sheets (DWG files) of study area at scale 1:2000 that were collected from the municipality of Tehran. Paper maps about police stations, precinct, and block were collected from police stations.

3.3. Data preparation

This step includes the following tasks:

- Joining digital map sheets (merged maps) was done when the study area spread across more than one map. Most spatial data available in IRAN use a rectangular lattice as basic spatial units. They are provided as separate map sheets. Therefore, it is often necessary to join separate spatial data even if the existing data are used.
- 31 digital map sheets covering the area were joined in AutoCAD 2000.
- Creation of different required layers using CAD, because the lack of different layers only one layer for all of features.
- Spatial data acquisition of this research depicted in Table 3.3.

Table 3.3 Collected dataset and their format

	Features	Spatial type	Format
1	Boundary (Precinct)	Polygon	Shape file
2	Block	Polygon	Shape file
3	Population	Polygon (block)	Shape file
4	Network road (main streets)	Line	Shape file
5	Bus line	Line	Shape file
6	Police station	Point	Shape file
7	Bank	Point	Shape file

8	Military (restriction area)	Point	Shape file
9	Embassy	Point	Shape file
10	Government offices	Point	Shape file
11	Car parking	Point	Shape file
12	Educational centre	Point	Shape file
13	Entertainment cultural	Point	Shape file
14	Gas station	Point	Shape file
15	Fire station	Point	Shape file
16	Public health centre	Point	Shape file

- Conversion of data format in AutoCAD 2000 to the Arc View (ESRI) shape file for using and adding database.
- Georefrencing; used WGS_1984_UTM_Zone-39N projected coordinate systems (metric).
- Geocoding; if the location is given only by its address, the data cannot be directly handled in GIS. In such a case we have to convert the address into its XY coordinates such as longitude and latitude coordinates, this process is called geocoding.

For example:
Address of Police station number 109:

No.10, alley Shahid TAGHAVI, street JOMHURI-YE-ESLAMI, Tehran-IRAN.

Geocoding Process ↓

Police station no109, 537986X, and 3948851Y

- Conversion of shape file to coverage in Arc Info (ESRI) Arc Catalog in order to use in Arc map.
- Exporting shape files using custom values to the coverage file, using different grid level for features, and WGS_1984_UTM_Zone-39N projected coordinate systems.
- Importing coverage files to Geodatabase using custom value.

3.4. Database Magement System

A database management system (DBMS), or simply a database system (DBS), consists of:

- A collection of interrelated and persistent data (usually referred to as the database).
- A set of application programs used to access, update and manage that data (which form the data management system).

The goal of a DBMS is to provide an environment that is both convenient and efficient for:

- Retrieving information from the database.
- Storing information into the database.

Why database management systems are necessary?
It’s necessary for the following reasons:

1- Development of the system

- New application programs must be written as the need arises.
- New permanent files are created as required.
- But over a long period of time files may be in different formats, and
- Application programs may be in different languages.

2- There is problems with the straight file-processing approach

- Data redundancy and inconsistency
- Multiple users
- Difficulty in accessing data
- Data isolation
- Security problems
- Integrity problems

3.4.1. The Entity Relationship (ER) diagram

The entity-relationship models use diagrams to depict the entities and their relationships. In this diagrams rectangles represent entity types and diamonds represent relationships. Relationships are linked to their constituent entity types by arcs, and the degree of the relationship is indicated on the arc.

For example:

The entity types POLICE STATION, PRECINCT, and BLOCK might be represented schematically as shown in figure 3.3. Each police station has many blocks but only one precinct. A block belongs to only one police station.

The entity types for this situation (with primary key attributes underlined) are as follows:

1) Entity type POLICE STATION with attribute <u>POL-ID</u> (a unique police station ID), X, and Y.
2) Entity type PRECINCT with attribute <u>PR-ID</u> (a unique precinct ID), Non-RD, Area, Perimeter, RD, and pol-ID.
3) Entity type BLOCK with attribute <u>block-ID</u> (a unique block ID), Non-RD, Area, Perimeter, RD, Non-rd, BU, AU, MO, TH, RO, AD, PI, and PR-ID.

The relationships among the entity types are as follows:

The 1:1 relationship HAS_TO between POLICE STATION and PRECINCT.

The 1:N relationship CONTAINS between PRECINCT and BLOCK.

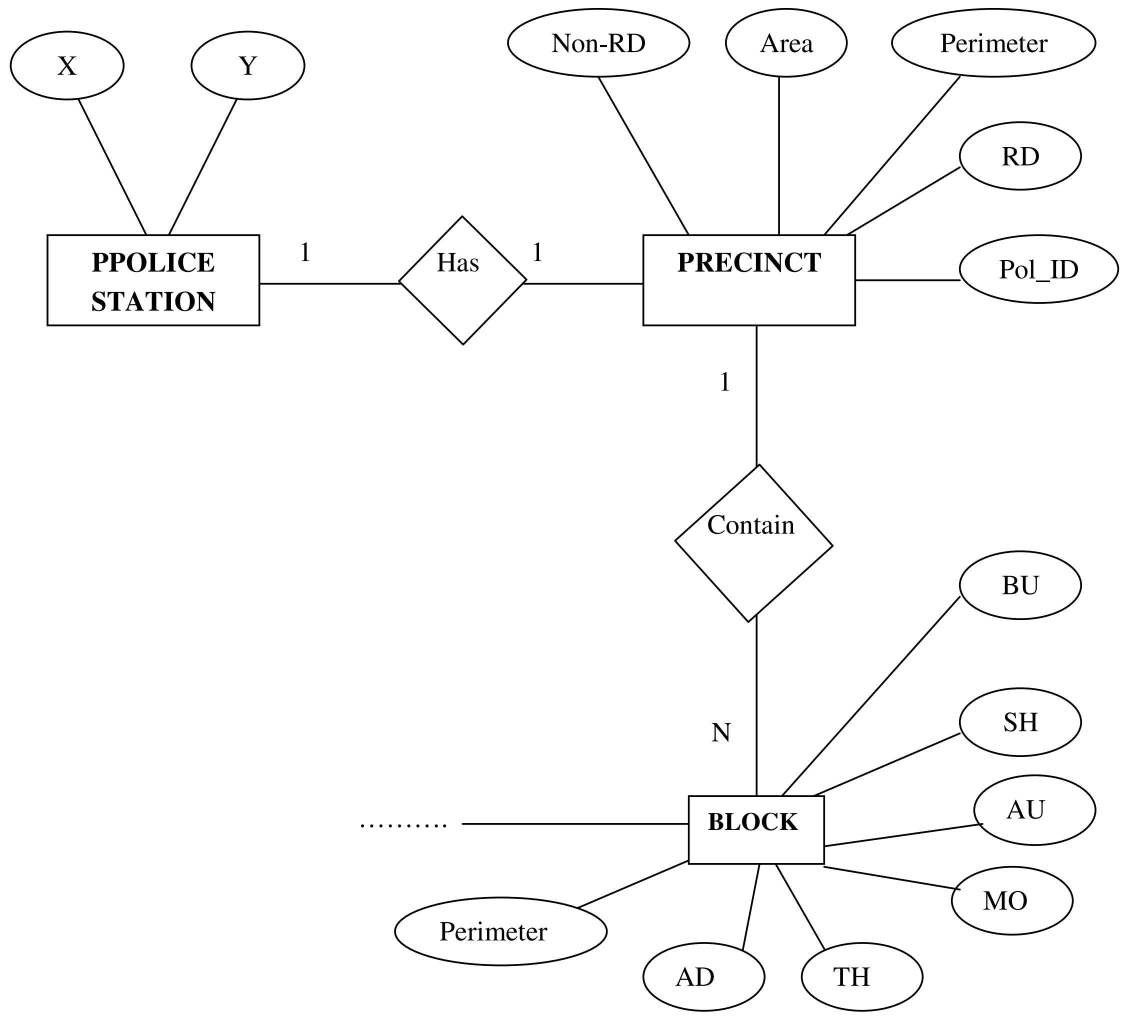


Figure 3.3 A sample ER diagrams.

3.4.2. Description of entities

- Police station: national law and enforcement office, which is in charge of boundary.
- Boundary: The political unit under jurisdiction of police station.
- Block: The smallest political unit under jurisdiction of police station.

3.4.3. Enterprise Rules

The enterprise rules based on which all constraints between the entity types are constructed can be listed as follows:

A police station must contain a precinct,

Each precinct includes several blocks, and

Many blocks are under jurisdiction of a police station.

3.4.4. Skeleton tables

Police station	Pol_ID*	X	Y

Boundary	PR_ID*	Area	Perimeter	RD	Non-RD	Pol_ID^F

Block	B_ID*	Area	Perimeter	RD	Non-RD	BU	SH	AU	FR	TH	RO	AD	PI	HO	PR_ID^F

* Refers to primary key, F and refers to foreign key.

3.4.5. Data dictionary

Data catalogue (dictionary) is a repository of information about the data in the database (data about data); it can perhaps be the best view as the yellow page of the database. It contains information as the following about data:

Table 3.4 Descriptions of entity types and their attributes

Abbreviation	Description
Pol_ID	Police station identify (ID)
X	Longitude
Y	Latitude
PR_ID	Precinct ID
RD	Residential Population
Non RD	Non Residential Population
B_ID	Block ID
BU	Burglary
SH	Shoplifting
AU	Auto theft
FU	Fraud
TH	Theft from vehicle
RO	Robbery
AD	Addiction
PI	Pick pocket
HO	Hold up

4. Multicriteria Decision Making

Introduction

Police have learned from experience that there are particular environments that concentration of crimes is larger-than-expected. Sometimes these hot spot areas are defined by particular activities (e.g., burglary), other times by specific concentrations of land uses (e.g., bus station), and sometimes by interactions between activities and land uses, such as shoplifting in commercial areas or pick-pocket in bus or bus stop. While there are some theoretical concerns about what links disparate crime incidents together into a cluster, nonetheless, the concept is very useful. Police officers patrolling a precinct can focus their attention on particular environments because they know that crime incidents will continually reappear in these places. Crime prevention units can target their efforts knowing that they will achieve a positive effect in reducing crime with limited resources.

