GIS Technologies in Crime Analysis and Crime Mapping

M. Vijaya Kumar, C. Chandrasekar

Abstract— Common and geographic issues, such as location of Apartments or neighbourhoods' with different financial status within an area, can manipulate the patterns and rate of crime incidents in that area. Crime analysis and crime mapping, achieved by GIS, have a major role in reducing crime and improving the effective police activities. Chennai district includes significant attentions of evening, late-night and shopping occasions in Tamil Nadu. Using knowledge such as where and when crime occurs, this paper highlights what the inputs and outputs of crime analysis could be. The relationship between financial characteristics and crime rate for police areas of Tamil Nadu was inquired in to. Then, spatial GIS analyses using Spatial Analyst, Hotspot Analysis was performed. The findings of this paper give the possible incident sites.

Index Terms— Crime analysis, Hotspot analysis, data manipulation, spatial crime distribution

I. INTRODUCTION

The rate of crime events is increasing in all developing countries due to transform of capability and majestic lifestyle and also due to poor socio, political, and environmental conditions. The sharing of incidents across the landscape is not geographically chance since incidents are human incident. Several factors, including the attract of potential targets and simple geographic convenience for an offender, influence where people select to break the law.

Naturally crime does not disappear by itself. Police departments are on the duty of defending the citizen's safety and taking precautions to minimize the risk of crime. It's long been common practice for the police to identify locations and times that are more liable to criminal activity .To reduce or eliminate the crime, some actions, such as crime prevention methods, ought to be taken. Crime prevention can be signified as a set of ideas for combating incident and includes the activities taken by individuals and groups, both public and private.

The first step of crime avoidance is to analyze the current status of incidents such as determining the density or pattern of the events. Claims that the finding that event often concentrates in positive locations may be an effective beginning point for crime analysis. Define highest incident density areas as "hotspots" In this paper the identification of a hotspot is punctual analysis to expose what factors make a location a great spot for crime.

These are an suitable target, a motivated offender and an absence of guardians. Besides these criteria the acceptable

land use and suitable time could be added in to the reasons of incidents. In this paper Relationship between land use, time and incidents in their studies. Particular areas may be dedicated to different types of land use based on its land use type the activities and population outline of an area may vary considerably according to the day of the week or time of day.

The usage of Geographic Knowledge Systems in knowledge storage, direction and display makes incident avoidance method more manageable, more practical and case specific. The results of GIS give an plan about the present position of occurrence crime. Due to its spatial operation capability, GIS helps police and also other individuals who have an interest in events, to imagine and analyze the spatial associations between different crime types such as events and land use, to forecast for future incidents.

The knowledge derived through GIS provides a simple geographic gathering (e.g., indicate the location of all events that occurred within a sure time age in a specific location) or display different spatial prototypes (e.g., the locations of burglaries may vary by the time of day late-night event locations may differ greatly from midday event locations) or presents the results of more composite analyses.

Using information, which are recorded by the Chennai city police in 2007, including the spatial and temporal information of events, this paper highlights the high-event areas and the relationship between events and land use for two important police areas of Chennai District of Tamil Nadu; Centre of North Police Station Zone and South Police Station Zone. The land use data used in the study are the land use types which are generated by digitizing ICONS 1m resolution colored Kernel Density map descriptions.

This paper attempts to apply spatial data analysis join together with GIS and analyze what land uses are Apartments to event and why event is higher in one area than another. Knowing even these two essential facts; time and Space; show that many problems cluster in certain time and location.

II. MOST IMPORTANT IDEA OF CRIME AND CRIME EVENTS

Crime is a complete design that can be defined in authorized and non- authorized intelligence. An executive point of view, it refers to violates of the criminal laws that govern particular geographic areas and are aimed at securing the lives, property and rights of citizens within those commands. A crime is a criminal act against a person (for example, murder and sexual assault), or his/her property (for example, theft and property destroy) and regulation (for example, traffic violations).

