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Crime Mapping in India: A GIS Implementation in Chennai City Policing*

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Abstract

In India, though the Police agencies of Bangalore, Hyderabad, Goa, Mumbai, Delhi, Kolkata, Chennai and Trivandrum use customized GIS, its application is still in a rudimentary stage. There is a felt need for the fullest application of this potent technology in Indian policing. Hence, researchers in the University of Madras collaborated with the Chennai Police department and developed this study. This research work was submitted to the Police Commissioner, Chennai city and was implemented. The findings of this study showed that, using GIS is a much more compatible means of crime pattern analysis than current processes because of its geographic referencing capabilities. This research has provided valuable information concerning property crimes in Chennai city, including data on the social and physical characteristics of these areas that contribute to localized criminal activity.

I. INTRODUCTION

In India, the Police agencies of Bangalore, Hyderabad, Goa, Mumbai, Delhi, Kolkata, Chennai and Trivandrum use customized GIS. Most of these GIS implementations are done by private organizations. Still, the application of GIS in policing is in a rudimentary stage. There is a felt need for the fullest application of this potent technology in Indian policing. Hence, researchers in the University of Madras collaborated with the Chennai Police department and developed this study.

The aim of this study is to analyze the crime scenario of Chennai City using GIS technology. Various GIS techniques were used for analysis and several maps were prepared (*Due to space limitations only few maps are presented in this article*). In the description and analysis of these maps the researchers succeeded in identifying hotspots of crime, the proximity of crimes with police stations, displacement of crime, and illustrating the relationship between the mapped crime pattern and the socio-economic characteristics of the city. This research work was submitted to the Police Commissioner, Chennai City and was implemented.

The present study is a base level logical model for the implementation of GIS in Indian Policing. This study also outlines obstacles, opportunities, and action steps relevant to the application of GIS technology and tries to build some strategies for its implementation in Indian police departments. This study will be helpful in charting out framework for police

patrol planning and preventive measures. This research work can be utilized to understand the hot spots of crimes and criminals and in the reduction of such hot spots in future. Since, the utilization of high-end technologies such as GIS and GPS in Indian policing is catching up and the use of GIS based data analysis can be useful to the police across the major cities to tackle the increasing crime scenario.

II. STUDY AREA

The study area is Chennai City (Figure 1). It lies in between Latitude 28°35' N, Longitude 77°12'E. Chennai (*formerly Madras*) is the fourth largest city in India - outranked by New Delhi, Mumbai and Kolkata and the capital of Tamil Nadu State. The size of study area is about 172-km² urban area and the Population is 5.36 million. Located on a 17 km stretch of the Coromandel coast, the city is trisected by the rivers *Cooum* and *Adyar* and the *Buckingham Canal*. Chennai is a city that is growing, expanding, and changing every year. Chennai represents a culture that is distinctly different from that of northern India. Music, dance, and all other art forms of the South are cherished and nurtured in this city, which, though industrialized, continues to be traditional and conventional in many ways. Property Crime rate is always higher in Chennai city. Normally, every year the rate of house breaking would be around an average of 1,500 and above in Chennai city alone. However, the recent crime graph (2003) has shown a historic downfall compared to yesteryear.

*Revised version of the paper titled "Crime Analysis Mapping in India: A GIS implementation in Chennai city", presented in the Fifth International Crime Mapping Research Conference held in Texas, Dallas, USA, on 4th December 2001.

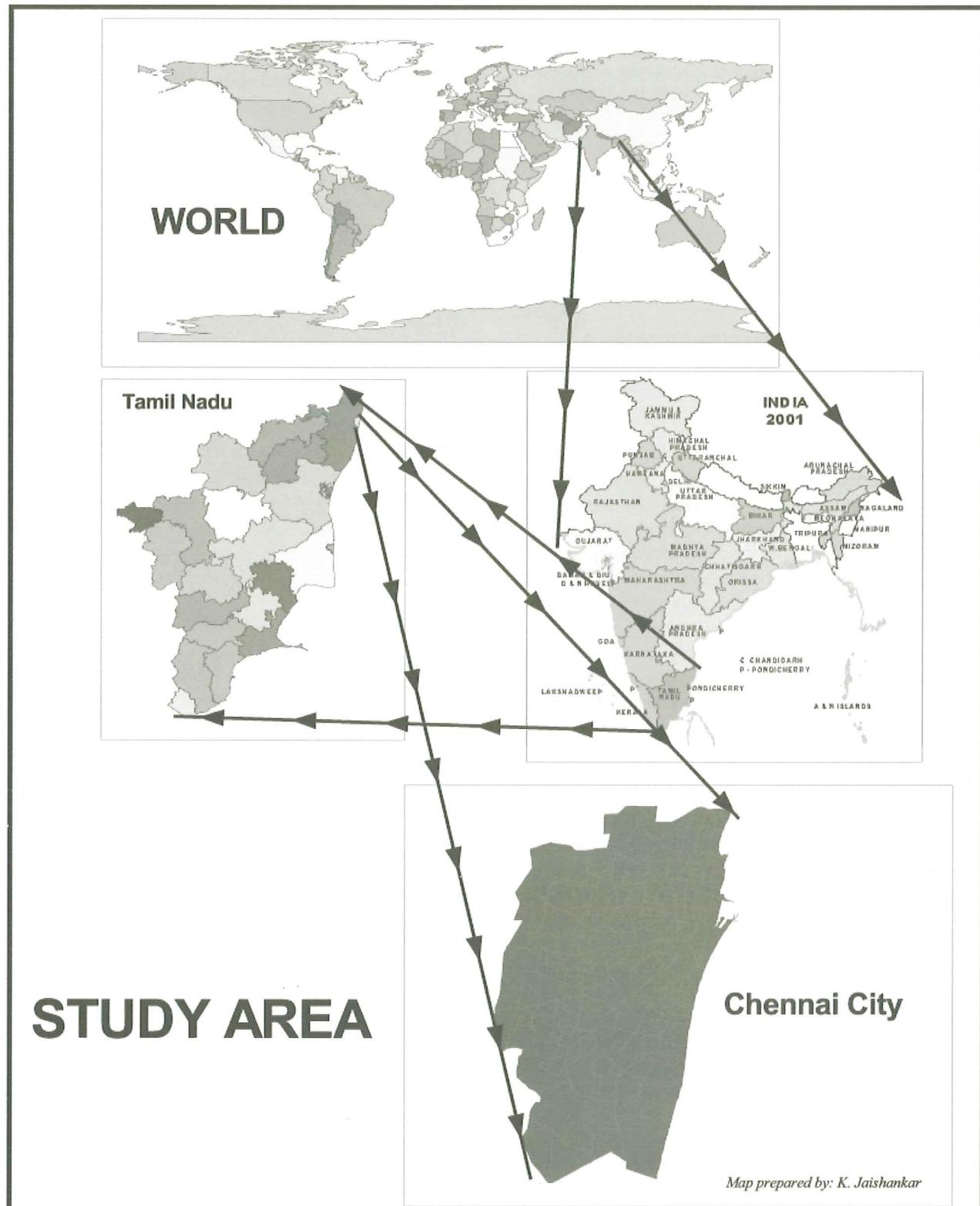


Figure 1.

III. OBJECTIVES OF THE STUDY

- To create a spatial and attribute database for the crime scenario of Chennai City in a GIS environment
- To identify hot spots and analyze spatio-temporal

- patterns of crimes of Chennai City
- To highlight the potency of GIS as a mapping and analytical tool for Indian policing.