Unfortunately, measuring a hot spot is also a complicated problem. There are different statistical techniques designed to identify ‘hot spots’. Many, but not all, of the techniques are typically known under the general statistical label of cluster analysis. These are statistical techniques aimed at grouping cases together into relatively coherent clusters. All of the techniques depend on optimising various statistical criteria, but the techniques differ among themselves in their methodology as well as in the criteria used for identification. Because ‘hot spots are perceptual constructs, any technique that is used must approximate how someone would perceive an area. The techniques do this through various mathematical criteria.

Types of cluster analysis (Hot Spot) methods

Several typologies of cluster analysis have been developed as cluster routines typically fall into several general categories:

- Point locations: This is the most intuitive type of cluster involving the number of incidents occurring at different locations. Locations with the most number of incidents are defined as ‘hot spots’.
- Partitioning techniques: frequently called the K-means technique, partitioning technique where all points are assigned to clusters and are displayed as ellipses.
- Density techniques: Identify clusters by searching for dense concentrations of incidents, one type of density search algorithm using the Kernel Density method.
- Risk -based techniques: Identify clusters in relation to an underlying base ‘at risk ’ variable, such as population, employment, or active targets.
- Miscellaneous techniques: other methods that are less commonly used including techniques applied to zones, not incidents.
- Hierarchical techniques: are like an inverted tree diagram in which two or more incidents are first grouped on the basis of some criteria.

Based on the above-mentioned reasons and the available data (general and only vector data) hierarchical methods (multicriteria decision-making) were used for detection of hot spots for crime prevention.

4.1. Multi Criteria Evaluation to Support Decision Making

Colson and Bruyn (1989) as cited by Sharifi (2001) defines Multicriteria Decision Making (MCDM) as a world of concepts, approaches and methods to help decision makers to describe, evaluate, sort, rank and select or reject on the basis of evaluation (expressed by score, value, preference intensities) based on several criteria. To what extent an alternative course of action attains the objectives can be measured by a set of criteria. Evaluation aims at rationalizing the planning and the Decision Making Process (DMP) by structuring the relevant aspect of the problem.

Colson and Bruyn (1989) classify MCDM into the two methods, namely, the Multiobject Decision Making Methods (MODM) and the Multi Attribute Decision Making Methods (MADM). The MADM is concerned with choice out of finite set of options. Attributes are evaluated, the alternatives are ranked, the best-chosen or bad rejected decision space to only good alternatives. The distinction between MADM and MODM is based on the classification of evaluation criteria into attributes or objectives. 'Criteria' is a generic term that includes both attributes and objectives. An objective is a statement about the desired state of the system under consideration. For any given objective, one or more different attributes are used to measure the performance in relation to that objective(Sharifi 2001).

Multi objective methods (MODM) attempt to help DM to make a good (efficient) decision that would be satisfied. MODM problems involve designing the alternatives and searching for the best decision among an infinite or very large set of feasible alternatives. The MODM, which are sometimes viewed as a natural extension of mathematical programming, consider several objective functions simultaneously.

Multiattribute methods (MADS) a good solution is selected based on various assumptions concerning DM. Usually preference of DM in the form of trade-off, pair wise comparisons, included in the analysis. MADM problems involve obtaining the performances of options on each attribute in order to analyse and rank a finite, moderate, small and discrete set of alternatives. A common goal to both is an attempt to help the DMs make good (efficient) decisions that makes them satisfied.

The components of a MADM are: Alternatives, criteria (attribute), criterion score, criterion priorities (rank order), and multicriteria evaluation method and sensitivity analysis of the results, are shown in Fig 4.1.

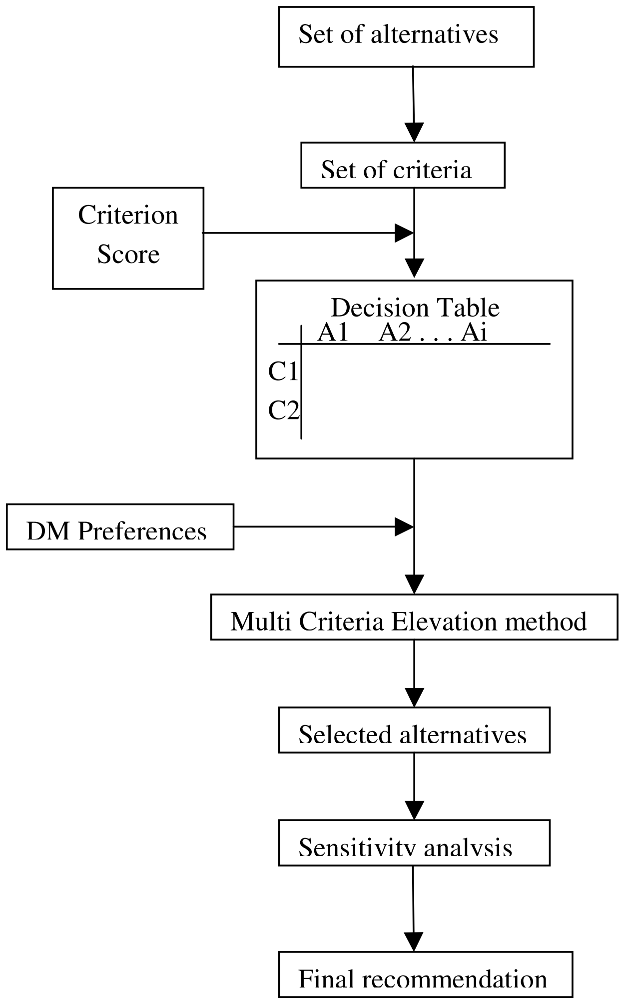


Figure 4.1 General model of MADM, Jankowski, 1995

4.2. Crime definition and type

It is important to understand the critical features of crime and the criminal justice system. Crime is a multifaceted concept that can be defined in both a legal and non-legal sense. From a legal point of view it refers to breaches of the criminal laws that govern particular geographic areas (jurisdictions), and are aimed at protecting the lives, property and rights of citizens within those jurisdiction. A non-legal point of view would define crime as acts that violate socially accepted rules of human ethical or moral behaviour.

- Burglary: The unlawful entry of a structure to commit a felony or theft. The use of force to gain entry is not required to classify an offence as burglary, originally under English common law burglary was limited to entry in residences at night, but it has been expanded to all criminal entries into any building.
- Shoplifting: The unlawful entry of a shop to commit a theft, usually occur when the shops closed.

- Auto theft: the crime of stealing automobile.
- Motor theft: the crime of stealing motorcycle.
- Theft from vehicle: Defined as the theft or attempted theft of a motor vehicle, this offence category includes the stealing of automobiles, trucks, buses, motorcycles, motor scooters, snowmobiles, etc.
- Robbery: Robbery is the taking or attempting to take anything of value from the care, custody, or control of a person or persons by force or threat of force or violence and/or by putting the victim in fear. Uses force on any person or puts or seek to put any person in fear of being then and there subjected to force.
- Addiction: the need to have something regularly because you are addicted to it: *drug addiction.*
- Abuse of confidence: the crime of stealing on the cheap things.
- Pickpocket: someone who steals things from people's pockets, especially in a crowd places.
- Fraud: Fraudulent conversion and obtaining money or property by false pretenses.

Crime classification

There are several types of crime classification. In this research the following classification is used:

Crime I: security

A group of crime focus on security, and important crime as viewpoint of security against of person. Crimes in this division are classified into the following groups: Hold up, Burglary, shoplifting, robbery, and motor theft.

Crime II: Economic

A group of crime focus on economic, and important crime as viewpoint of economic against of money or property of person. Crimes in this division are classified into the following groups: auto theft, shoplifting, burglary, and Fraud.

Crime III: social

A group of crime focus on social, and important crime as viewpoint of social. Crimes in this division are classified into the following groups: Addiction, robbery, pick pocket, and Theft from vehicle.

4.3. Multicriteria evaluation applied for crime assessments

Multicriteria evaluation concept has been used to assess the crime rate in various blocks of Tehran city. To achieve that the general model of MCDM is adapted for crime assessment as presented in figure 4.2.

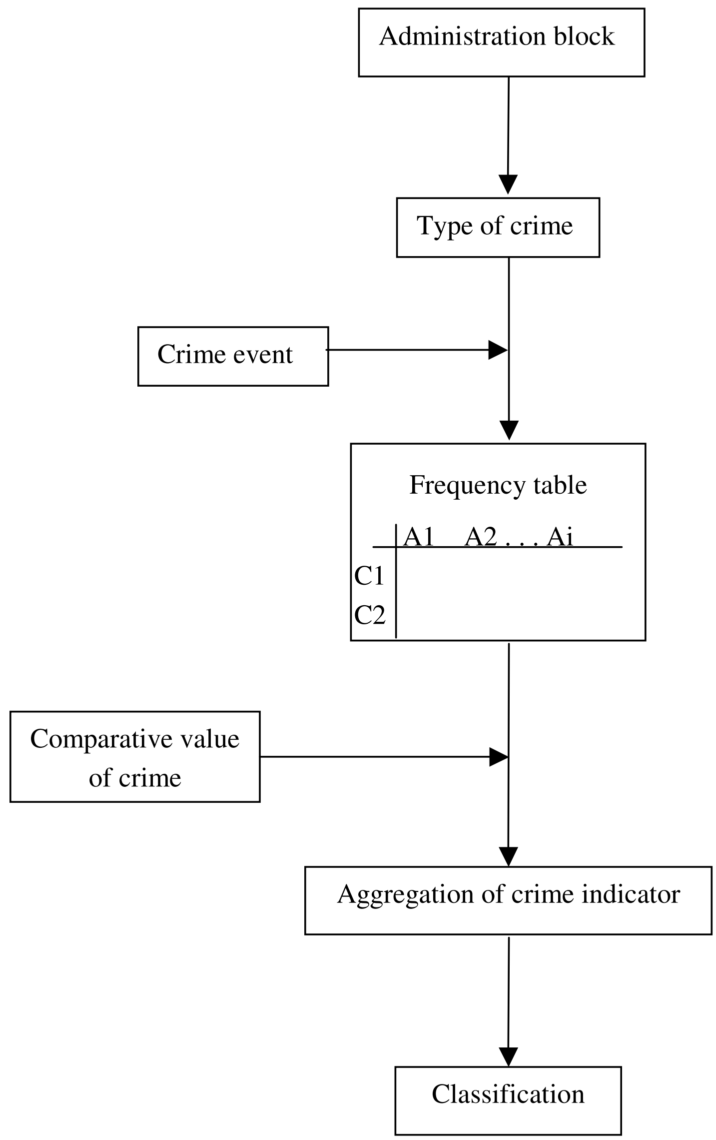


Figure 4.2 General model of MCE of crime

Components of this method

A set of alternatives and criteria for a decision problem is established. Then together with the criterion score are placed in a frequency table (effected table, decision table), the alternatives forming the columns and the criteria forming the rows. Alternatives' score on each criterion are entered into the table.