Non-legal point of view would define crime as acts that violate collectively accepted rules of moral behaviour. As the respectable principles that support the concept of crime are subject to steady changing over time, the types of behaviour defined by the official technique as criminal may also alter. Examples of behaviours that have been de-criminalized in some authorities include abortion, tried suicide and gay intercourse. Other behaviours, such as tax equivocation or credit card fraud, have been criminalized over time.

There are lots of reasons for occurring crime. Victim's actual or perceived race, color, religion, nationality, country of origin, disability, economic standing, gender or sexual orientation create the offender to interrupt the criminal law. But incident is that the act of violating a certain or implied security owner. Inquiring in to the causes or beginnings of crime needs lots of researches by several disciplines like psychology, criminology or unemployment, age, household size, history of receiving public help are solely few samples of the possible effects of crime. Some reasons that have effects on the amount and kind of crime occurring from place to position are given below

- Population density and amount of urbanization with dimension, locality and its border area.
- Differences in masterpiece of the population, particularly childhood concentration.
- strength of population with respect to residents' mobility, commuting patterns, and transient factors.
- Modes of transportation and highway system.
- Economic conditions, including median income, poverty level, and job availability.
- Cultural factors, educational, recreational and religious characteristics.
- Family conditions with respect to divorce and family cohesiveness.
- Climate.
- Effective strength of law enforcement agencies.
- Administrative and investigative emphases of law enforcement.
- Policies of other components of the criminal justice system (e.g. prosecutorial, judicial, correctional, and probational).
- Citizens' attitudes toward crime.
- Crime reporting practices of the citizens.

However the paper does not take in hand the reasons of crime or socioeconomic position of the criminal. It deals with the spatial and temporal pattern of events such as when and where events occur and how spatial reasons achieve crime locations determination.

III. THE RELATIONSHIP BETWEEN EVENTS AND CRIME PLACES

An important feature for the geographic analysis of crime is the understanding that event does not occur in accidental or unpredictable locations. Rather, criminal offences occur in evident structures that are prejudiced by the landscape in which they occur, and the psychological factors that read out the offender's movement. It is this maxim that makes geographic profiling as a powerful investigative tool.

Analyzing crime events using geography has extensive been a valuable resource for the criminal investigative procedure. With records dating back as far as the 80s, sociologists and criminologists have long unstated the role of geography as a primary component of crime. By the early 90, people began to understand the advantage of using wall-sized pin-maps that detailed the allocation of crime events. By incorporating these maps within their Investigations, detectives were able to visualize and look at crime in relation to its neighbouring landscape.

While building police pounds the districts or survey areas are usually divided according to boundaries of survey zones or apartment houses. But the rank of service needed, number of events and also the land use are more important reasons that must to be looked at while locating the police beats. In addition dividing the beats based on only demographics, may outcomes the resources being allocated improperly. Because there may be several areas where there's thousand populations but they generate few calls for service, while there's less people that need much greater levels of service.

Many authors like Block (1998), mentioned the relationship between incident and land use. Issues given below have an influence on the location, time, type and rate of the incident:

- Land use data sets containing information on each parcel of land in the city (for example, vacant or not, abandoned or not, residential or commercial, state of repair, specific function such as tavern or convenience store, and so on)
- Public transit data sets (train or bus stops and routes)
- Schools (grammar, high schools, private)
- Community organizations (block clubs, religious centers, social service agencies)
- Parks and other open areas (with park roads, field houses, lagoons)
- Emergency locations (hospitals, fire houses, police stations)
- Public housing (by type, showing roads and play lots)
- Places holding liquor licenses (by type of establishment and licence)
- Census data

In this case the following analysis may be generated in order to identify the incident pattern (Canter, 1998; Block 1998):

- identify areas that may likely be targeted by an offender;
- determine whether common attributes exits among a group of reported cases
- explore relationships between incident and other geographic features such as land use and the built environment
- study the movement of offenders to predict the location of future targets to establish interdiction locations along escape routes
- detect whether the incident locations are clustered

- determine if incidents tend to be located close to a specific location such as taverns or gang territories or the periphery of a county or in the centre

IV. GIS IN EVENT ANALYSIS

The location of an incident and any other geographic features associated with a criminal event are important attribute features. They can provide clues for identifying the suspects, assist in the design of prevention or apprehension strategies, aid in the evaluation of programs, and help gain a better understanding of environmental factors that may affect the incident.