IV. CRIMINOLOGIC QUESTIONS

The research sought to determine if GIS could be used to generate data useful for answering the following questions:

- Where are the property crimes occurring in Chennai City?
- Where are the criminals residing?
- Does the residence of the criminal and place of occurrence of crime vary?
- Which are the crime prone localities in Chennai City?
- Which are the criminal prone localities in Chennai City?
- Is there any proximity of crimes with police stations?
- Is there any spatial variation in property crimes occurring in Chennai City?
- Is there any temporal variation in crimes occurring in Chennai City?
- Is there any displacement in crimes temporally in a particular area?

V. DESCRIPTION OF DATA USED

The present study mainly relied on the data obtained from the Crime Records Bureau, Chennai city. Data pertaining to the property offences were taken for the years 1997 and 1999. The crime data were classified under the group of property offences as *robbery, grave theft (Theft of more than Rupees one million), house breaking (day), house breaking (Night), chain snatching, and automobile theft*. The crime data were collected with the support of the Commissioner of Police, from the State Crime Records Bureau, Chennai City. Census data and ward map were collected from the Municipal Corporation of Chennai.

VI. LIMITATIONS OF THE STUDY

Police boundary map was not available with the Commissioner of police, Chennai city. Since it was difficult to visit all the 75 stations in a short span to get individual boundaries for preparing a final zone map, the police boundaries could not be prepared. The idea of optimizing the police district boundaries in terms of its general location and in terms of its infrastructure also had to be dropped due to the time limitations. Hence, only ward map (Municipal boundaries), which was readily available with the Municipal commissioner, was utilized for the study. In future studies this issue will be taken into account and police boundary map will be used. Though there might be minor error in the locating the police stations, care has been taken to ensure that, all the police stations were located properly. In future, GPS will be used to locate the exact locations of the police stations and crime incidents. Due to the non-availability of a detailed network of streets and road map, the crime incidents were approximately plotted around the main locations. If a map of plot wise information and land use had been available, it would have enhanced the accuracy of the results. These are certain limitations, which require immediate attention for a proper utilization of GIS in Indian crime analysis.

VII. METHODOLOGY

A City map of Chennai of the year 1997 with a scale of 1:25000 was scanned using a flatbed scanner. A base map (Figure 2) consisting of Chennai City boundary, main road network, and ward boundaries were constructed by onscreen digitization in *Arcview GIS* and *PC Arc Info 3.5* was utilized to edit the digitized data. The locational data of the property crimes were taken from the records and plotted as point themes on the scanned raster map, in *Arcview GIS* and the output is saved as *shape files*. These *shape files* were converted to arc files in *Arc info* for editing and for the projection of the *coverages*. Twelve *coverages* of the crime data were obtained.

These *coverages* are brought again to *Arcview GIS* and were superimposed on the ward boundary map to know the number of crime incidents per ward. Attribute crime data were entered in *Microsoft Excel* and brought in to *Arcview*. For the purpose of hotspot analysis, the dbf files were taken in the *CrimeStat 1.0*. Software and hotspot analysis was done in one standard deviation level. Then the output is saved as shape files and exported to *Arcview GIS* and maps were prepared for final visualization.

VIII. RESULTS AND DISCUSSION

The six property crimes taken for this study are arranged together to get a picture of the annual crime of the city, for the years 1997 (Figure 3) and 1999 (Figure 4). The distribution of crime incidents shows that almost all parts of the city are affected by nefarious activities. Except for a few pockets and the forest cover zone in the down south, the whole of the city is witnessing crime incidents. The distribution cannot be labeled as uniform throughout as the level of concentration varies from place to place, area to area, and from crime to crime. Though there are variations over the time, these remain less significant when the picture of annual crime for the two years were taken for visual interpretation.

Hot spot analysis

Hot spots are clusters of geographical areas that contain an unusually high concentration of crime events. However, not all clusters are hot spots because the environments that help generate crime—the places where people are—also tend to be clusters. Therefore, any definition of hot spots has to be qualified (Harries 1999). Sherman (1995) defined hot spots “*as small places in which the occurrence of crime is so frequent that it is highly predictable, at least over one year period of time*”.

When the hot spot analysis was done on few crimes individually to find the change over a period, the change seemed to be significant. *CrimeStat 1.0*, (Ned Levine1999) statistical software was utilized for this analysis. The hot spot locations had markedly changed. It was found that not only

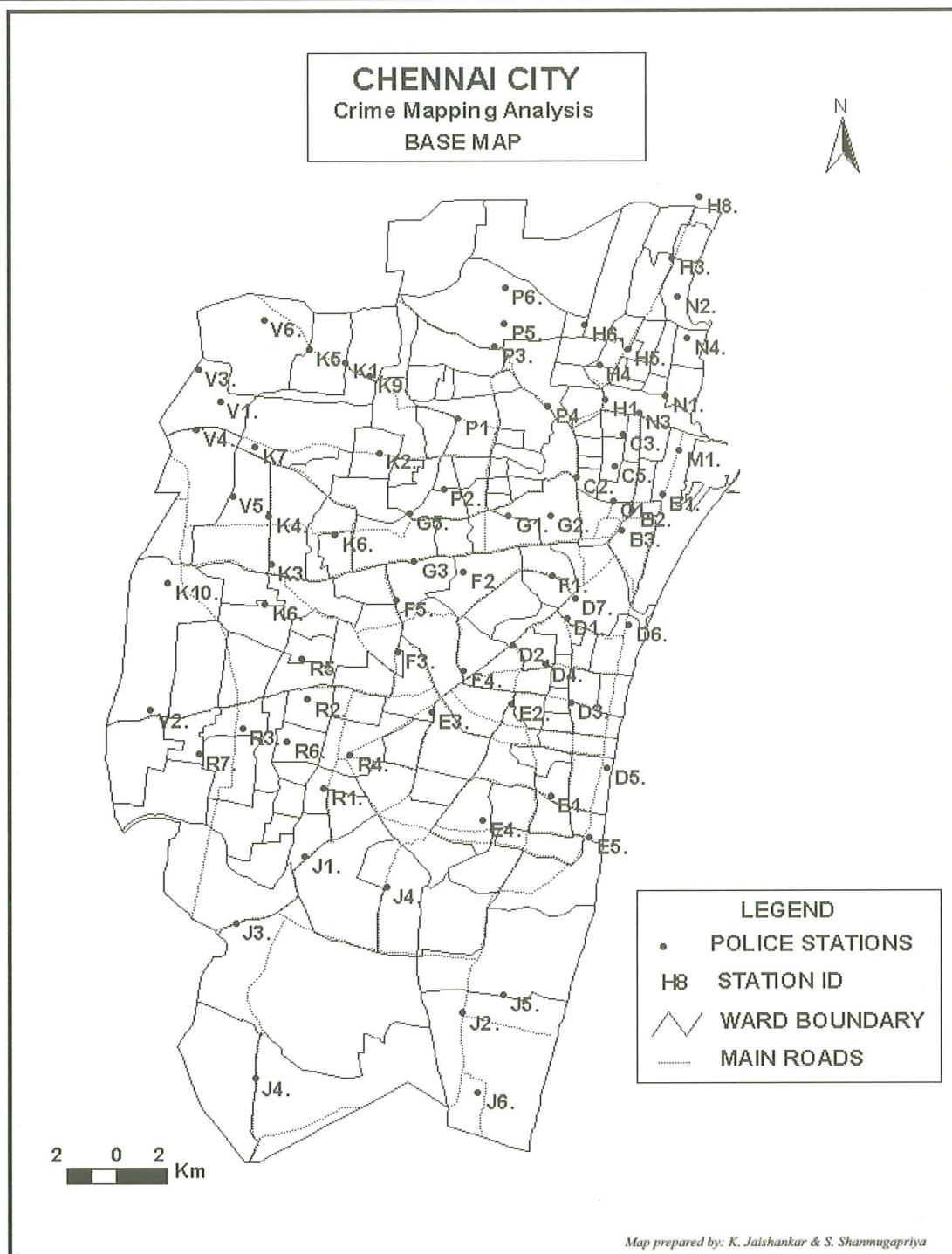


Figure 2.

there was a change in the location of the hot spots, but also in the areal extent enclosed by them. The numbers of hot spots have also shown difference over the time. The identification of these clusters of crime helps in providing police with information on the locations affected by frequent crime incidents and high crime rates. With careful planning and resource allocation, these hot spots could be turned into lesser crime prone zones. These hot spots were drawn based on the nearest neighbor principle, with default of one standard

deviation, which would cover 68% of the crime behind the formation of the hot spot.