For this study, the method for ranking is weighted summation. In this method as a first step all effect scores are standardized. An appraisal score is then calculated for each alternative first by multiplying these standardized effect scores by their appropriate weight, followed by summing the weighted scores of all effects. The final ranking of the alternatives is assessed based on the resulting appraisal scores for each alternative (Sharifi 2001). Scores from the various effects can only be compared if the measurement units are the same. Through the standardization procedure the measurement units are made uniform, and the scores lose their dimension along with their measurement unit (Voogd 1983). Based on Maximum method of standardization these criteria have been standardized (because of different unit). The maximum method is the best choice whenever we want to criterion is measured on a ratio scale, and standardized values are proportional to the original value (advantages), but it will be a disadvantage is that small differences between the alternatives do not become totally visible. In this method, the scores are normalized with a linear function between 0 and the highest absolute score.

In this study AHP method has been applied, the following brief description of method will be introduced.
Analytic Hierarchy Process (AHP) introduced by Saaty to overcome the difficulties of the weights and scores method and the trade off method (Appendix 2). It focuses on the achievement of objectives, and assumes a rational decision-making process with means: rational decision is one that best achieves the multitude of objectives of the decision maker. The key will be to focus on objectives, rather than alternatives, criteria or attributes. It contains three main components as follows:

Analytic
Analytic is a form of the world analysis, which means the separation of any material or abstract entity into its constituent elements. Analysis is the opposite of synthesis; AHP should really be called the Synthesis Hierarchy Process because at its core, AHP helps us measure and synthesise the multitude of factors involved in complex decisions.

Hierarchy
Herbert Simon, father of field of artificial Intelligence and Nobel laureate, writes: “Large organisations are almost universally hierarchical in structure. That is to say, they are divided into units, which are subdivision into smaller units, which are, in turn, subdivision and so on. Hierarchical subdivision is not a characteristic that is peculiar to human organizations. It is common to virtually all-complex systems of which we have knowledge.

Process
A process is a series of actions, changes, or functions that bring about an end or result. The AHP is not magic formula or model that finds the right answer. Rather it is a process that helps decision makers to find the best answer.

AHP is based on criteria that are measured on a ratio or ordinal scale. The decision maker has to make a comparison for every pair of criteria: first qualitative which is the transformed into quantitative scale from 1 to 9 as follows:

Equally preferred = EQUAL	1
Weak preference = MODERATE	3
Strong preference = STRONG	5
Demonstrable preference = VERY STRONG	7
Absolute preference = EXTREME	9

Frequency table

In this research the effects table contains most of the information necessary to evaluate the problem and is the basis for multicriteria methods. An effects table contains the alternatives, the criteria and the effects of the alternatives for the criteria. The names of the alternatives are listed in the first row include of block numbers: (1091,1092, …) for more details refer to chapter 3.2 in page 17, the names of the criteria in the first column include the type of crime (Burglary, …….) above some of crimes are defined, and the other part of table shows event numbers of crime (Per block and per type of crime). Showed different type of crime in fifteen blocks in table 4.1, 4.2, and 4.3 quality appraisals depend on the number of the criteria, the used priorities and the arithmetic technique.

Table 4.1 Frequency tables of crimes related to security

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
HOLDUP	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0
BURGLARY	8	3	0	4	2	5	2	12	3	1	10	4	3	2	5
SHOPLIFTIN	1	3	7	6	1	3	7	1	4	12	0	2	1	3	1
ROBBERY	3	0	1	0	1	1	2	3	2	1	4	3	2	0	1
MOTOR_THEF	8	20	28	11	29	15	13	9	17	24	5	4	3	5	3

Table 4.2 Frequency tables of crime related to economic

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
AUTO_THEFT	6	5	5	2	6	1	0	1	1	2	0	1	0	0	1
SHOPLIFTIN	1	3	7	6	1	3	7	1	4	12	0	2	1	3	1
BURGLARY	8	3	0	4	2	5	2	12	3	1	10	4	3	2	5
FRAUD	25	18	20	22	15	25	22	20	23	35	5	8	10	7	6

Table 4.3 Frequency tables of crimes related to social

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ADDICTION	17	15	14	23	12	17	13	19	28	29	30	60	20	80	120
PICK_POCKE	20	18	14	18	10	15	9	20	1	4	0	3	1	2	2
THEFT_FROM	27	16	10	18	7	11	6	8	9	15	4	5	2	5	3
ABUSE_OF_CO	30	50	50	32	37	39	50	45	62	88	18	14	23	20	12

Crime density assessment

In this part we used two methods for crime density assessment:

- Crime assessment based on crime per block (an absolute number of incidents reported in each block).
- Crime assessment based on density of crime (the block count expressed as a rate per, 1000 resident population).

4.3.1. Crime assessment based on crime per block

Normalization (Standardization):

This falls under the MCE process. Because of the different nature of the criteria, the criterion scores are usually incompatible (unrelated) due to differences in the measuring units and scales. Normalization transforms the score into one common measurement scale. Voogd (1983) says it's a mechanical way of rescaling value. He identifies three types of normalization:

- Transform to 0-1 with additivity constraint (N=raw (i)/sum raw).
- Transform to 0-1 with ratio scale properties, referred to as Maximum (N=raw (i) /Max raw).
- Transform to 0-1 with interval scale properties, refer to as Interval (N=(raw (i)-Min raw (i))/(Max raw-Min raw)(Voogd 1983).

In this research used <u>Ratio scale</u> methods for normalized (Transform to 0-1 with ratio scale properties, referred to as Maximum (N=raw (i) /Max raw), or each raw score in effected table (4.1, 4.2, and 4.3) is divided by the highest raw score in the effects table of the criterion depicted in table (4.4, 4.5, 4.6) is very useful in standardizing an evaluation matrix that will be analysed by a weighted summation technique or any other technique which utilizes the magnitude of the individual scores. This range is very important as a reference for weighting the effects.

Table 4.4 Normalized table (ratio scale) presenting the crime related to security

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
HOLDUP	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0
BURGLARY	0.67	0.25	0	0.33	0.17	0.42	0.17	1	0.25	0.08	0.83	0.33	0.25	0.17	0.42
SHOPLIFTIN	0.08	0.25	0.58	0.5	0.08	0.25	0.58	0.08	0.33	1	0	0.17	0.08	0.25	0.08
ROBBERY	0.75	0	0.25	0	0.25	0.25	0.5	0.75	0.5	0.25	1	0.75	0.5	0	0.25
MOTOR_THEF	0.28	0.69	0.97	0.38	1	0.52	0.45	0.31	0.59	0.83	0.17	0.14	0.1	0.17	0.1

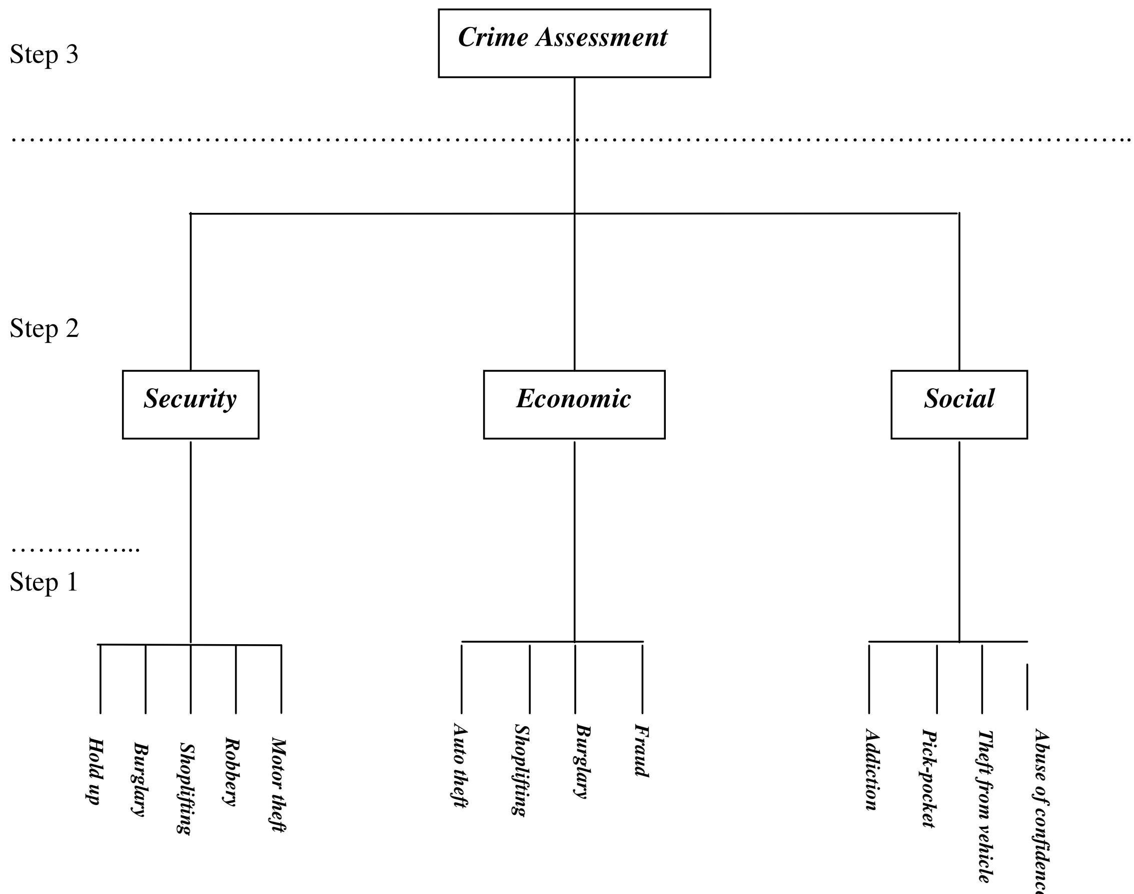
Table 4.5 Normalized table (ratio scale) presenting the crime related to economic