Police analysts are particularly interested in identifying incident patterns and determining whether these patterns are randomly distributed due to chance, or if there is a tendency for a set of cases to statistically group or cluster. In this case they try to identify the areas of the highest incident concentration.

In order to examine the spatial distribution of incident locations, police places pushpins in wall maps (Canter, 1998). In the maps which contain all of the streets for an area of interest such as a police precinct or a municipality, incident locations are usually represented by a pin. Thus the relationship between a specific point location such as street robbery to other geographic features such as bus cease or shopping middle could be determined.

However because of the increase in the number of incidents the amount of hard work for maintaining pin maps by hand, become difficult and problematic. The limitations of the manual pin mapping compromise the geographic accuracy of the incident locations. Since the geographic location of an incident on a pin map is not quantifiable, analysts are unable to check hypotheses about the spatial distribution of incident. The maps require to be periodically updated for new roads or other geographic features. Thus it is inescapable that police needs to make use of GIS to support incident mapping and analysis.

With GIS, police can produce more versatile electronic maps by combining their databases of reported incident locations with digitized maps of the areas they serve. GIS opens new opportunities for the use of digital mapping in incident control and prevention programs. GIS allows police personnel to make designs effectively for emergency response, decide mitigation priorities, analyze historical events, and predict future events; it helps crime officers to decide potential incident sites & facilitates to explore the relationship between incident and land use.

V. DEFINITION OF THE STUDY AREA

The study area is comprised of two police precincts of Tamil Nadu, South Chennai Police Station Zone and North Chennai Police Station Zone. Centre of Tamil Nadu Police Station Zone includes 15 neighbourhoods and the second zone includes 4 neighbourhoods.

District of Chennai has significant concentrations of evening and late-night leisure areas. These properties of the district influence the rate and location of incidents. Especially South Chennai which is the city centre of Tamil Nadu, and surrounding neighbourhoods have many entertainment functions and shopping opportunities. In addition, land use type such as residential and income level make Bahcelievler neighbourhood an attractive area for incidents. Therefore Centre of South Chennai Police Station Zone and Bahcelievler Police Station Zone were chosen as a case study area.

VI. DATA USED IN THE STUDY

Data used in the study are compiled from government Quters and private Promoters Apartments in Tamil Nadu. Spatial and temporal information regarding two incidents were obtained from Tamil Nadu Police Directorate. The data include the incidents that occurred in 2007 and recorded by the police stations in Tamil Nadu. The incident data are classified as murder, usurp, burglary, auto and pickpocket with their detail information as incident location address, occurrence time.

The other data that include the land use types were obtained by digitizing the Kernal density Maps that were acquired in 2007. The image that was collected by GOOGLE Chennai Maps was provided The data include the information of roads, landmarks, residential and commercial areas.

The socioeconomic data which were provided by State Institution of Statistics include population, income level, employed-unemployed rate, literacy and the size of households.