The map showing hot spots for both the *house breaking at day & night* (Figure 5) gives an interesting representation. The hot spots of *day time house breaks* were only confined to a smaller area in the west of the city, where as, the hot spots of *night house breaks* were observed in all parts of the city. *Velachery, Gandhi Nagar, CPT, Mylapore, Parrys Corner,*

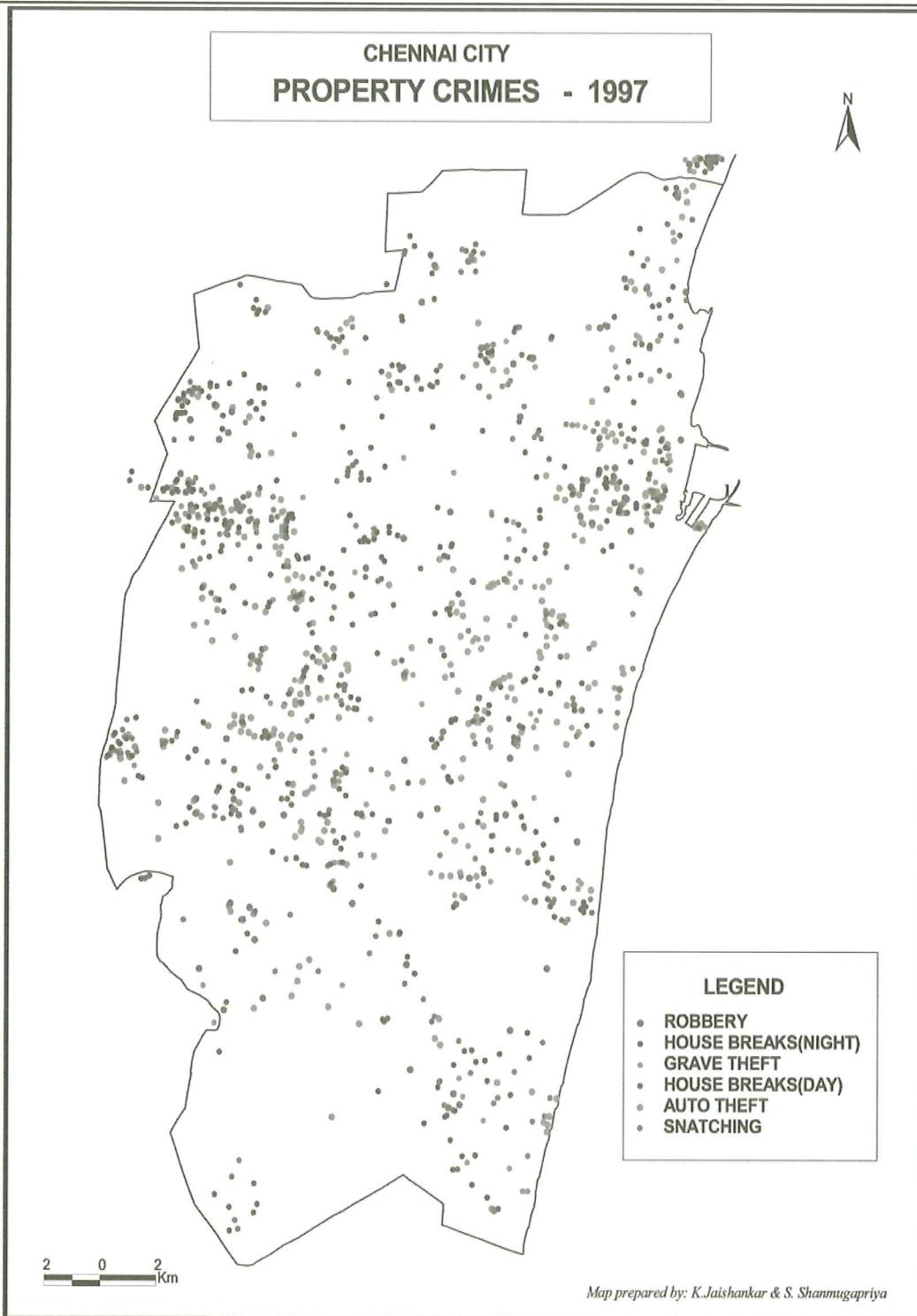
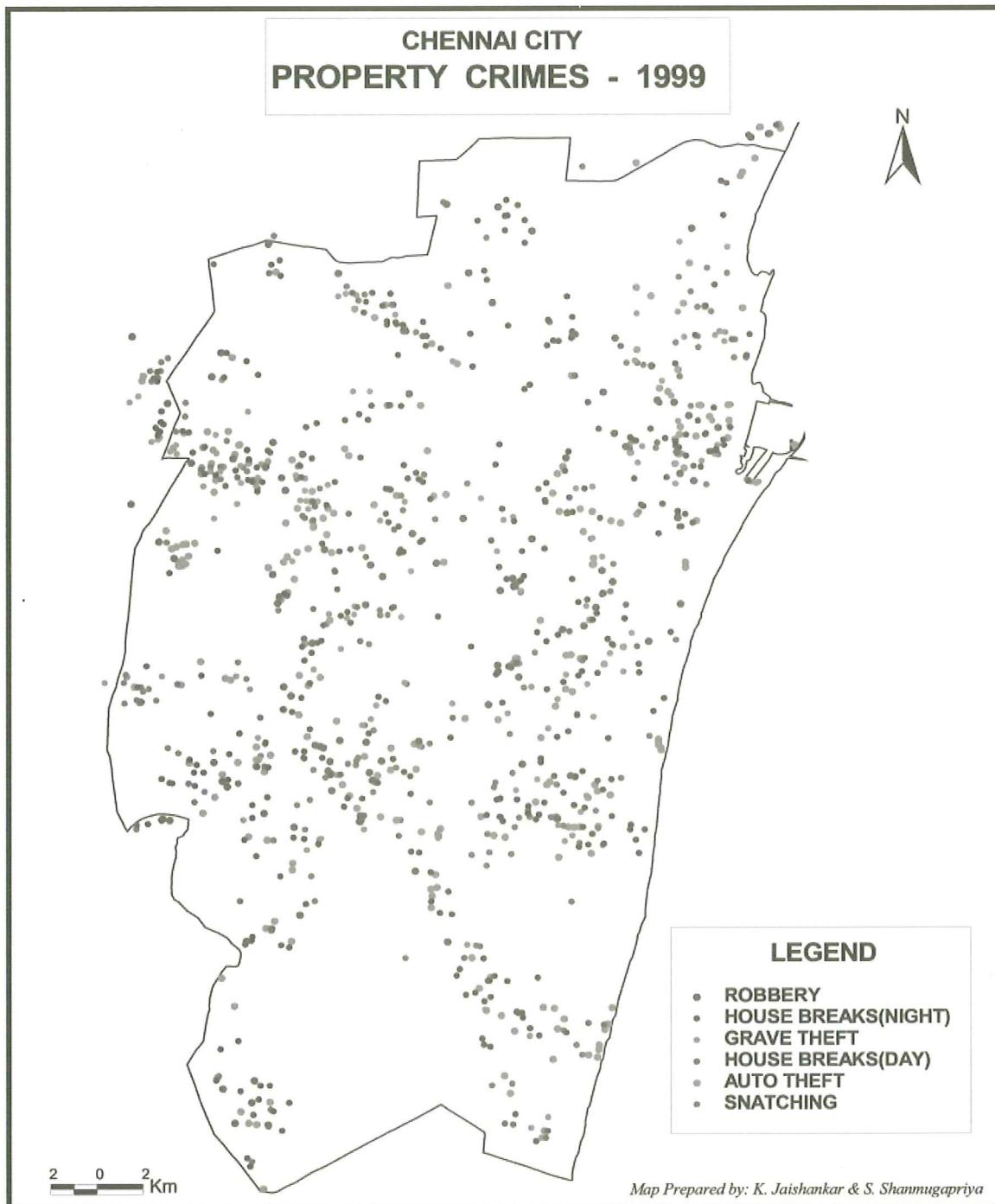


Figure 3.