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
AUTO_THEFT	1	0.83	0.83	0.33	1	0.17	0	0.17	0.17	0.33	0	0.17	0	0	0.17
SHOPLIFTIN	0.08	0.25	0.58	0.5	0.08	0.25	0.58	0.08	0.33	1	0	0.17	0.08	0.25	0.08
BURGLARY	0.67	0.25	0	0.33	0.17	0.42	0.17	1	0.25	0.08	0.83	0.33	0.25	0.17	0.42
FRAUD	0.71	0.51	0.57	0.63	0.43	0.71	0.63	0.57	0.66	1	0.14	0.23	0.29	0.2	0.17

Table 4.6 Normalized table (ratio scale) presenting the crime related to social

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ADDICTION	0.14	0.13	0.12	0.19	0.1	0.14	0.11	0.16	0.23	0.24	0.25	0.5	0.17	0.67	1
PICK_POCKE	1	0.9	0.7	0.9	0.5	0.75	0.45	1	0.05	0.2	0	0.15	0.05	0.1	0.1
THEFT_FROM	1	0.59	0.37	0.67	0.26	0.41	0.22	0.3	0.33	0.56	0.15	0.19	0.07	0.19	0.11
ABUSE_OF_CO	0.34	0.57	0.57	0.36	0.42	0.44	0.57	0.51	0.7	1	0.2	0.16	0.26	0.23	0.14

BUILDING CRIME HIRARCHY



Relative Importance of various crimes

The aim of this part is to find the relative importance of various types of crimes, as well as different category of crimes:

- Security
- Economic

- Social

There are several methods to drive the relative importance of crimes among which Pair wise comparison has been selected for this study.

Weighted derivation

There are several methods for derivation weights, but in this research pair wise comparison is used which, are basic to the AHP methodology. When comparing a pair of factors (may be objectives, sub-objectives, scenarios, players, or alternatives), a ratio of relative importance, preference of the factors can be established. This ratio need not be based on some standard scale such as feet or meters but merely represents the relationship of the two factors being compared. This method creates a matrix containing the pair wise comparison judgments for the criteria (table 4.7, 4.8, and 4.9), from which a priority vector is derived of relative weights for these elements (This procedure can be used to assess effect values).

Weights or criteria priorities allow the decision maker to specify the perceived importance of individual factors relative to the others included in the evaluation. Assigning weights to criteria scores is a crucial step into the process.

Table 4.7 Pair wise comparison table of crime related to security (by Expert)

	Hold up	Burglary	Shoplifting	Robbery	Motor theft
Hold up	1	2	3	3	4
Burglary	0.5	1	2	2	3
Shoplifting	0.33	0.5	1	1	2
Robbery	0.33	0.5	1	1	2
Motor theft	0.25	0.33	0.5	0.5	1

Table 4.8 Pair wise comparison table of crime related to economic (by Expert)

	Auto theft	Shoplifting	Burglary	Fraud
Auto theft	1	2	2	3
Shoplifting	0.5	1	1	2
Burglary	0.5	1	1	2
Fraud	0.33	0.5	0.5	1

Table 4.9 Pair wise comparison table of crime related to social (by Expert)

	Addiction	Pickpocket	Theft from vehicle	Abuse of confidence
Addiction	1	2	3	4
Pickpocket	0.5	1	2	3
Theft from vehicle	0.33	0.5	1	2
Abuse of confidence	0.25	0.33	0.5	1

Next step normalized of pair wise comparison tables; In this research used Additivity constraint methods (Transform to 0-1 with additivity constraint properties, referred to (N=column (i) /sum column (i)), or each column score in pair wise comparison table (4.7, 4.8, 4.9) is divided by the sum of column scores in pair wise comparison table. This kind of transformation is especially in normalizing various sets of different criterion weights are shown in table 4.10, 4.11, and 4.12.

Table 4.10 Normalized of pair wise comparison of crime related to security

	Hold up	Burglary	Shoplifting	Robbery	Motor theft	Weight
Hold up	0.42	0.5	0.4	0.4	0.33	0.4
Burglary	0.21	0.2	0.3	0.3	0.25	0.24
Shoplifting	0.14	0.1	0.1	0.1	0.17	0.14
Robbery	0.14	0.1	0.1	0.1	0.17	0.14
Motor theft	0.1	0.1	0.1	0.1	0.08	0.08

Table 4.11 Normalized of pair wise comparison of crime related to economic

	Auto theft	Shoplifting	Burglary	Fraud	Weight
Auto theft	0.4	0.4	0.4	0.4	0.42
Shoplifting	0.2	0.2	0.2	0.3	0.23
Burglary	0.2	0.2	0.2	0.3	0.23
Fraud	0.1	0.1	0.1	0.1	0.12

Table 4.12 Normalized of pair wise comparison of crime related to social

	Addiction	Pickpocket	Theft from vehicle	Abuse of confidence	Weight
Addiction	0.5	0.571	0.5	0.4	0.46
Pickpocket	0.3	0.286	0.333	0.3	0.28
Theft from vehicle	0.2	0.143	0.167	0.2	0.16
Abuse of confidence	0.1	0.086	0.077	0.1	0.1

Aggregation method

Weight summation is a simple and frequently used evaluation method. This procedure generates a ranking of the effectives based on the weighted sum of the alternative scores. As a first step all effect score are normalized, and then sum of each raw and divided by type of crime (number of columns) showed in table (4.5, 4.6, and 4.7). Alternatives rank orders were obtained by totalling the products of the normalized value (see table 4.4, 4.4, and 4.6) with the weights of each criterion (see table 4.10, 4.11, and 4.12) use this formula(Sharifi and Marijnen 2002):

OVERALL ASSESMENT (i)= $\sum_{i=1}^{n} Wi * Ci.$

i: indices of each criterion.

W: weight of each criterion.

C: normalized score of each criterion.

Overall assessment (i) is equal value (degree) of crime in each block (zero is equal no crime event and one is equal (100%crime) or critical area depicted in table 4.13.

Table 4.13 Ranking the alternatives

Security		Economic		Social	
Block numbers	Rank	Block numbers	Rank	Block numbers	Rank
1161	0.75	1161	0.82	1091	0.54
1091	0.70	1135	0.79	1165	0.52
1093	0.59	1091	0.68	1094	0.48
1133	0.38	1132	0.49	1092	0.46
1135	0.26	1094	0.48	1133	0.45
1132	0.23	1093	0.45	1131	0.38
1134	0.22	1133	0.35	1093	0.37
1162	0.22	1134	0.35	1135	0.36
1131	0.21	1131	0.34	1164	0.36
1094	0.18	1092	0.28	1162	0.32
1095	0.17	1162	0.22	1095	0.27
1165	0.16	1164	0.22	1132	0.27
1163	0.15	1165	0.17	1134	0.25
1092	0.15	1163	0.15	1161	0.16
1164	0.09	1095	0.14	1163	0.13

Overall assessment of crime rate

This part creates the final ranks instead of crime classification and preference of crime classification based on which one importance than others, and changes this preference. .

Table 4.14 Effect table

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Security	0.70	0.15	0.59	0.18	0.17	0.21	0.23	0.38	0.22	0.26	0.75	0.22	0.15	0.09	0.16
Economic	0.68	0.28	0.45	0.48	0.14	0.34	0.49	0.35	0.35	0.79	0.21	0.21	0.15	0.22	0.17
Social	0.54	0.46	0.37	0.48	0.27	0.38	0.27	0.45	0.25	0.36	0.16	0.32	0.13	0.36	0.52

This research used three-perspective form of crimes for ranking:

- Security perspectives: this vision security is important than others, and shows preference and weight in table 4.15. When comparing a pair of crime classification, a ratio of relative importance, preference of the factors can be established. This ratio need not be based on some standard scale such as feet or meters but merely represents the relationship of the two factors being compared.

Table 4.15 Preference of security perspective

	Secu-rity	Economic	Social	Weight
Security	1	2	3	0.54
Economic	1/2	1	2	0.30
Social	1/3	1/2	1	0.16

Overall assessment for security perspectives and maps of ranking showed in figure 4.3.

