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**THEME: Geo-Budget: Enabling Sustainable Growth**

### **Application of GIS in Crime Analysis: A Gateway to Safe City**

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#### **Abstract**

The need of effective utilization of Information Technology in public safety management is increasing in the present Indian scenario of crime. This paper applies the utilities of GIS to identify the hotspots of crime as well as to facilitate the development of investigation preference strategy for policing. The capabilities of Kriging as well as weighted overlay analysis were effectively applied to identify the crime patterns in the district of Jhunjhunu on a GIS platform, integrated with socio-economic attributes. The study identified the social factors affecting different types of crime in the study area. The methodological framework applied in the present investigation for crime mapping can be effectively applied for development of user-interfaces platform for the development of safe city strategies.

**Key words:** GIS, Kriging, Weighted overlay, Crime mapping.

#### **Introduction**

In India, Police is a critical component of civil administration. There has been an enormous increase in crime in the recent past. The cops in their role to catch criminals are required to remain convincingly ahead in the eternal race between law breakers and law enforcers. One of the key concerns of the law enforcers is how to enhance investigative effectiveness of the police. There is an urgent need to analyse the increasing number of crimes as approximately 17 lakhs Indian Penal Code (IPC) crime, and 38 lakhs local and Special Law crimes per year. The police should use the current technologies <sup>[1] [3]</sup> to give themselves the much-needed edge.

The traditional strategy of intelligence and criminal record maintenance has failed to meet the requirements of the present crime scenario. Manual processes neither provide accurate, reliable and comprehensive data round the clock nor does it help in trend prediction and decision support. The lack of public capability to guide and support the transition from “crime mapping in the police” to “mapping with the community” for local policies are increasing at alarming rate. Under this perspective, the effective utilization of Information Technology helps to change the paradigm of public safety management and useful for community policing processes.

The use of Geographic Information System (GIS) for crime mapping facilitates to map, visualize, and analyze crime hot spots, along with other trends and patterns. It is a key component of crime analysis and the policing strategy. GIS uses geography and computer-generated maps as an interface for integrating and accessing massive amounts of location-based information. GIS allows police personnel to plan effectively for

emergency response, determine mitigation priorities, analyse historical events, and predict future events. It can also be used to get critical information to emergency responders upon dispatch or while en route to an incident to assist in tactical planning and response. GIS helps crime officers determine potential crime sites by examining complex seemingly unrelated criteria and displaying them all in a graphical, layered, spatial interface or map.

The present study highlights application of GIS for crime mapping in Jhunjhunu district of Rajasthan. The study utilizes the various crime records integrated with ancillary information to derive the hotspots of crime within the study area. The research was carried out with following objectives.

- To identify hot spots as well as driving forces for different types of crime.
- To help police to take preventive measures like deployment of forces in area prone to crime.
- To develop a methodological framework for crime mapping using GIS.

### Methodology

Geographic profiling is an investigative methodology that uses the locations of a connected series of crimes to determine the most probable area that an offender lives in [2]. Although it is generally applied in serial murder, rape, arson, robbery, and bombing cases, geographic profiling also can be used in single crimes that involve multiple scenes or other significant geographic characteristics. The methodology is based on a model that describes the hunting behavior of the offender. The criminal geographic targeting program uses overlapping distance-decay functions centered on each crime location to produce *jeopardy surfaces*—three-dimensional probability surfaces that indicate the area where the offender probably lives. The distance-decay concept conveys the idea that people, including criminals, generally take more short trips and fewer long trips in the course of their daily lives, which may include criminal activities. Thus *overlapping distance-decay functions* [5] are sets of curves expressing this phenomenon and suggesting, for example, that it is more likely that offenders live close to the sites of their crimes than far away. Probability surfaces can be displayed on both two- and three dimensional color Isopleths maps, which then provide a focus for investigative efforts. [4]. ArcGIS 9.0 software was used to achieve the objectives. Brief methodology applied in the present investigation is shown in Figure 1.