VII. EXPLORING THE RELATIONSHIP BETWEEN PROPERTY POPULATIONS CHARACTERISTICS AND CRIME RATE

According to socioeconomic information and crime rates of the districts, thematic maps were prepared to see the relationship between them. Even though many studies have demonstrated that low socioeconomic status is a cause of crime, figures do not show a clear relationship between crime rate and socioeconomic conditions in the district of Chennai. Since Chennai has a dense population; the other socioeconomic values are accordingly higher in Chennai, except education and household status which are the reverse. However highest crime rate is seen in Chennai. Although relations are not very strong it can be said that, higher the population density, higher the crime rate; higher the income level, higher the crime rate (naturally burglars prefer rich places); higher the unemployment rate, higher the crime rate; lower the education level, higher the crime rate; larger the household size, higher the crime rate (Figure 1).
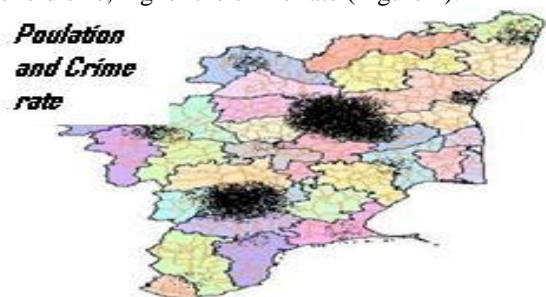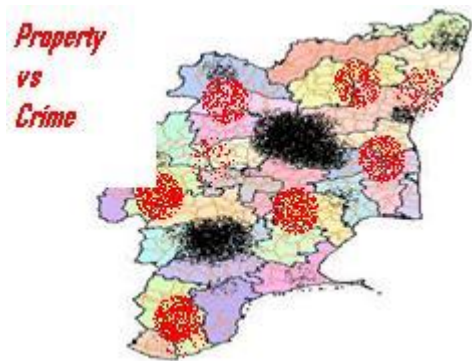
Figure1. The Relationship between Population and property Crime Rate.

In order to examine the socioeconomic characteristics of the main study area in Chennai, thematic maps are generated for the neighborhoods. In the study area that includes the two important police precincts, left part which is mostly covered by residential areas is naturally denser than the right part which is mostly covered by commercial areas. According to the income level, the neighborhoods are generally in moderate level.

VIII. TEMPORAL AND SPATIAL DISTRIBUTION OF THE INCIDENTS

In the study area, most cases of burglary occurred at a higher rate compared to the types of incidents (Table 1). Theft of office and home are the most widely seen incidents in this type. Then follows the pickpocket incidents of auto (auto theft and auto theft). The incidents of murder and appropriate have lower rates.

Table1. event Types

Incident Types	Numbers
Burglary	1045
Auto	370
Pick Pocket	361

The temporal pattern of incidents was considered in terms of day of week and time of event. Figure 2 shows the days and times of the day in which the levels of incidents are mostly based on types of incidents.
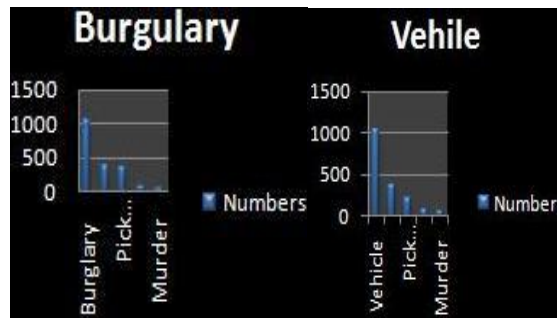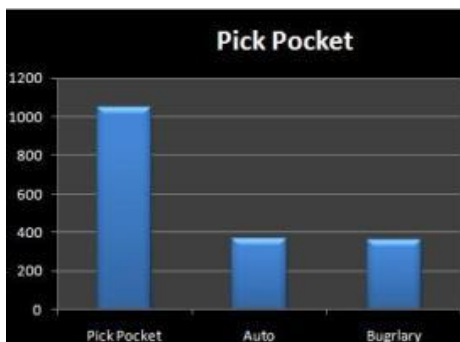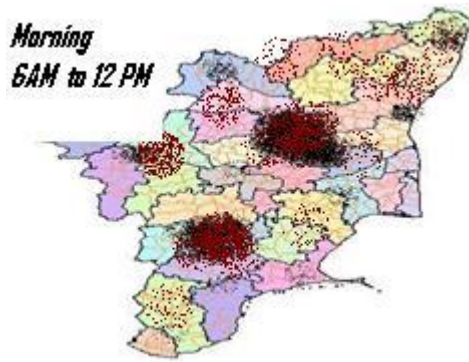

Figure 2. The Date of the Occurrence of the Incident.

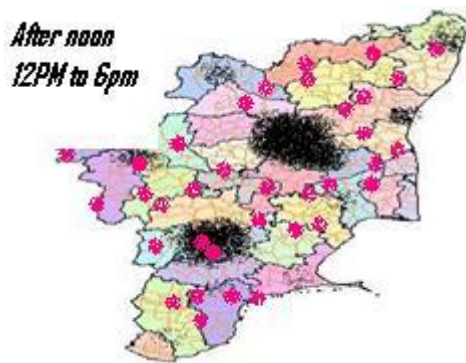In order to analyze the hourly pattern of occurrence of incident, the time is investigated in 3 groups (Figure 3).