Block . No	Rank
1091	0.70
1161	0.53
1093	0.50
1135	0.39
1133	0.38
1094	0.31
1132	0.29
1131	0.26
1162	0.24
1134	0.23
1165	0.23
1092	0.21
1164	0.18
1163	0.15
1095	0.13

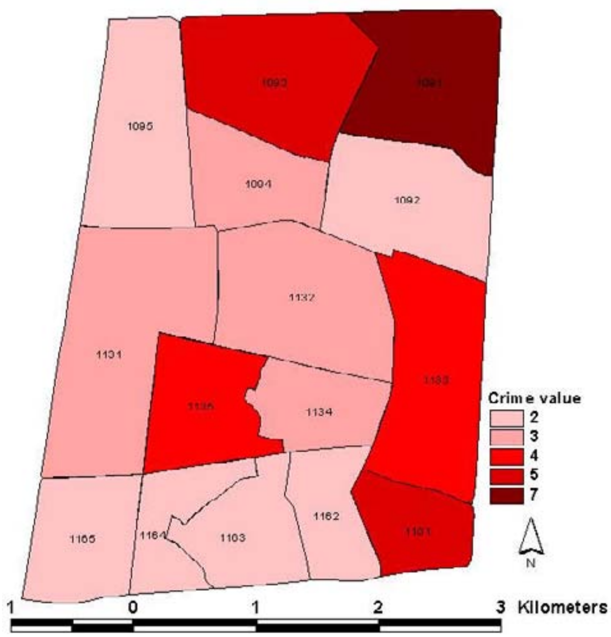


Figure 4.3 Overall assessment for security

- Economic perspectives: economic perspectives: this vision economic is important than others, and preference and weight are shown in table 4.16.

Table 4.16 Preference of economic perspective

	Economic	Security	Social	Weight
Economic	1	1	2	0.43
Security	1/2	1	2	0.35
Social	1/2	1/2	1	0.22

Overall assessment for economic perspectives and maps of ranking showed in figure 4.4.

Block . No	Rank
1091	0.68
1093	0.48
1161	0.46
1135	0.42
1133	0.38
1094	0.34
1132	0.31
1131	0.28
1165	0.26
1092	0.24
1134	0.24
1162	0.24
1164	0.20
1095	0.14
1163	0.14

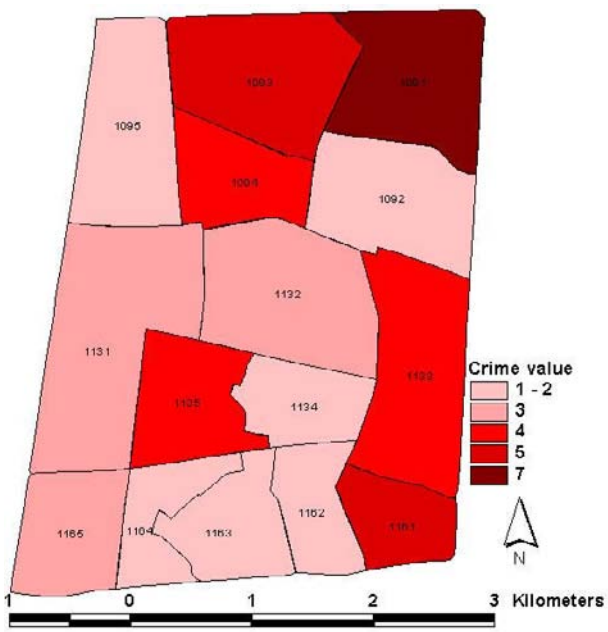


Figure 4.4 Overall assessment for economic

- Social perspectives: social perspectives: IN this vision, social is important than others, and preference and weight are shown in table 4.17.

Table 4.17 Preference of social perspective

	Social	Security	Economic	Weight
Social	1	1	3	0.43
Security	1	1	3	0.43
Economic	1/3	1/2	1	0.14

Overall assessment for security perspectives and maps of ranking are shown in figure 4.5.

Block . No	Rank
1091	0.67
1093	0.50
1135	0.50
1161	0.44
1133	0.38
1094	0.35
1131	0.29
1132	0.35
1134	0.28
1092	0.25
1162	0.23
1163	0.15
1164	0.19
1165	0.21
1095	0.17

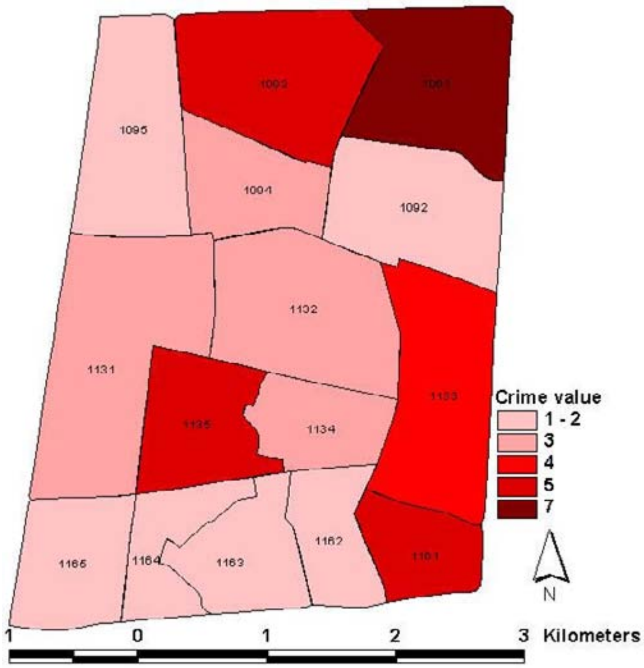
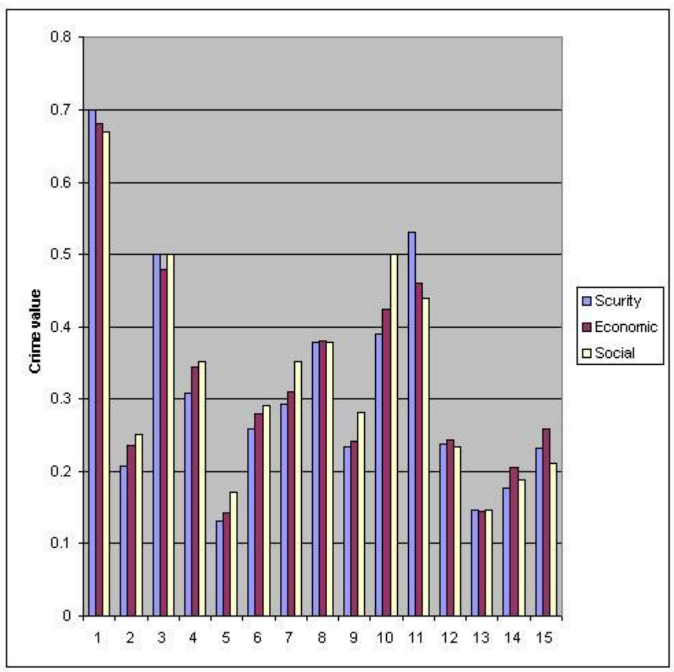


Figure 4.5 Overall assessments for social

The MCE approach was implemented on the types of crimes. The results are summarized in graph 4.1.

Block . No	Block
1091	1
1092	2
1093	3
1094	4
1095	5
1131	6
1132	7
1133	8
1134	9
1135	10
1161	11
1162	12
1163	13
1164	14
1165	15



Graph 4-1 Classify of crime value depend on three category

Based on the above-mentioned reasons and comparison of three figures, the following shows the results:

The reason for sudden crime increasing in block 1161 from security viewpoint can be follows:

- High population.
- Immigration.
- Accommodation of offences.
- Accessibility to suburbs.

The reason for sudden crime increasing in block 1135 from social viewpoint can be follows:

- Frequent trade centres.
- High floating population.
- Time limit of traffic.

The reason for sudden crime increasing in block 1132 and 1134 from social viewpoint can be follows:

- Closeness of trade centre.
- Lack of entertainment and cultural centres.

4.3.2. Crime assessment based on density of crime

In the most general sense, measurement is the foundation of scientific analysis, and it lies behind any quantitative analytical statement. To calculate this density we must know how many crime incidents have occurred, and, if we are calculating a population-based density, how many persons there are per block. Density value is calculated for each block (Harries 2001).

$$\text{Density} = \frac{Number\ of\ incidents\ per\ bloc}{Population\ per\ block}$$

These density values can be used to create a chloropleth map, which uses colour to represent different values among blocks within the study area. An application of density analysis is shown in figures 4.6, 4.7 and 4.8 for three vision of crime.

Table 4.18 Population per block

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Population	80	75	60	40	45	130	150	230	15	20	110	50	80	50	60

1 indicated 1000 people.

For calculation of density use frequency tables 4.1, 4.2, and 4.3 divided by population per block showed in tables 4.19, 4.20 and 4.21.

Table 4.19 Density tables presenting the crime related to security

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
HOLDUP	0.01	0	0.02	0	0	0	0	0	0	0	0.01	0	0	0	0
BURGLARY	0.1	0.04	0	0.1	0.04	0.04	0.01	0.05	0.2	0.05	0.09	0.08	0.04	0.04	0.08
SHOPLIFTIN	0.01	0.04	0.12	0.15	0.02	0.02	0.05	0	0.27	0.6	0	0.04	0.01	0.06	0.02
ROBBERY	0.04	0	0.02	0	0.02	0.01	0.01	0.01	0.13	0.05	0.04	0.06	0.03	0	0.02
MOTOR_THEF	0.1	0.27	0.47	0.28	0.64	0.12	0.12	0.23	1.13	1.2	0.05	0.08	0.04	0.1	0.05

Table 4.20 Density tables presenting the crime related to economic

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
AUTO_THEFT	0.08	0.07	0.08	0.05	0.13	0.01	0	0	0.07	0.1	0	0.02	0	0	0.02
SHOPLIFTIN	0.01	0.04	0.12	0.15	0.02	0.02	0.05	0	0.27	0.6	0	0.04	0.01	0.06	0.02
BURGLARY	0.1	0.04	0	0.1	0.04	0.04	0.01	0.05	0.2	0.05	0.09	0.08	0.04	0.04	0.08
FRAUD	0.1	0.24	0.33	0.55	0.33	0.19	0.15	0.09	1.53	1.75	0.05	0.16	0.13	0.14	0.1

Table 4.21 Density table presenting the crime related to social

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ADDICTION	0.21	0.2	0.23	0.58	0.27	0.13	0.09	0.08	1.87	1.45	0.27	1.2	0.25	1.6	2
PICK_POCKE	0.25	0.24	0.23	0.45	0.22	0.12	0.06	0.09	0.07	0.2	0	0.06	0.01	0.04	0.03
THEFT_FROM	0.34	0.21	0.17	0.45	0.16	0.08	0.04	0.03	0.6	0.75	0.04	0.1	0.03	0.1	0.05
ABUSE_OF_CO	0.38	0.67	0.83	0.8	0.82	0.3	0.33	0.2	4.13	4.4	0.16	0.28	0.29	0.4	0.2

Then aggregated method (weight summation is a simple and frequently used evaluation method. This procedure generates a ranking of the effectives based on the weighted sum of the alternative scores. Alternatives rank orders were obtained by totalling the products of the density value (see table 4.19, 4.20, and 4.21) with the weights of each criterion (see table 4.10, 4.11, and 4.12) used in this formula(Sharifi and Marijnen 2002):

OVERALL ASSESMENT (i)= $\sum_{i=1}^{n} Wi*Ci.$

Also, ranks are shown in table 4.22.