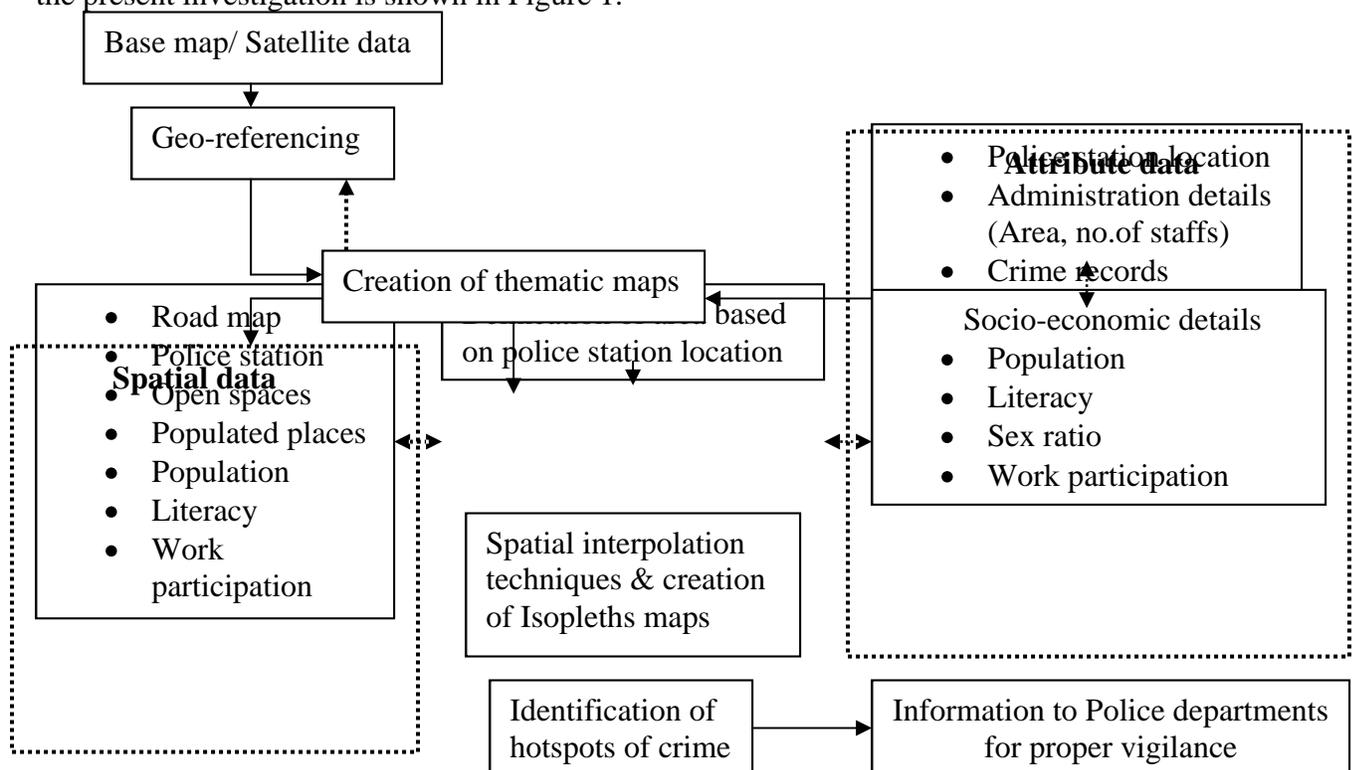


Figure 1. Methodology of crime mapping using GIS

## Results and Discussions

The map showing the locations of police stations were created and the corresponding administrative area were delineated for each station. The attribute details including crime records and socio-economic details were collected to create the geodatabase for crime analysis within Jhunjhunu district. The socio-economic as well as crime details were represented as spatial function in the geographic domain to visualize the pattern of crime within the area. The details of crime committed in the year 2006 were collected for the crime analysis. Based on the distance decay analysis, cost distance from each police station was computed. The whole area was categorized into different zones based on the analysis and identified the proximity locations of crime.

To obtain a spatial function from point data of crime, Kriging method was applied. Kriging is mathematically closely related to regression analysis. Both theories derive a best linear unbiased estimator, based on assumptions on covariances, make use of Gauss- Markov theorem to prove independence of the estimate and error, and make use of very similar formulae. Based on Kriging, crime maps for kidnapping, rape, robbery, riot, theft and other crime were created.

### *Crime and Social factors*

The spatial distribution of social factors (literacy, work participation, sex ratio etc) were also created to correlate the crime types with the social conditions of the place where the crime is being committed. Data, based on 2007 Census, was collected, which pertained to the employment, sex-ratio and educational standards. The maps of work-participation rates, literacy ratio and sex ratio data were created tehsil-wise.

Based on the analysis, tehsil of Buhana has maximum work participation rate, then Khetri, followed by Surajgarh and Malsisar. On the other hand, Tehsils of Jhunjhunu, Nawalgarh and Udaipurwati have the lowest. It is justified to assume that crime-rates would have a relationship with work-participation, since normally unemployment is a reason for committing crimes like theft, burglary and kidnapping.

In the case of literacy, highest rates were observed in the tehsils of Buhana, Udaipurwati and Jhunjhunu. Hence it is assumed that percentages of crime should be lower in these areas since education is more. On the other hand, literacy is lowest in Khetri, Nawalgarh, Surajgarh, and Malsisar of this district. The trends of crime cases like theft, kidnapping and crimes against women in areas where assumed to be more as literacy is lower. Especially crimes against women are expected to be more in these lower literacy zones since people are less conscious. Sex-ratio on the whole is pretty low in the district of Jhunjhunu. Notably in Chirawa, Khetri, Malsisar, have the lowest sex ratio. Khetri reports the greatest number of rape cases in the district.