Chembium, Peravallore, and Kodingaiyur were the areas that are found to be hot spots of *house breaking (night)*. The areas of *Anna Nagar West, Thirumangalam, Anna Nagar* and *Choolaimedu* are found to be the hot spots of *house breaking at day*. Since some parts of *Anna Nagar West and Thirumangalam* were found as hot spots for both the types of crime, it gives an imperative insight to the discussion. The results showed, that the upper middle class area of Anna

Nagar and its neighborhood areas are more prone to daytime House breaking. In this area, there may be more working professionals, and both spouses may be going for work. This may be one of the reasons making this area more prone to *daytime house breaking*. Moreover, in the upper middle-class areas of the city, an urban attitude of not having good neighborhood relationship prevails, leading to the occurrences of crimes. The results of hot spot analysis corroborates with

**Figure 4.**

the routine activities theory.

The routine activity theory was first introduced in Cohen and Felson (1979), later refined in Felson (1986, 1994), and extended to crime pattern theory in Brantingham and Brantingham (1993). According to the routine activity theory, the economically prosperous areas with low unemployment and high population are prone to certain types of crimes. The possibility of guardians in a specific location will deter crime. "A fear with being involved with some one else's problems"

causes people to look the other way when such incidences occur. Place is central to this perspective, serving as the locus where motivated offenders come together with desirable targets in the absence of crime suppressors (who include guardians, intimate handlers (Felson 1986), and place managers) (Eck 1994). This convergence of crime opportunities in space and time is facilitated by various situational features, of both the physical and social variety, that provide a context or setting that is more or less conducive to crime (Clarke 1992).

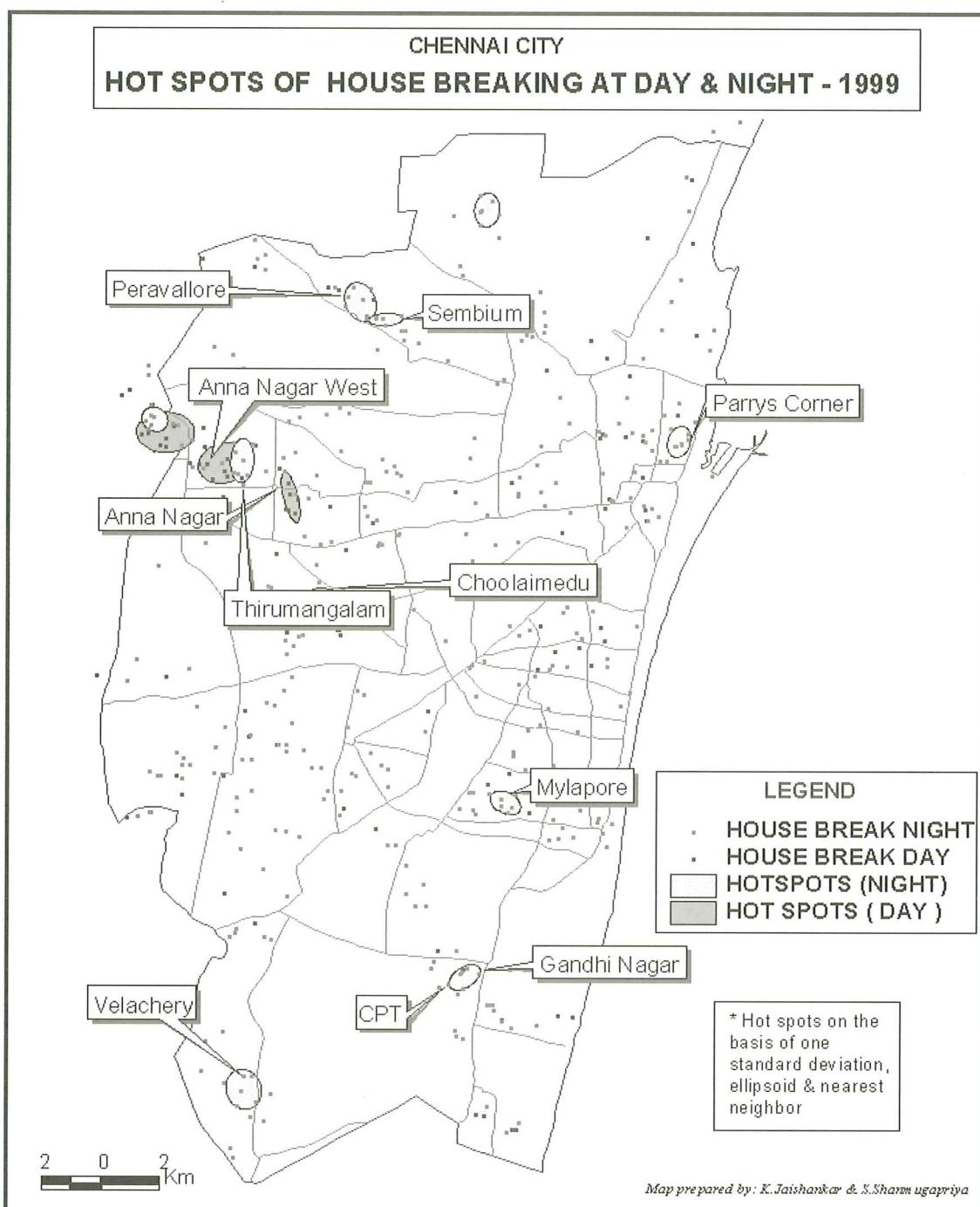


Figure 5.

The results of temporal analysis made on the hot spots of *house breaks at night* (Figure 6) revealed that not only the locations of the hot spots had changed in two years, but also their number of occurrences have also changed. Areas such as *Velachery*, *Mylapore*, *Royapettah*, *Kodingaiyur* and *Peravallore* have become new hot spots of housebreaks at night. The hot spots of *nighttime breaks* have displaced their distribution towards the north and southern parts of the city from their original position in the year 1997. In addition, their number of occurrences has decreased in 1999. The reason for the displacement and decrease of hot spots may be the

intensive police patrolling in those areas. However, there is evidence that police officers patrol high and low crime areas differently, responding to their own perceptions of the crime rate in an area (Klinger 1997).