Table 4.22 Ranking the alternatives

Security

Block numbers	Rank
1161	0.03
1091	0.04
1093	0.06
1133	0.03
1135	0.20
1132	0.02
1134	0.19
1162	0.04
1131	0.02
1094	0.07
1095	0.07
1165	0.03
1163	0.02
1092	0.04
1164	0.03

Economic

Block numbers	Rank
1161	0.03
1135	0.40
1091	0.07
1132	0.03
1094	0.14
1093	0.10
1133	0.03
1134	0.32
1131	0.04
1092	0.08
1162	0.06
1164	0.04
1165	0.04
1163	0.03
1095	0.11

Social

Block numbers	Rank
1091	0.26
1165	0.96
1094	0.54
1092	0.26
1133	0.09
1131	0.14
1093	0.28
1135	1.28
1164	0.80
1162	0.61
1095	0.29
1132	0.10
1134	1.39
1161	0.15
1163	0.15

Overall assessment of crime density

This part creates the final ranks instead of crime classification and preference of crime classification based on which one important than others, and changes this preference.

Table 4.23 Effect table

Police station No	109	109	109	109	109	113	113	113	113	113	116	116	116	116	116
Block Numbers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Security	0.04	0.04	0.06	0.07	0.07	0.02	0.02	0.03	0.19	0.2	0.03	0.04	0.02	0.03	0.03
Economic	0.07	0.08	0.1	0.14	0.11	0.04	0.03	0.03	0.32	0.4	0.03	0.06	0.03	0.04	0.04
Social	0.26	0.26	0.28	0.54	0.29	0.14	0.1	0.09	1.39	1.28	0.15	0.61	0.15	0.80	0.96

This research used three-perspective form of crimes for ranking:

Security perspectives: In this vision security is important than others, and shows preference and weight in table 4.15. When comparing a pair of crime classification, a ratio of relative importance, preference of the factors can be established. Overall assessment for security perspectives and maps of ranking, density maps offer the map user a broader look at where crimes occur without his having to interpret a large number of individual locations shows in figure 4.

Block . No	Rank
1135	0.43
1134	0.42
1165	0.18
1094	0.17
1164	0.15
1162	0.14
1095	0.12
1093	0.11
1092	0.09
1091	0.08
1161	0.05
1131	0.04
1132	0.04
1133	0.04
1163	0.04

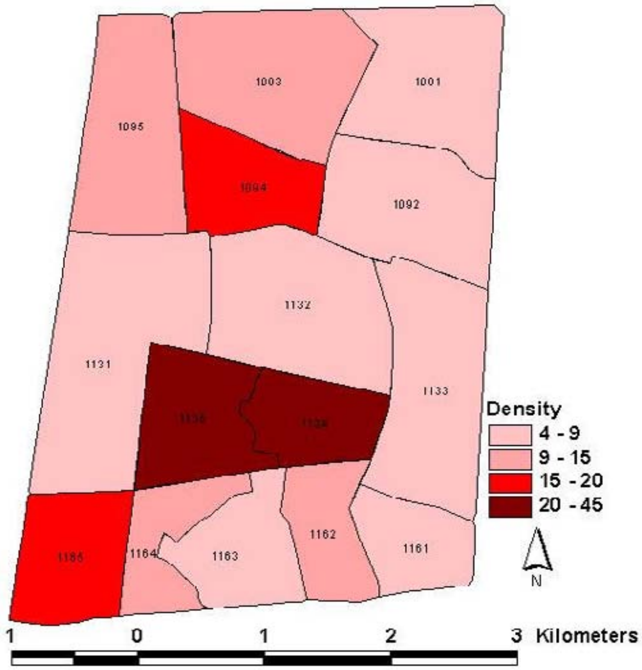


Figure 4.6 Overall assessment of crime density for security

- Economic perspectives: economic perspectives: this vision economic is important than others, and preference and weight are shown in table 4.16. Overall assessment for security perspectives and maps of ranking showed in figure 4.5.

Block. No	Rank
1135	0.51
1134	0.50
1165	0.24
1094	0.20
1164	0.20
1162	0.17
1095	0.13
1093	0.12
1091	0.10
1092	0.10
1131	0.05
1161	0.05
1163	0.05
1132	0.04
1133	0.04

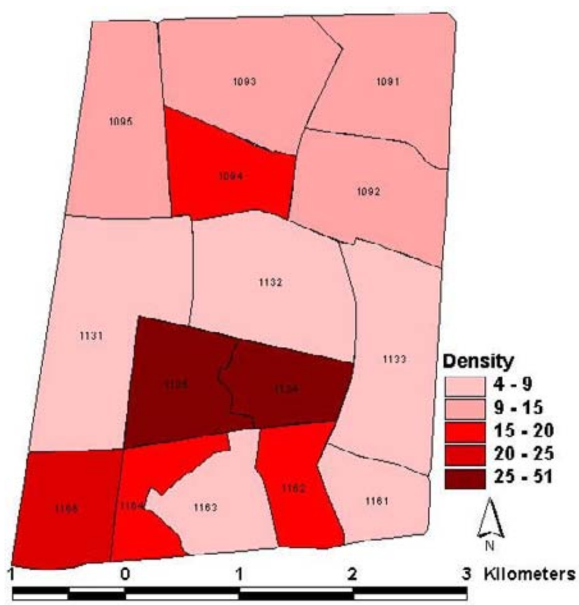


Figure 4.7 Overall assessment of crime density for economic

- Social perspectives: social perspectives: this vision social is important than others, and preference and weight are shown in table 4.17. Overall assessment for security perspectives and maps of ranking are shown in figure 4.5.

Block. No	Rank
1135	0.44
1134	0.41
1094	0.17
1165	0.16
1164	0.14
1162	0.13
1095	0.12
1093	0.11
1092	0.09
1091	0.08
1131	0.05
1132	0.04
1133	0.04
1161	0.04
1163	0.04

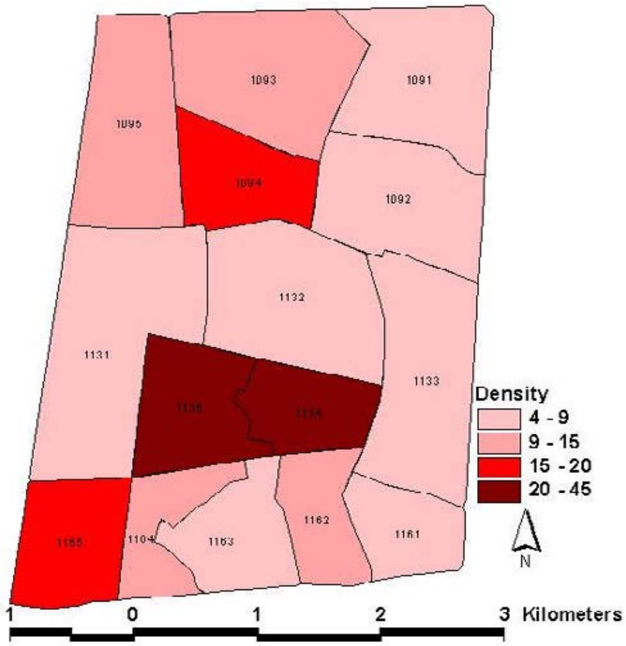
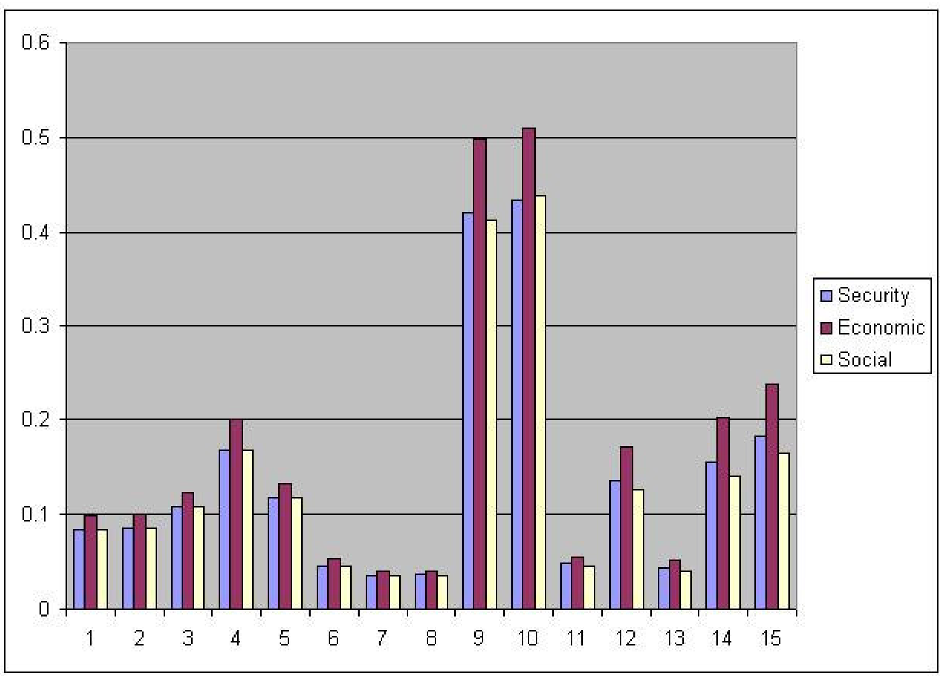


Figure 4.8 Overall assessment of crime density for social

The MCE approach was implemented on the types of crimes. The results are summarized in graph 4.2.