Time 12:00PM-05:59AM

Incident Types	Numbers
Burglary	415
Auto	146
Pick Pocket	19

Time 06:00AM-12:00PM

Incident Types	Numbers
Burglary	333
Auto	100
Pick Pocket	245

Time 12:00PM-06:00PM

Incident Types	Numbers
Burglary	297
Auto	124
Pick Pocket	97

Figure 3. The Time Period of the Occurrence of the Incidents

In order to analyze the spatial distribution of incidents, in other words determine the hotspot areas, there are many methods using the capabilities of ArcGIS. One of them is generating Kernel Density maps.
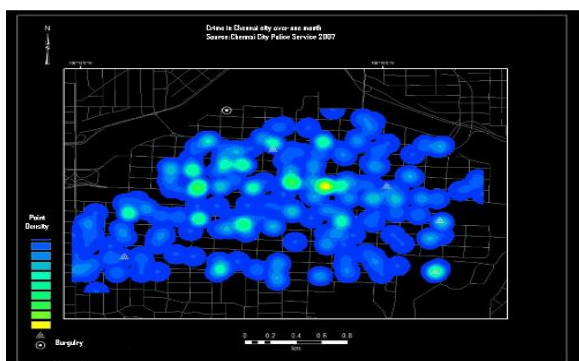

Figure 4. Density Analysis by Kernel Estimation

This used for determining the hotspot areas is kernel estimation which is performed by Density Analysis in ArcGIS (Figure 4). Kernel estimation was originally developed to obtain a smooth estimate of a univariate or multivariate probability density from an observed sample of observations (Bailey and Gatrell, 1995).

Most of the police analysts in developed countries identify a high-incident area by the method of standard deviational ellipse. The standard deviational ellipse is computed using the Illinois Criminal Justice Authority's Spatial and Temporal Analysis of Crime (STAC) program (Figure 5). It is a spatial statistics program for the analysis of incident locations developed by Ned Levine and Associates under grants from National Institute of Justice, and has also a new version called Crime Stat II.

CrimeStat is a spatial statistics package that can analyze crime incident location data and it is able to link to GIS software. By using CrimeStat it is easy to detect the hotspot areas.

Generating hotspot areas is possible with an input that includes x, y coordinate pairs for each incident location, a search radius, and a set of parameters used to define the search area. For mapping, each of these dense clusters is bounded by the best-fitting standard deviational ellipse (ICJIA, 1996).
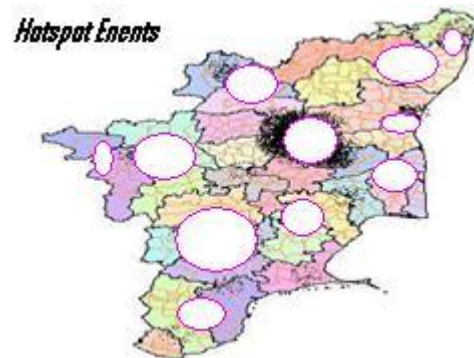

Figure5. Hotspot Areas by STAC

There is an interesting comparison by overlaying the STAC ellipses on the kernel density result. As shown in Figure 6 there is some correspondence between some of the clusters and the higher elevation densities, but not at all. In part, this may due to the different densities in the clusters.
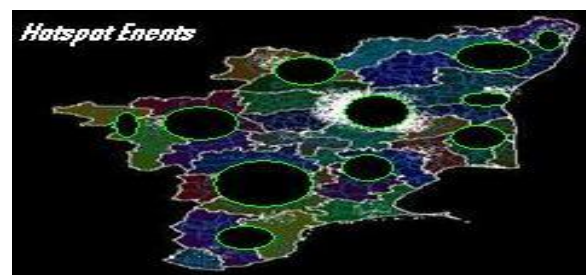

Figure6. Density Map

IX. ANALYSES CARRIED FOR DETERMINING THE RELATIONSHIP BETWEEN LAND USE AND INCIDENTS

The rate of the incidents changes based on the type of the location means land use. Figure 7 indicates that the locations with more offices and houses have higher number of incidents. This is the result of most of the incidents' being as burglary type. Then common usage places such as streets and roads are following, since the pick pocket type has also higher rate.