An alternative method of visualizing high volume crime hotspot is the use of continuous surfaces. Continuous surfaces allow the distribution of crime across a whole area to be visualized and easily understood. There are a number of different ways to do this, and a map was created with *Spatial Analyst*, an add-on program of *Arcview GIS*, using the same data. The

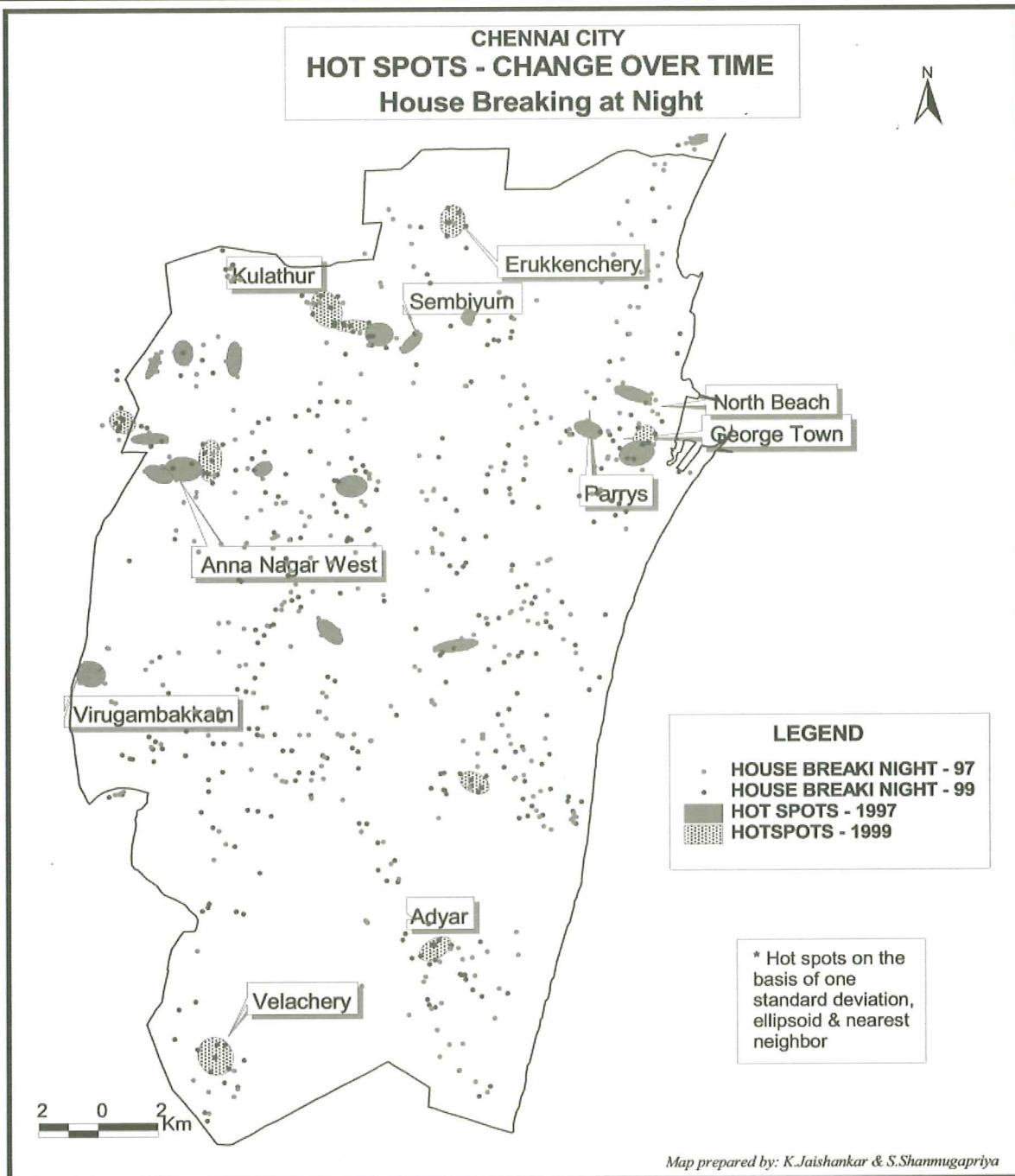


Figure 6.

locations of property crimes are plotted on the surface interpolated for the criminal distribution (Figure 7). The results revealed that the zone extending from the central north to farther south is almost free from residence of criminals, but have a higher concentration of crimes.

The zones with higher concentration of criminals in the west (*Koyembedu*, *Virugambakkam*) and in the south *Thiruvanmiyur*, *Shastri Nagar* regions have a higher concentration of crimes as well. Areas like *Thiruvanmiyur*, *Virugambakkam*, *SIDCO*, and *Villiwakkam* are found to be the hot spots of criminals. The areas where criminals resided

in Chennai city are the areas that are disorganized. This finding corroborates with the Social disorganization theory. Social Disorganization Theory (Shaw and McKay 1942) suggests that the "*economic composition of a local community is related to crime rates*". When a community is not unified, lacks the values, and lacks the interest in protecting the neighborhood, an area is considered socially disorganized. Indicators of this include high unemployment rates, high school drop out rates, mobility rates, low-income levels, and a large number of single parent households. Shaw and McKay (1942) believe disorganized areas are highly populated, economically poor, and transient.

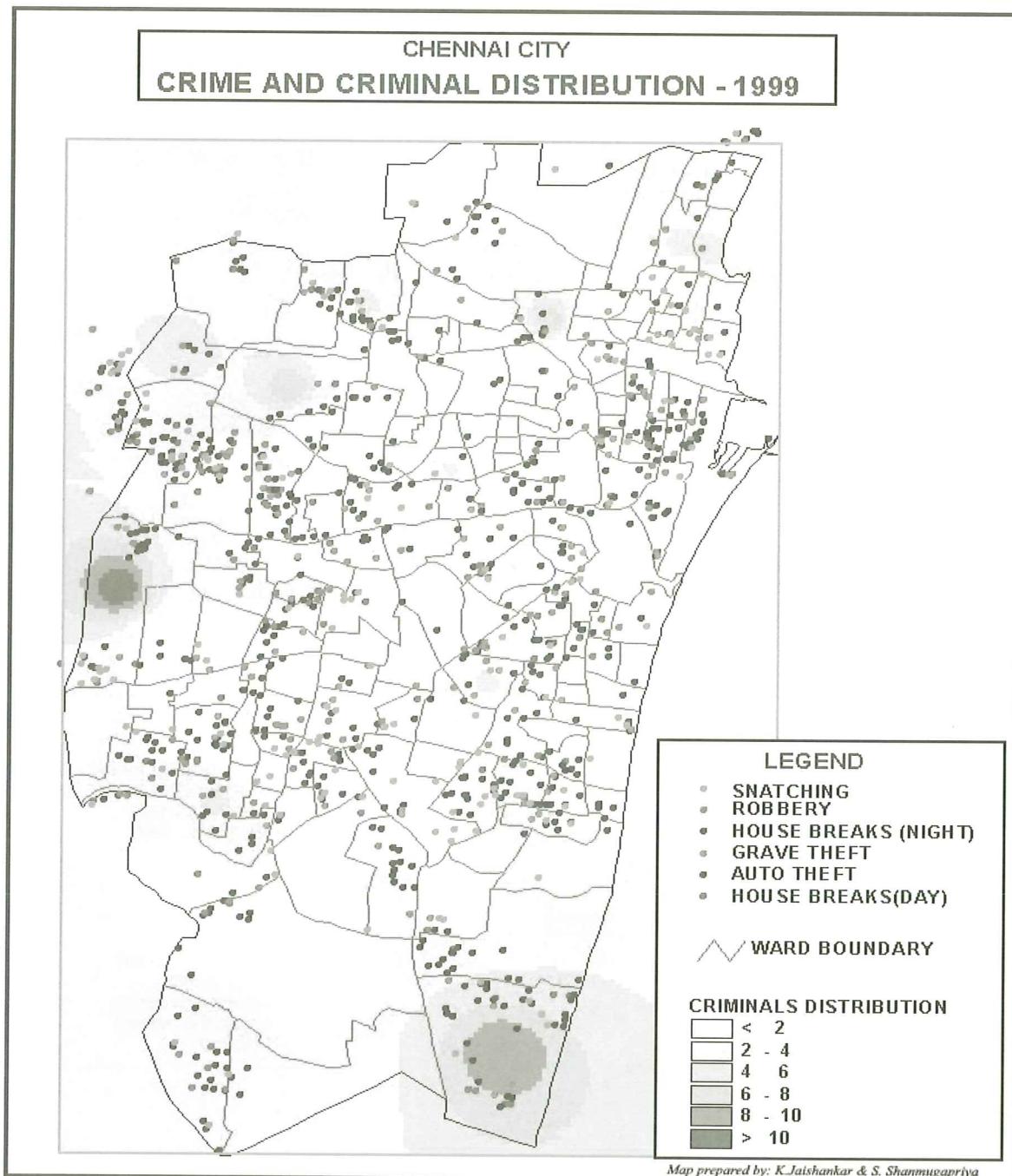


Figure 7.