Block . No	Block
1091	1
1092	2
1093	3
1094	4
1095	5
1131	6
1132	7
1133	8
1134	9
1135	10
1161	11
1162	12
1163	13
1164	14
1165	15



Graph 4-2 Classify of crime value depend on three category

Based on the above mentioned reasons and compared three figures, the following shows the results: The reason for sudden crime increasing in block 1134 and 1135 from security, economic and social viewpoint can be follows:

- Frequent trade centres.
- High floating population.
- Time limit of traffic.

4.4. Analysis of the result

The most suitable locations for the police stations are selected based on closeness to the crime area. After interviewing a few police officers the value and effects of each crime was examined, depending on the behaviour of criminals, some might prefer quiet and some might prefer busy areas for their activities, therefore, if we transfer the different criminals behaviour on a chart, problem solving could be impossible due to complications.

In crime assessment, based on crime per block, mostly there is direct relationship between crime values and distance from police stations. Therefore, by increasing the number of new police stations, it is possible to reduce crime rate in the area located between the stations. But, in crime assessment based on density of crime, peaks occurred near the central business district and in the high population area. Therefore, by increasing the number of police officers, it is possible to reduce crime rate in these areas.

5. Analysis

The data used in this research is from a part of Tehran city police department. Purpose of this research is crime prevention by using different methods, focused on hold up, burglary, shoplifting, auto theft, fraud, robbery, pick pocket, theft from vehicle, abuse of confidence and addiction data, since these types of crimes are the major types of interest to the command structure of the police department.

Crime mapping can help law enforcement and protects citizens more effectively in the areas they serve. Simple maps display the locations where crimes or concentrations of crimes have occurred, and they can be used to help direct patrols to the places where they are most needed. Policy makers in police departments might use more complex maps to observe trends in criminal activities, and maps may have invaluable roles in solving criminal cases.

Result of multicriteria evaluation (crime assessment based on crime per block) for determined hot spots is shown as follow:

Table 5.1 Crime value of blocks

Block. No	Preference	Crime value
1091	1	7
1093	2	5
1161	3	5
1133	4	4
1135	5	4
1094	6	3
1131	7	3
1132	8	3
1162	9	2.5
1092	10	2
1134	11	2.5
1164	12	2
1165	13	2
1163	14	1.5
1095	15	2

Classification of crime value:

1. Hot spots with crime value >= 4.
2. Important spots with crime value=3.
3. Negligible spots with crime value<3.

For crime prevention the three following approaches were used:

- Concentration of police force in the hot spot areas.

- Finding suitable location for establishing new police stations.
- Relocation of current boundary of police stations, after established new police station..

Multicriteria evaluation was used to determine hot spots or areas with high concentration of crime. Highlighting such areas is the simplest way to help police to direct patrols to where they are most needed. Presence of police has positive effect on the reduction of crime (recent experiments in USA have good results as showed in BBC).
The following criteria will be used to find the suitable location for establishment of police stations. There are two methods to find suitable locations; one method is to query your data to identify locations that meet your criteria; the other method is to produce a suitability map through the combination of datasets to find out the suitability of each location in the area.

Criteria for establishing new police stations:

- Closeness to places with hotspot values
- Appropriate distance from existing police station
- Closeness to the main streets.

Suitability model
The aim of the model is to find optimum locations. A suitability model might identify suitable locations for a new police station.
Therefore the suitable locations can be founded for a new police station as follow:

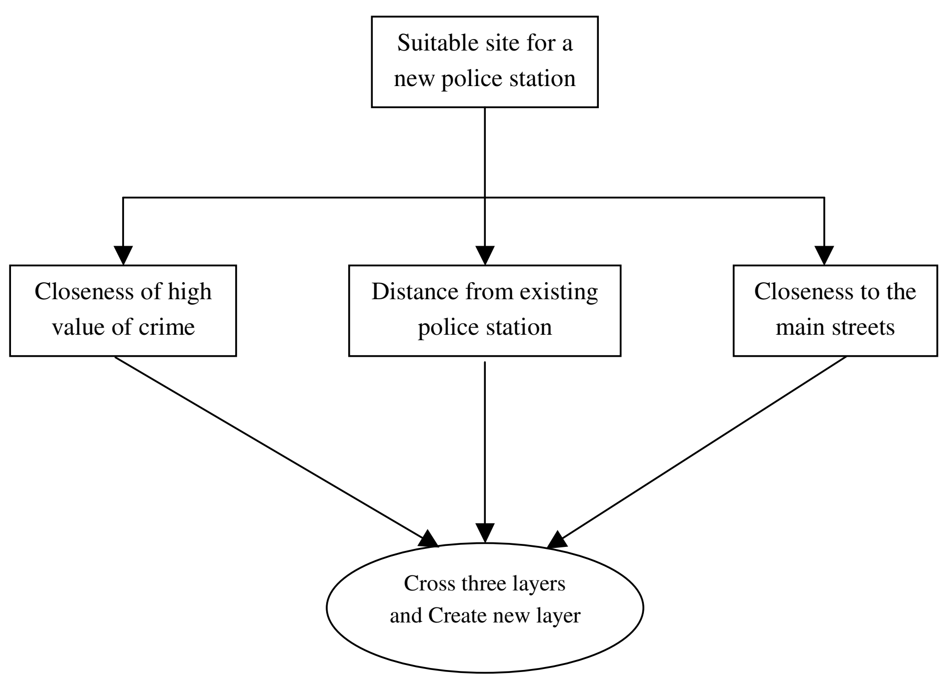


Figure 5.1 Method for establish new police station

Producing a suitability map

Figure 5.2(A) is a chloropleth map. It shows Crime rate based on block, and Figure 5.2(B) shows suitable distance around each police station, to find out areas beyond 50-meter buffer along main streets, suitable distance from existing police station, and within hot spot areas.

(A) (B)

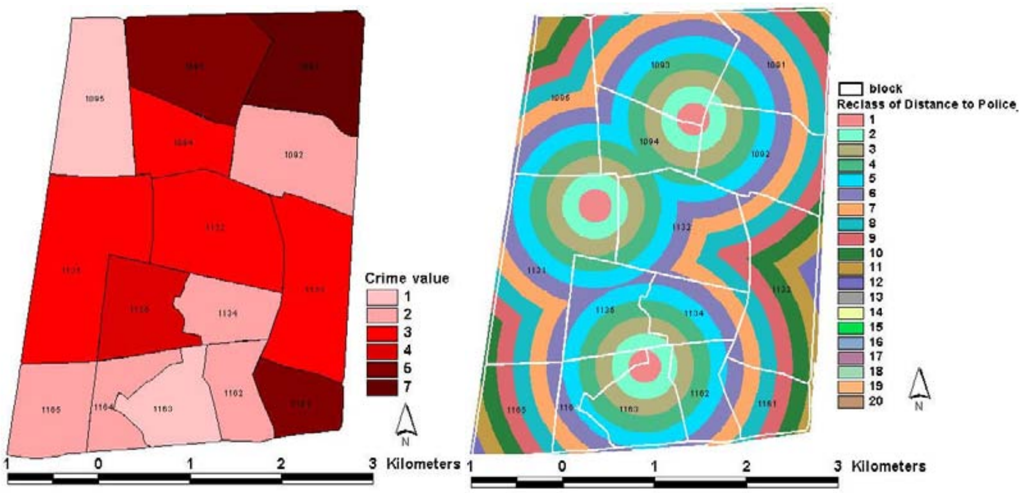
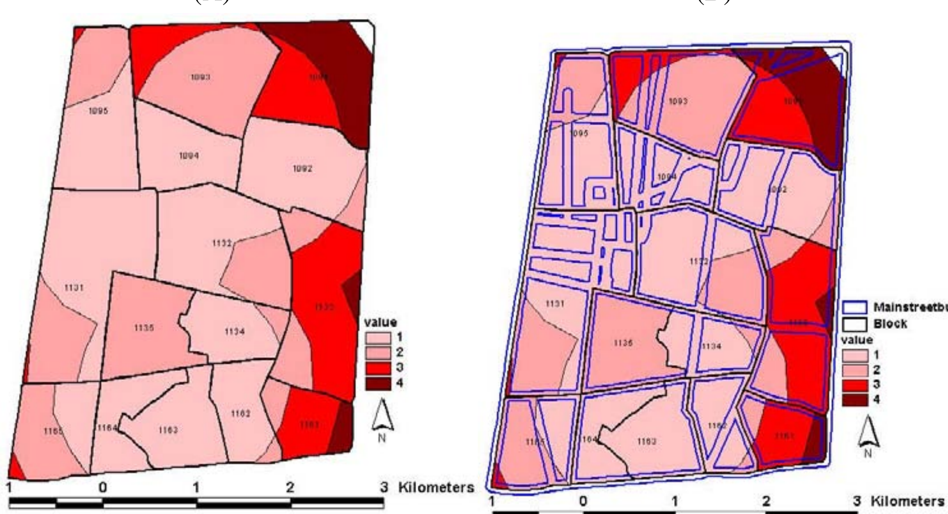


Figure 5.2 Show hotspots area in (A), and buffers of police stations (B)

The map shown in figure 5.3(A) is the result of map calculation of two layers (figures 5.2(A), 5.2(B)), and figure 5.3(B) shows result of map calculation and overlay with buffer of main-Street.