Social standards of education, sex-ratio and employment are now compared with areas where crime is maximum. The aim is to derive a relationship between crime rates and lifestyles of the people inhabiting the area. Crimes which are sporadic such as robbery, murder, dacoity and riots are found to have insufficient occurrences to warrant an analysis.

It was observed that, not much correlation between literacy and burglary, though slight overlap exists. However, it is to be stated that literacy is not the only factor that affects burglary. There might be other influences as well, such as work-participation, and sex ratio. However with these steps, it helps us to analyse how much does a particular parameter affects a particular crime type. Based on the analysis of social factors and

kidnapping cases, we found a good correlation between kidnapping and work participation (Figure 2).

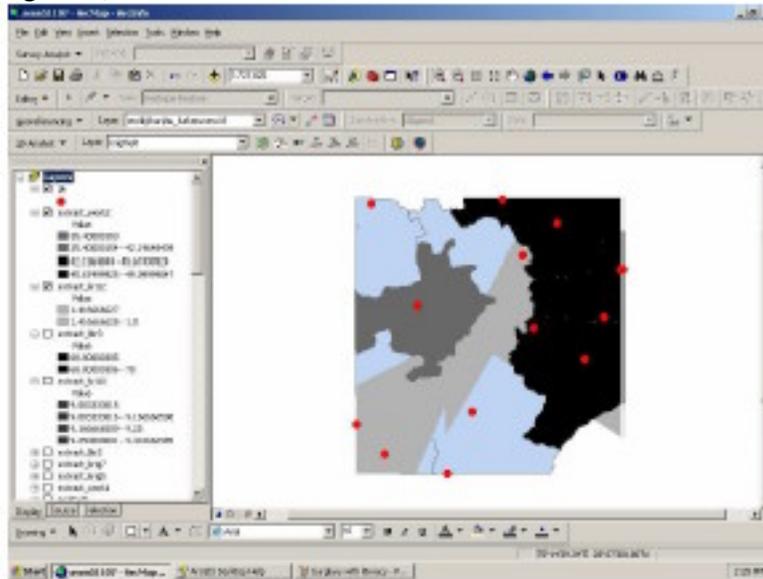


Figure 2. Comparison of kidnapping with work participation rate

Black portions denote maximum work-participation.

\_ Light Gray portions denote minimum work participation.

\_ Deep Gray denotes zone of maximum kidnapping.

The maximum cases of kidnapping were reported in areas where work-participation is maximum and where it is lowest. One line of reasoning might lead us to the fact that people from lower employment zones hunt in areas where work participation is more. Also, since there is a decent probability of the kidnapers being caught in either zone, they are distributed in both these zones. Again, it is to be mentioned here, apart from work-participation, literacy might also play a role in these crimes. A definite correlation exists between theft and work-participation (Figure 3).

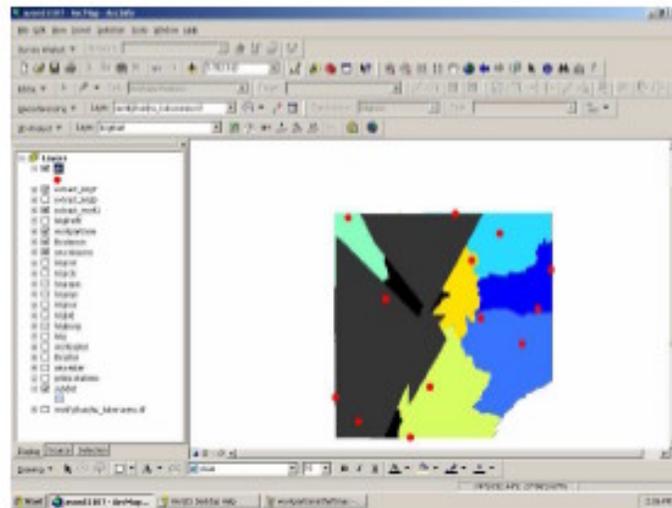


Figure 3. Comparison of theft and work participation rate

- The black portions denote the areas with minimum work-participation rate.

- The deep gray portions denote the zone of maximum theft.