Place	Events
Bank	3
Bar	19
Building inside	21
House Inside	48
Hospital	19
Office	5
Restaurant	36
Park	25
Apartments	37

Figure 7. The Place of the Occurrence of the Incident

Whether the events take place inside the houses or on the streets, an assessment of the exact location of events expose that their overall allocation clearly returns the location of residential and commercial areas. Also exact locations such as apartments, major roads, police stations and the distance to these places are the attract places for the events. For this reason, besides residential and commercial areas, these specific locations were selected to be inspected in detail.

In addition to the number and type of events in the commercial and residential areas, the same information within 500 meter distance of Apartments were also determined by hotspot Analysis (Figure 8).
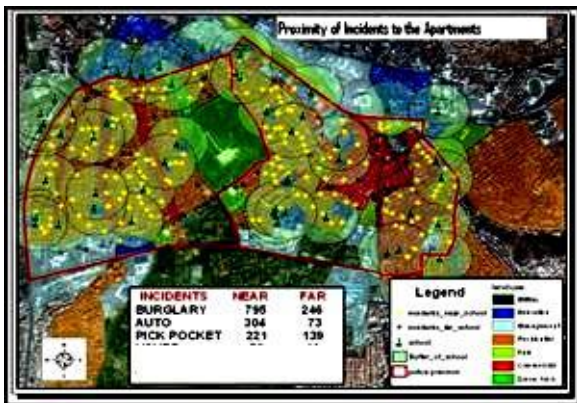

Figure 8. Proximity of Incidents

Likewise how many crimes and what types of crimes were happening within 100 meter of key Apartments are determined. One reason for choosing key Apartments is when it is the main strip; the escaping ways are limited compared to the centre area of networks where there are lots of bend and rotate which make the runaway an easier one. Also patrolling will be additional in case of main roads.

Naturally events take place remote from the police stations.

To see the difference between the numbers of crimes far and near the police stations, same analysis were achieved (Table 2).

Land Use	Burglary		Auto		Pick Pocket		Total	
	Near	Far	Near	Far	Near	Far	Near	Far
Residential	499	542	204	173	70	290	813	1097
Commercial	486	555	138	239	262	98	961	949
Schools	795	246	304	73	221	139	1417	493
Major Roads	451	590	136	241	217	143	891	1019
Police Stations	92	949	19	358	28	332	157	1753

Table 2. The number of Incidents based on the distance to Locations

Based on these analyses, possible events locations and thus suitable areas for a police station could be identified by using comparable analyses in ArcGIS. Distance Analysis, and Raster Calculation are the tools which are used for detecting the potential events areas. After Distance Analysis was obtaining according to the buffers that were executed for Residential, police stations and major apartments, they were reclassified. In the reclassification higher values specify that particular variable's value is risky for events. It means the criteria that have result on incident rate and position were given 10, shown in shady colours and the others, which have fewer effects, were given measured numbers, shown in lighter colours (Figure 9).
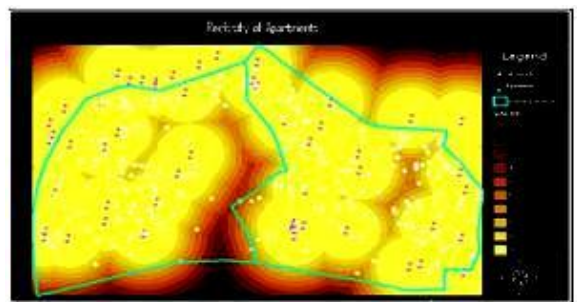

Figure 10. Distance Analysis and Reclassify of Apartments

X. CONCLUSION

This study has emphasized the value of using a combination of different types of information in identifying the patterns of crime by analyzing a range of variables recorded by the police, relating to where and when incident occurs.