(A) (B)



0

Figure 5.3 Map calculation of hot spot and buffers of police station in (A), and overlay of map calculation with buffer of main streets in (B)

The final map shows that blocks no.1091, 1133, and 1161 have the highest potential for establishing new police station.

We should now assess these locations to see which might be the suitable location. This should be done in the field, as well as by examining the data we have on each potential area.

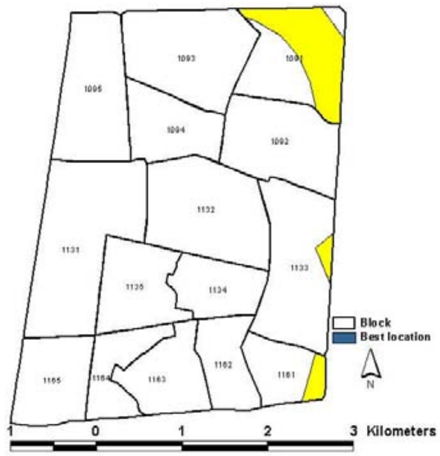


Figure 5.4 Suitable areas for new police station

From the above view, it is clear that the outer area represents the suitable areas for new police station. After identifying the suitable location for new police station, a method is required to relocate the police station boundaries, which in this study theissen polygon was used as shown in figure 5.5(A), which shows the relocation of boundary for establishing one new police station and in figure 5.5(B), which shows the relocation of boundary for establishing two new police station (used assign proximity).

(A) (B)

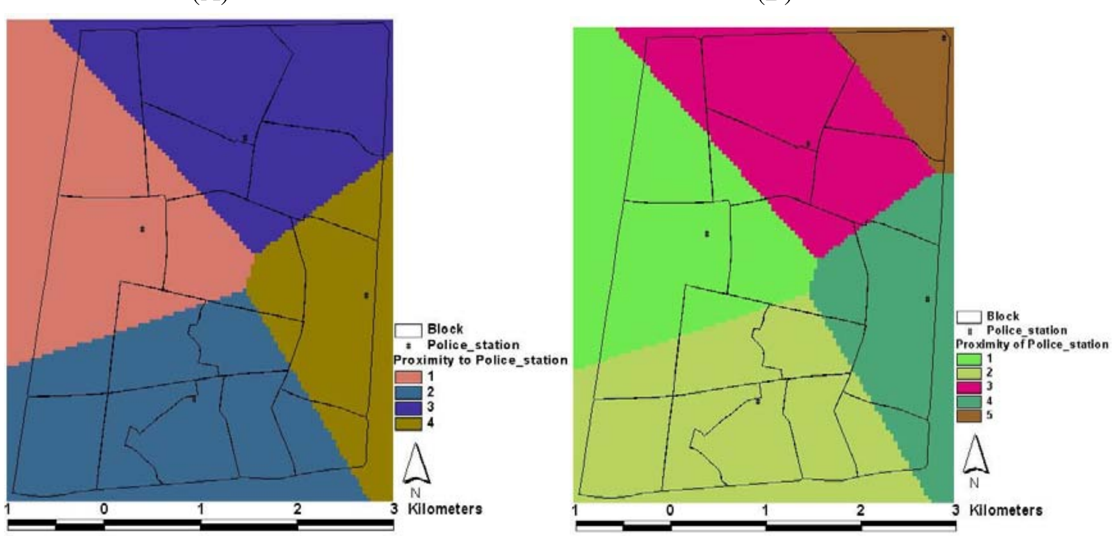


Figure 5.5 Relocation of boundary

A technique for spatial analysis is Voronoi diagrams, which has wide application in many disciplines. Voronoi diagrams or theissen polygons divide a mapped area into a number of polygons. Each polygon is constructed around a generating point. Almost all of the boundaries might be changed.
The main reason could be that, it is impossible for police department to relocate all of the boundaries of police station, therefore buffering method is used around suitable area as shown in figure 5.6, the result of buffering shows only relocation of boundaries in neighbouring blocks.

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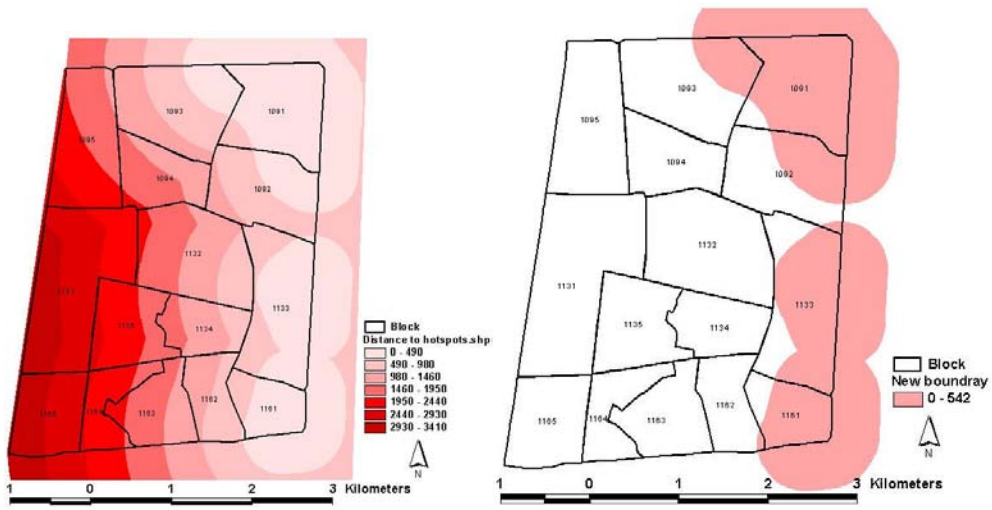

Figure 5.6 Suggestion of new boundary for establishing new police stations

6. Conclusion and Recommendation

6.1. concloution

Crime mapping and spatial analysis are important tools for mapping, analysis, and visualisation of crime data. Adapting spatial clustering (block) analysis to support crime analysis and decision-making. Law enforcement has been using these methods to examine the associations between crime and environment features, to allocate resources for crime prevention in areas where they are most needed.

This technique (crime includes of blocks) has several advantages:

- It is easy to calculate and the output is easy to explain.
- The block technique is precise and also flexible (precisely identifies which blocks have large amounts of crime and which one do not).
- Analysis at block level can still be very useful, by ranking the blocks based on crime value.

Limitation

- This technique does not handle small amount of data well.
- The size of the blocks may skew the data. Some blocks incorporate parks, while others refer only to small underpass areas. Large blocks, not surprisingly, often have a lot of crime, but may not be especially hotspots comparing to the areas with same size, that are divided into two or three blocks.

This technique is used because the advantages outweighed the shortcomings, useful tool for studying historic crime patterns, and provides a valuable foundation for exploring the associations between crime and socio-economic conditions. Regional crime analysis is powerful tool, and also easy-to-use in geographic information system because it contains mapping, analysis, and reporting tools for police officers, crime analysts, and police managers.

Good crime analysis should precede good crime prevention policy and planning. I believe that crime rate can be reduced through good management and it is as essential to 21st century policy, as it follows new information technology. If crime is not simply a function of individual pathology or inevitable cycles, then it can be affected by how and where resources are deployed, and by what strategies and tactics are employed. Goals must be set, and decisions must be based on good information.
Many of the most successful law enforcement agencies in other countries are using crime mapping, crime pattern analysis, and data-driven management to support community policing, problem solving, crime prevention and crime rate reduction.

6.2. Recommendation

- A system for recording crime data based on points is recommended.

- It is recommended to kernel density estimation, this method is used to generate a continuous crime density surface from crime point data. The analyst begins with a dot map of crime event. A particular benefit of this method is that unlike in block aggregation, the analysis is not limited to some arbitrary geographic boundary, and it is much easier to discern spatial patterns than a complex point map.
- It would be beautiful to use animation, changes in crime distributions over time and to relate these changes to crime prevention interventions in area. The animation works with crime density maps generated by kernel density, because they are visually appealing and easy to comprehend in the short time interval of the animation.

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Appendices

Appendex1: The form of crime incidents in blotters:

Number	Code of crime	Type of crime	Time	Rate of damage	Address
1	$\frac{66/1/50}{13-10-2002}$	Theft	16:40	1000$	No32, street Azadi
2	$\frac{60/5/150}{13-10-2002}$	Robbery	17	100$	No12, street Behboudi
3	$\frac{44/2/5}{13-10-2002}$	Fraud	17:25	100000$	No11, street Jomhori

Appendex2: Trade-off procedure

A trade-off procedure (keeney and Raiffa, 1979) can be used for the assessment of weights within a linear additive value function or as an approximation for a more complex value function. A trade-off procedure is based on trade-offs between the criteria. A decision maker has to answer questions of type:

- One unit of criterion C_1 is equally attractive as how much of criterion C_2.
- How much are we ready to spend (sacrifice) from C_1 in order to gain one unit of C_2.

By repeating these kind of question for all pairs of criteria the weights of all criteria can be determined.

Example

To clarify the calculations that have to be made assume a problem with three criteria (C_1, C_2, and C_3). The first question to be answered is: one unit of C_1 is equivalent to how many units of C_2? Assume the answer is 2. This results in the following question:

$C_1/C_2=2$

The second question to be answered is: one unit of C_2 is equivalent to how many units of C_3? Assume the answer is 1.5. This results in the following equation:

$C_2/C_3=3/2$

Now the two questions have been answered three equations leads us to the weights of the three criteria.

$$\left.\begin{cases} C1 = C2 \\ 2C2 = 3C3 \\ C1 + C2 + C3 = 1 \end{cases}\right\} \Rightarrow 2C2 + C2 + 2/3C2 = 1 \Leftrightarrow 11C2 = 3 \Leftrightarrow C2 = 3/11$$

$$\Rightarrow C1 = 2.3/11 = 6/11$$

$$\Rightarrow C3 = 2/3.3/11 = 2/11$$

Appendix3: Spatial function

Spatial function is an operation for performing spatial analysis. All spatial operations on the spatial analyst user interface are classified as spatial functions, for example: distance, slope, or density.