In the present study, *in toto*, it was found that most of the areas in the north and south Chennai were disorganized. However, north Chennai, was found to be home of notorious criminals and criminal activities. North Chennai is dotted with numerous polluting industries with environmental degradation at its worst. The existing living conditions (high density), pollution of air and water are some of the geographical factors that may very well trigger even a healthy individual to involve in violent activities.

Buffer analysis

Buffers are the zones of interest around the selected entity

(Harries 1999). The extent of these zones depends upon the requirement of the study. Buffer zones were prepared for the police station locations. The two rings in the map were drawn at an interval of 250 meter. The inner ring covers the first 250-meter from the station and the outer one encloses 500 meter from the point of station. It is a general perception that crimes will occur well away from the police stations. However, when the data is plotted a different picture was obtained, crimes occur anywhere in the city irrespective of whether a police station is present or not in that locality. It is to be noted that policing needs mobility, and the police officers of a particular police station will always be away from their own area. Therefore, those station areas become vulnerable targets for

the criminals. This necessitates the police to ensure that sufficient protection is given to the people, as the criminals seem to take advantage of any loopholes in the scene of the security.

Koyambedu, Virugambakkam, Mambalam, Pondy Bazaar, Mylapore, Anna Nagar, and Aminjikarai police stations area have a higher concentration of crimes (*Auto theft & Snatching*) (Figure 8), within half a km radius from their location. In the north eastern part of the city there was relatively greater number of police stations making their 500 meter buffer merge together, with the crimes. In this area, the crimes are relatively lesser when compared to the strip of region between *Virugambakkam* in the west to *Mylapore*.

Crime and demography

What is the relationship between population density and crime rate? Over the years, sociologists and criminologists have investigated factors related to crime rate. Several major theories such as social disorganization theory, relative deprivation and sub cultural deviance theory, and general strain theory contend that community-level variables, such as density and overcrowding, are among the factors directly or indirectly contributing to crime through reducing social control and/or increasing strain (Wirth 1938; Coleman 1990; Agnew 1992, 1999). These theories have been empirically tested. However, the effects of density on crime rate remain nebulous. While some studies found that population density, housing quality, and overcrowding are not the predictors of crime and other social pathologies of poor neighborhoods (Burns 1970; Choldin 1978); others suggested that high density has harmful side effects including possible social disorder and crime (Wirth 1938; Brown and Liu 1999).

Crime studies offer a better result when they combine together with the demographic data. In the present study, an attempt was made to find the relationship between population density and property Crimes. A map of property crimes (1999), using graduated symbol was superimposed on the population map prepared for the city. The map (Figure 9) of population and crime gives us the idea that with the increase in the population, the number of crime incidents also increases. Though this concept cannot be generalized, as there are exceptional cases with lower population and higher crime incidents, this holds good for most parts of the city.

Index of Concentration

The index of concentration of a certain crime would give the concentration of that crime in a particular area in relation to its surrounding areas. These indexes were calculated for *snatching* for both the years 1997 and 1999. The calculation was based upon the total number of crime occurrences in each of 155 wards. Then, these individual total were compared with the city as well as zone's total crime counts and with the sum of selected crime counts to get a relative picture of the

concentration. The resultant map gives the ward-wise concentration of crimes. The concentration varies with wards as well with time.

In the case of *snatching* in 1997 (Figure 10) *T. Nagar, Harbour, George Town, Shenoy Nagar, Anna Nagar, Aminjikarai* are the areas of very high concentration. In 1999, these areas have relatively lesser concentration. The relative picture obtained helps police personnel to concentrate more on the affected regions.

On the final analysis, it is found that the crimes have reduced in the year 1999 when compared to 1997. One of the main reasons might be the increase in the patrolling and other preventive measures taken by the police department.

IX. PROBLEMS AND CONSTRAINTS FOR THE GIS IMPLEMENTATION

From this study, it is found that there are many bottlenecks in the implementation of GIS in Indian police departments. The current problems that hamper the development and availability of GIS in Police Departments are:

Data output

In India, the individual police departments, both rural and urban, collect crime data. Most of the data are collected from the complaints from victims or informants in the form of First Information Report (FIR). Later they are sent to the district crime records bureau and later sent to State crime records bureau. State crime records bureau compile the data and send to the National crime records bureau. With the data, the National Crime Records Bureau (NCRB) publish a report called "*Crime in India*" every year. This publication have graphical and map representations but no significant spatial analysis output is presented. State Crime records bureaus produce only graphical representation on crime scenario and they have never thought of serious analysis. Moreover, the conversion of data to information is insufficient. State crime records bureaus are data rich, but they are information poor. On the other hand, computerization of records in those bureaus have been done long back and NCRB has its own software (*Crime and Criminal Information System (CCIS)*) and it gives training in this software for the personnel of all State crime records bureau. Unfortunately, hot technologies like GIS and GPS are not given enough priority. GIS technology is still beyond the limits of crime records bureaus, due to lack of awareness and ignorance of its importance.

Data dissemination, Data secrecy, and Fear of crime

Indian police does data dissemination of crime efficiently. A network to the state headquarters connects most of the districts. This makes the police to collect the data from all the districts. Nevertheless, the problem here is the lack of trained