For the two police areas the locations of police stations should be reshaped according to the results of this analysis, which confirm that some districts are not managed successfully.

Main verdicts of this paper can be classified into two ideas. The first one is on the parts of GIS based techniques in event allotment analysis. The second one is on the relationship between event positions and land use.

In the development of determining the association between event and space use, hotspot areas are determined in some exact locations. This is why the relationship between event and space use is examined.

Further studies may spotlight directly on objective propose components of crime prevention. The objective characteristics of an area can control the activities of both residents and possible criminals. Increased lighting, use of surveillance tools, access control, alarms and other objective changes are planned to bring about greater communal cohesion, citizen fear and association, and eventually, reduce crime and fear of crime.

It is also examined that the capability of GIS such as overseeing data, classifying in different spatial units, providing immediate and purpose results and linking the spatial and other class of information produce better results of event analysis.

The results of this paper demonstrated that using GIS is useful for event analysis. GIS has much potential in event mapping and analysis. It allows police personnel to map effectively for crisis reply, determine improvement priority, analyze past events, and predict future events; it helps crime officers to determine possible event locations.

As a conclusion an accepting of anywhere and why crimes happen can improve challenges fighting crime. Mapping crime helps to decrease and avoid crime, reduce distress by victims, punish responsible and recognize crime travel areas.

REFERENCES

1. HOME DEPARTMENT TAMIL NADU POLICE POLICY NOTE FOR 2006-2007.Tamil Nadu Police Service Annual Statistical Report 2006 – 2007. Statistical Summary.
2. Impact Assessment of Modernization of Police Forces (MPF) (From 2000 to 2010). Bureau of Police Research and Development Ministry of Home Affairs 2010
3. EXECUTIVE SUMMARY of Tamil Nadu Police Statistical Report 2002 – 2009. Statistical Summary.
4. CRIME REVIEW TAMIL NADU 2007. State Crime Records Bureau Crime CID, Chennai Tamil Nadu.
5. Tamil Nadu Police Website http://www.tnpolice.gov.in/
6. *Crime Mapping in India: A GIS implementation in Chennai City Policing*, Geographic Information Sciences, Vol.10, No1, June 2004. Jaishankar K., and Debarati.
7. Chennai City Map: http://www.mapsofindia.com/maps/tamilnadu/chennai-map.htm
8. E. Akpinar, N. Usul "Geographic Information Systems Technologies in Crime Analysis and Crime Mapping", proceedings. ESRI.
9. Canter, P.R. (1998) "Geographic Information Systems and Crime Analysis in Baltimore Country, Maryland" in **Crime Mapping and Crime Prevention,** Weisburd, D. and McEwen T. (eds.), Criminal Justice Press, Monsey, New York, USA, 157-190.
10. Chaffin, J. W. (2004) Criminal Intelligence Analyst, Hillsborough County Sheriff's Office, Hillsborough County Traffic Crash Management System, Traffic Analysis Program, Tampa, FL, interview on 4th March 2004.
11. Cohen, L.E and Felson, M. (1979) Social Change and Crime Rate Trends: A Routine Activity Approach, American Sociological Review.
12. ICJIA (Illinois Criminal Justice Information Authority) (1996) Spatial and Temporal Analysis of Crime Program (STAC) User Manual, Chicago.
13. Lab P. S. (2000) Crime Prevention: Approaches, Practices and Evaluations, Anderson Publishing Co., Cincinnati,OH.
14. Ractiffe, J.H. and McCullagh, M.J. (1999) "Hotbeds of crime and the search for spatial accuracy", Geographical Systems, 1, 385-398.
15. Weisburd, D and McEwen, T. (1998) Crime Mapping and Crime Prevention, Crime Prevention Studies, Vol. 8, Criminal Justice Press, Monsey, New York, USA
16. Wieczorek, W. and Hanson, C. E. (1997) "New Modeling Methods, Geographic Information Systems and Spatial Analysis", Journal of Alcohol Health and Research World, Vol. 21 (4), pp. 331-339.