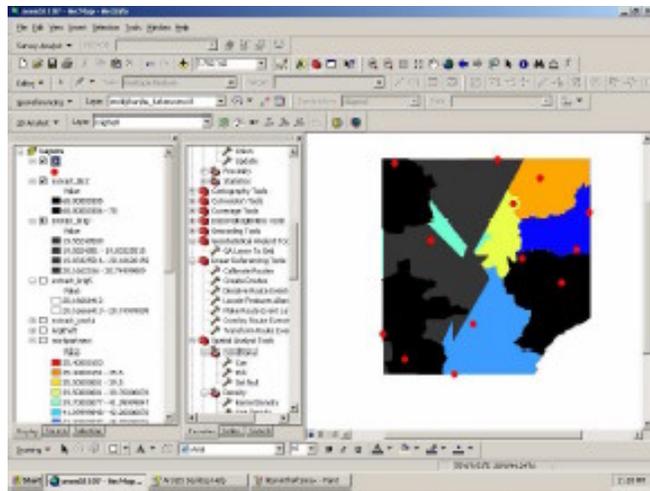


Figure 4. Comparison of theft and literacy rate

- The black portions denote the areas with minimum literacy rate.
- The deep gray portions denote the zone of maximum theft.

Based on the correlation between theft and literacy rate (Figure 4) it is clear that areas of low literacy rates are more prone to the incidents of reported theft cases

From the above analysis it is evident that literacy affects crime and so does work participation to a reasonable extent, whereas sex-ratio doesn't cast such a major influence.

The weighted overlay analysis of social factors with crime pattern was carried out to identify the hotspots of crime locations. The following social factors with weights were considered for the analysis.

- Sex ratio – 20%
- Literacy rate – 40 %
- Work Participation rate – 40%

Based on the weighted overlay analysis, the various hotspots of different types of crime were identified (Figure 5). The investigation preference areas (Table 1) for different types of crime were also suggested to ensure public safety.

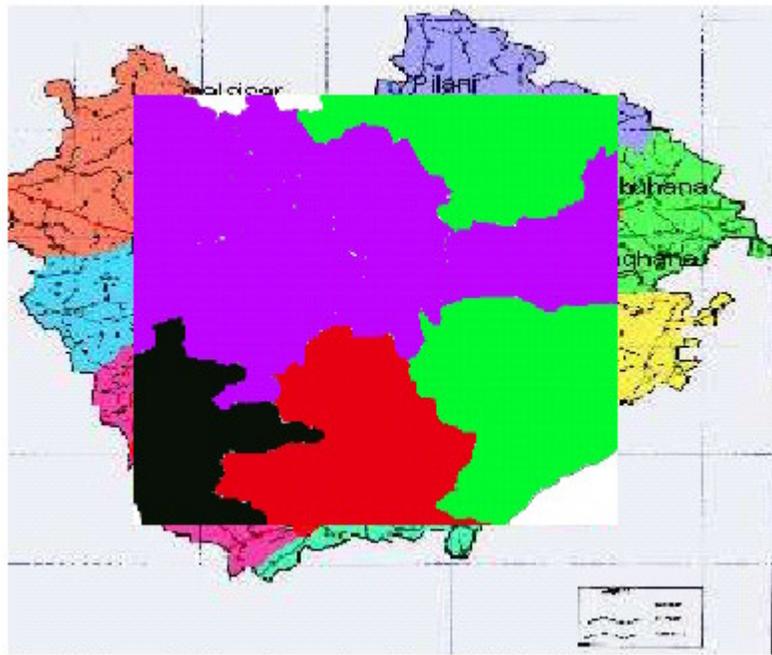


Figure 5 The weighted overlay raster with map in the background

For sporadic crimes such as murder, rape, dacoity and riot, which are not so prevalent in the district of Jhunjhunu, a relationship cannot be drawn and for such catching such criminals, the promptness of the police machinery is to be relied on. Also, it is advised to improve literacy, employment and sex-ratio in the district of Jhunjhunu since a direct correlation is found between these and crime-rates.

Table 2 Investigation preferences for each type of recurring crime

| Crime type          | 1 <sup>st</sup> preference | 2 <sup>nd</sup> preference | 3 <sup>rd</sup> Preference |
|---------------------|----------------------------|----------------------------|----------------------------|
| Burglary            | Red                        |                            |                            |
| Theft               | Black                      | Violet                     |                            |
| Kidnapping          | Black                      | Violet                     | Green                      |
| Crime against woman | Green                      | Red                        |                            |

### Conclusion

The representation of crime as a spatial function is of paramount importance. The crime data depicted on a spatial domain can be overlaid with education, sex and occupational data to obtain a correlation between each type of crime committed and the social conditions of the place. It leads to the identification of hotspots of different types of crime on a GIS platform. The methodological frame work applied in the present investigation for crime mapping has very promising use in the current changing scenario and provides an effective method to law enforcement agencies for crime detection and crime prevention. Hence, the proposed crime analysis method can be upgraded in the user interface platform to ensure public safety through proper crime analysis.

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