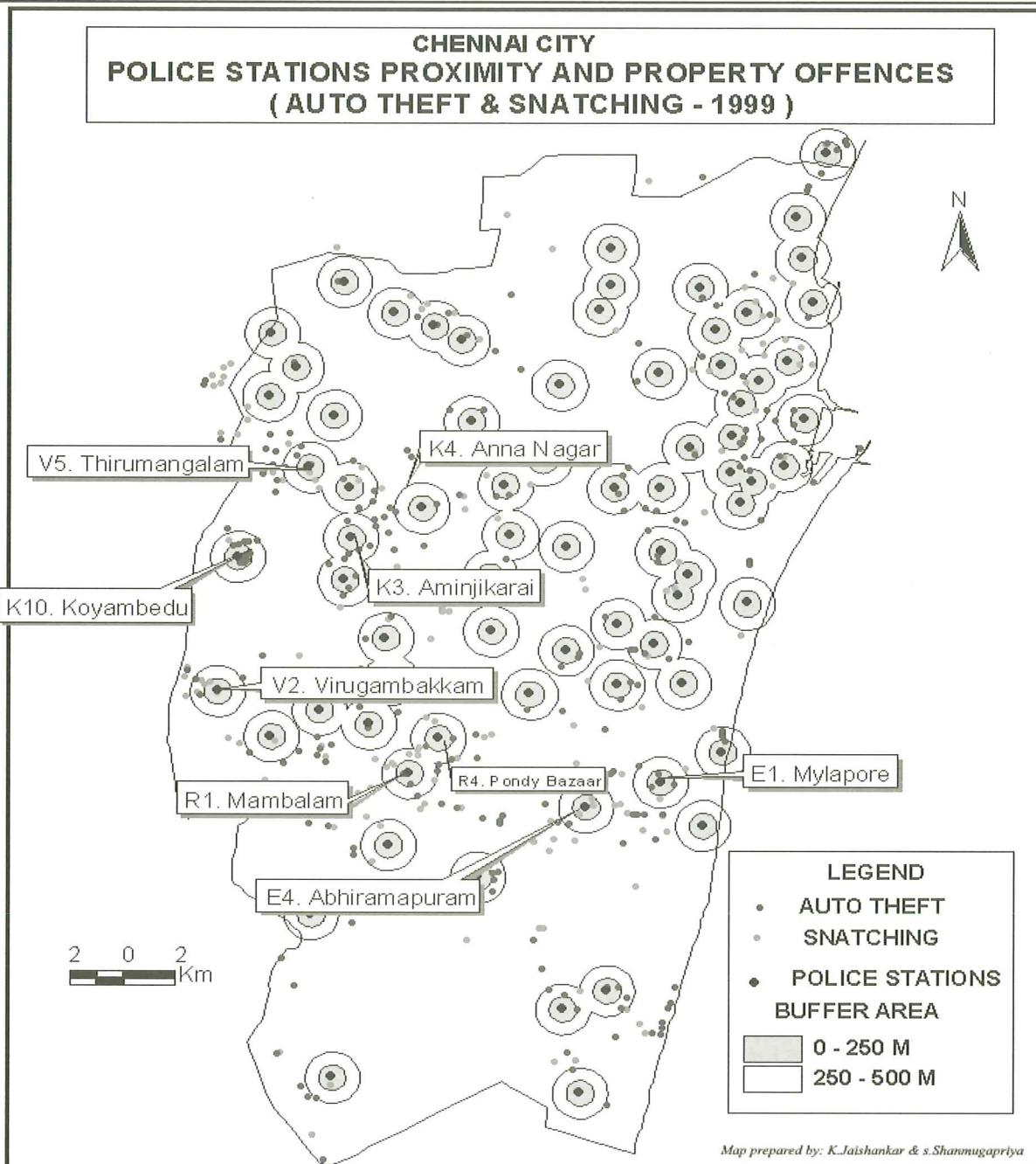


Figure 8.

officers to take care of the Network. In India, always crime data are maintained secretly. Even after the growth of Internet technologies, crime data is not published in the Internet. The reason is that, Indian police feel that showing the crime data publicly will create fear among the public. If even the crime data is not published in the Internet, then the difficulty in publishing crime maps needs to be understood. It is high time now that the Indian police understand the need for the creation of awareness of crime among the public, by publishing crime data, and maps in the Internet.

Money and time constraints

GIS is a technical science, which takes much time and energy to learn. The cost and time needed to train police officers to utilize and query a GIS are usually not available. Police departments have limited resources to purchase computer hardware, and GIS softwares. Building a comprehensive crime database that can be implemented, shared, and updated among the different units in a police department costs additional time and money. Presently, police departments get more money under the Police modernization scheme. Yet, the budget under the scheme to buy computers and software is very less when

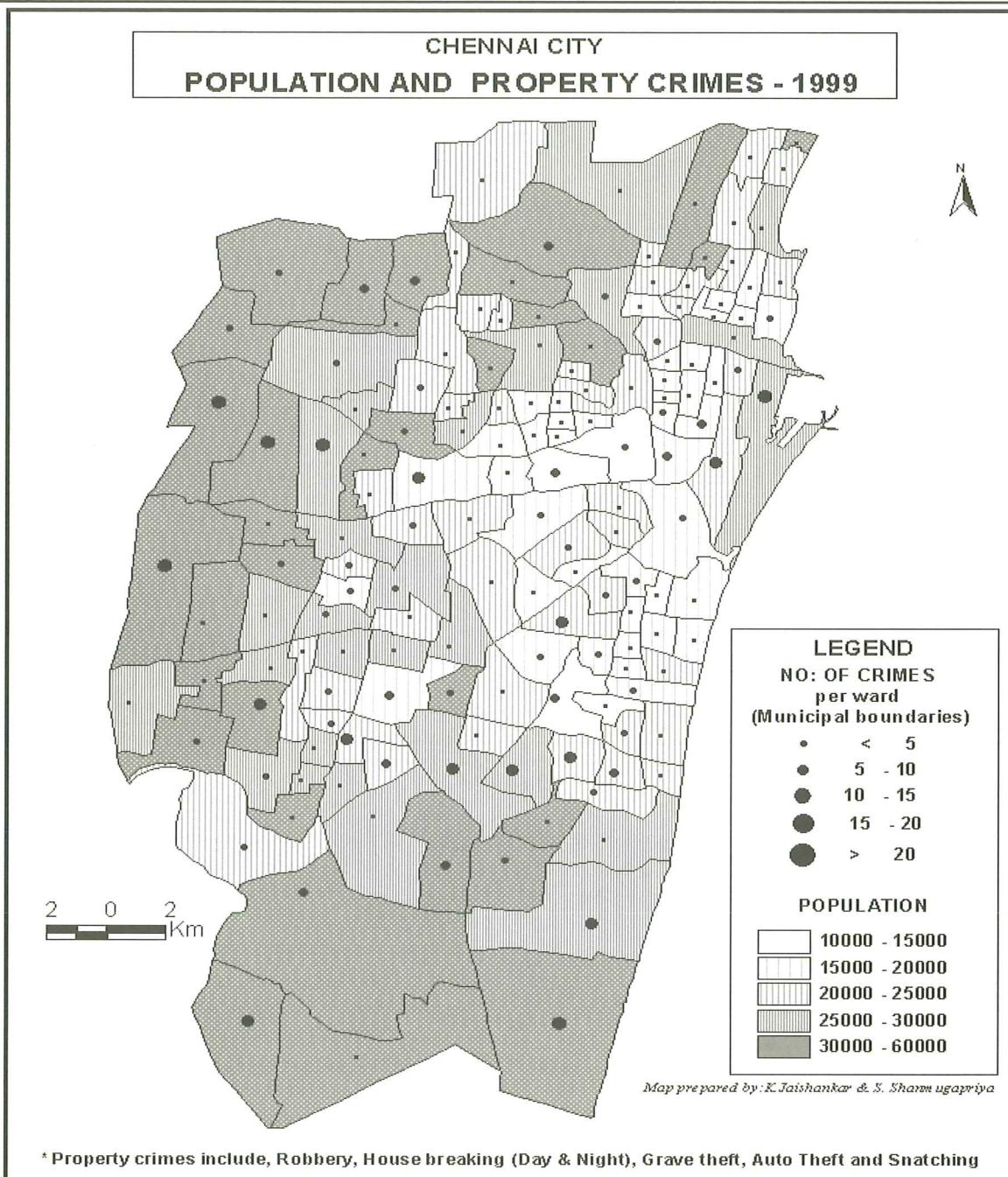


Figure 9.

compared to the money used to develop other infrastructure.

Lack of training in GIS, spatial analysis, and computer mapping

Police officers lack training in these new technologies and they might even be computer illiterates. For this reason any GIS software product developed for police departments needs to be easy to use, preferably with a point and click interface. The cost of training is also very high. The major problem in training is that the trained officer is frequently transferred to some other unit and the industry, which gave training, is not ready to impart training again. Therefore, state governments

should look in to this issue and should not transfer personnel who are working in the police computer unit at least for a period of three years.

Attitudinal problems

One of the serious difficulties that have been faced in the police computerization programme pertains to attitudinal problems. It has been found that most of the investigating officers do not show much faith or interest in collection of information using computers for investigation of crime. There has been lack of communication between investigating officers and computer experts. The systems and equipments can always

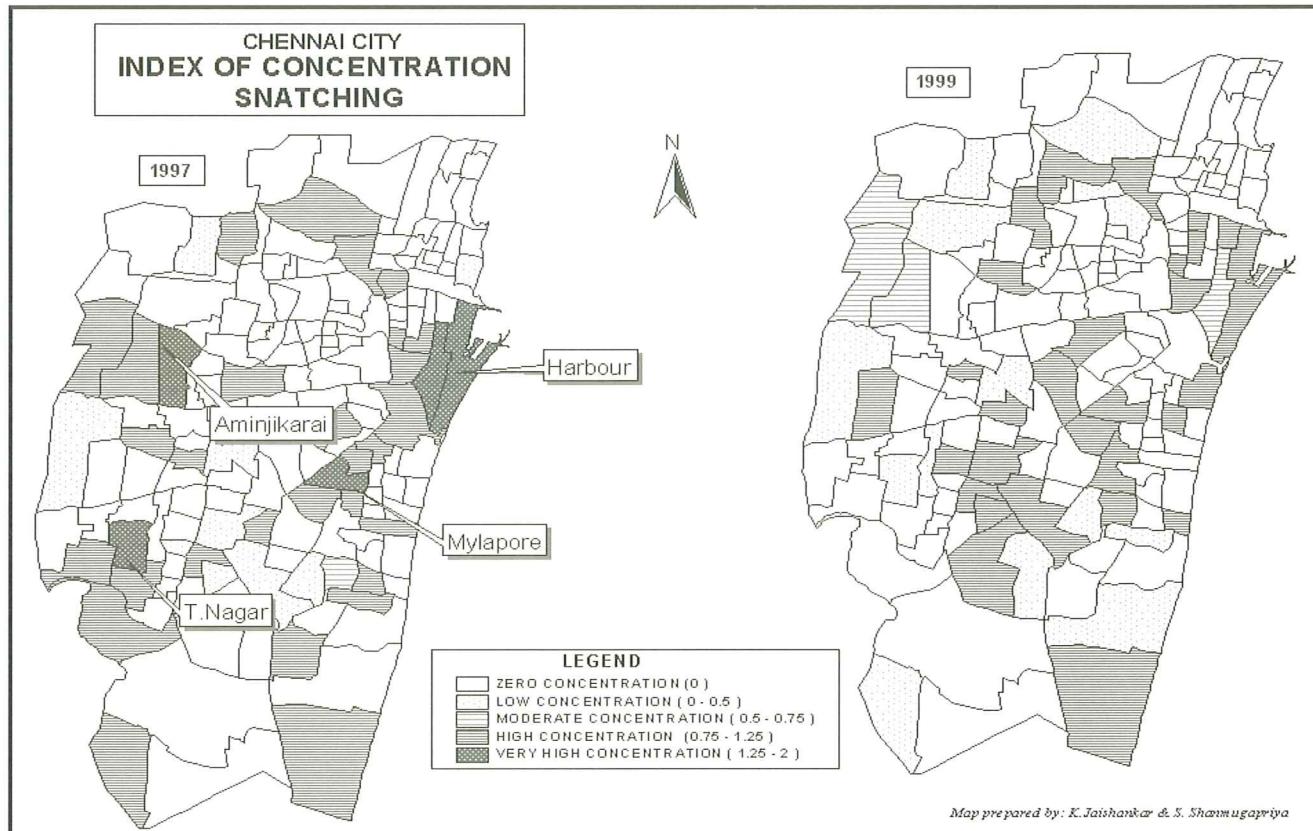


Figure 10.

be improved, but changing the attitude is a long drawn process. The Bureau of Police Research and Development (BPR&D) and National Crime Records Bureau (NCRB) should take necessary steps to solve this problem.

X. STRATEGIES FOR THE GIS IMPLEMENTATION

Creation of crime analysis units

In India, there are no crime analysis units attached to police departments as in the developed countries. Police personnel are only working on the analysis of crime data. This reduces their fieldwork and they need helping hands for crime analysis. So it is high time, crime analysis units are created within police departments to enhance the quality of data output. Universities should start courses in crime analysis and GIS.

Collaborating with academic and non-profit institutions

There is no dearth of spatial analysis and crime mapping studies in India. Srivastava (1963), Rao (1968), Sivamurthy (1980,1988), Jos (1993) Jaishankar (2003), have done several researches in the field of Spatial Criminology. Most of these studies were either submitted as reports or they are published. Indian Policing has not utilized those studies. So there were no practical applications of these studies. Hence, if the Police departments collaborate with academic institutions for GIS implementation

it would not only reduce the cost but also there will be an effective input of expertise that is available in those institutions. The cost of training is higher in private organizations, and hence it is appropriate that non-profit organizations like universities could train the police personnel in crime mapping and this might reduce the cost of training. In New Delhi, Center for Spatial data base management solutions a non-governmental organization is providing training to the Delhi police in implementing GIS and GPS systems.

Industry collaboration

The NCRB has collaborated with Microsoft for the creation of the Crime Criminal Information System (CCIS). Today, CCIS is in the process of standardizing the way criminal records that are maintained across the country, allowing efficient sharing of information and facilitating greater coordination at a national level. Therefore, if the NCRB and the police departments' collaborate with the industry, technology adoption will be easier and effective.

XI. CONTEMPORARY INITIATIVES

Pin mapping was always an integral part of Indian policing. However, computerized crime mapping has started recently, due to the growth of technologies like GIS and GPS. Now, computerized mapping has gained significance in Indian law

enforcement agencies. Following are some of the initiatives taken in the implementation of GIS in policing.

- ESRI India has sold two licenses of Arc view GIS software and has imparted training to the police constables of Chennai city.
- Sun Microsystems has produced *eCOPS* software for the Andhra Pradesh State Police Department. It is a significant step towards integration of state-of-the-art IT infrastructure. Software systems were developed with GIS and GPS capabilities. Government agencies such as the prisons, the judiciary, hospitals, internal revenues, and immigration will also be connected to the central *eCOPS* database. However, this is not a pure GIS/GPS solution providing software.
- A New Delhi based company *CE Info Systems* has developed *Mappis Suraksha*, an integrated GIS based crime control and analysis software tool. This software is a complete Information management solution for the police that manages the recording of information that comes into the police control room, dispatch of patrol vehicles, traffic management and crime records. The spatial image of a city that the system maintains down to the locality level enables the police to a faster and better decision making at all levels of the hierarchy.
- The Government of Maharashtra has sanctioned the proposal of Mumbai Police to implement GIS/GPS in Mumbai city police and the project is likely to be implemented very soon.
- Hyderabad Police will soon be using the Global Positioning System (GPS) as part of a series of measures to modernize the city police and improve efficiency in controlling crime. Automotive Vehicle Location Systems (AVLS) will be installed in police vehicles deployed at strategic points in the twin cities of Hyderabad and Secunderabad. Bangalore police is on the same way in the implementation of GPS.
- A sophisticated database built by *Amtron* in collaboration with a leading Kolkata based *Riddhi Management Services Private Limited* have produced a GIS crime system for the Assam police.

Still various developments have been done in the area of GIS and GPS implementation. This gives more hope for the development of holistic GIS systems for all the police departments in India.

XII. CONCLUSION

The findings of this study showed that using GIS is a much more compatible means of crime pattern analysis than current processes because of its geographic referencing capabilities. The present research has provided valuable information concerning property crimes in Chennai city, including data on the social and physical characteristics of these areas that contribute to localized criminal activity. The study has shown the benefits of using GIS as a crime prevention tool. Hence, it

is proposed that, a *National Crime Mapping Research Center (NCMRC)* under the lines of US CMRC (presently MAPS), should be created under the Ministry of Home Affairs in the Capital (New Delhi). All the states should have a State Crime Mapping Research Center (SCMRC) and it should be connected through a network with the NCMRC. GIS technology should be added to the curriculum of Sardar Vallabhbhai Patel National Police Academy, National Institute of Criminology and Forensic Science, Central Detective Training Schools, all Police Training colleges and all Criminology Departments of Universities.

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