CRIME MAPPING AND HOT SPOT ANALYSIS USING GEOSPACIAL TECHNIQUES: A CASE OF AJMER CITY

Dr. Monika Kannan
Professor, Dept. of Geography, Sophia Girls College, Ajmer. Email: kannanmonika@gmail.com
Dr. Kasina V. Rao
National Trainer (eAgri, eGov, EoT), MANAGE, Hyderabad. Email: kasinavrao@gmail.com
Mr. Mayur Raj
Assistant Professor, CAIT, AAU, Anand. Email: rajmayur2005@gmail.com
Mr. P. Alok Verma
Scientist-SC, Indian Institute of Remote Sensing, Dehradun. Email: prabhakar@iirs.gov.in

KEY WORDS: Spatial Crime Mapping, Spatial Crime Hot Spots, Spatial Decision Making, Surveillance Plan

ABSTRACT: The study aims to enable the Ajmer city police towards spatial crime mapping and demarcation of hot spot zones towards better crime prevention control. This macro level research may benefit and assist the police officials towards generating their surveillance plan and crime control strategy in the region. Its basic objective is to identify crime prone zones through crime mapping with probability of occurrence based on the past incidence of various crime locations. Then provide spatial crime hot spots so as police can plan better surveillance plan and scheduling so as to minimize crime incidences and take preventive action in short time based on minimum distance maps. As per the scope, it provides a spatial decision making system to Ajmer city police for better surveillance scheduling. The study also presents alarming results for the concerned administrative departments as it indicates some strong correlations between the socioeconomic parameters and crime sprawl.

INTRODUCTION

Crimes occurred and crimes solved per particular duration may not be that effective in India. Crime mapping is done physically to help trace suspects and establish their modus operandi in most of the states in India. It helps the police determine areas where a particular group of suspects or individuals are active. Crime is an exercise did by an individual or a group of persons which is unethical, harmful and unsocial to the society. Crime can be the consequence of illiteracy, poverty, or revenge (Ansari & Kale, 2014). A wide area of socio economic variables are classified including household income, educational achievement, employment status, and poverty status; other demographic variables age, religion and race. The relation between these variables and crime type provide understanding of crime in a spatial context (Mitchell, 2011).

On the basis of compared data, police officials trace local suspects and enhance patrolling in the affected areas. GIS is gradually picking as an important technology to the social crime prevention systems in India. Present Geographic Information System (GIS) provides an opportunity for crime analysis and make available inputs to crime prevention planning. The spatial research facilitates towards better community policing rather than analytical prediction. Crime mapping using GIS tools provides a basic criminal investigative analysis that includes activities such as geographic profile and specific case support based crime investigation. Such GIS enabled crime maps to provide law and order force to assist in strategic planning, crime analysis, and operations (Thangavelu, Sathyaraj, & Balasubramanian, 2013). Patrolling must be conducted scientifically after clearly studying crimes to leverage confidence and to install the sense of security among all citizens.

In this study we considered various types of crimes such as robbery, home/shop breaking, automobile theft, kidnapping, rape, murder and other theft. By preparing hotspots of various crimes mentioned, police can crackdown on criminals based on previous incidents of various years. The crime incidences are record based on coordinates using GPS system and fed using a tool so as to generate maps with colour coding for crime analysis. The basic idea of this does not only curb the crime but can provide a quick response by police patrolling units which are nearby. The system which is used for capturing, storing, converting data format, exploring and displaying geospatial data is known as Geographic Information System (GIS). The Geospatial data also known as geographically referenced data defines both the location and the characteristics of the piece called spatial feature which may contain of roads, land extents, and vegetation on the Earth surface (Shahebaz & Kale, 2014).

Geography of an area plays a dominating role in crime sprawl, as physical landscape and terrain can strongly defines the type and pattern of crime. The connectivity and inaccessibility of locations, transport network, economic profile and political scenario of an area governs crime. It may be home, work place or any other place which is in proximity to it (Ravi, Sarvesh, & Parul, 2016). Crime patterns change over space and time in an area and hence it is

of immense help to police by using GIS maps and spatial crime patterns to capture and study the patterns for better crime control (Pramod Kumar, Ravikumar, & Soma, 2012). For crime prevention sufficient allocation of resources is very important. GIS can be used as a tool to identify factors that are contributing to crime, by creating crime maps and providing solution to society through crime analysis by getting Clusters and Hotspots (Saravanakumar & Revathy, 2016). The ability to access and process information rapidly while displaying it in a spatial and visual medium permits agencies to distribute resources quickly and more effectively. GIS can aid huge amounts of location-based data from multiple fronts. It enables the user to layer the data and view the data most critical to the particular problem or operation (Johnson, 2000).

The appropriate tools of both spatial and statistical analyses such as neighborhood and correlation analysis, etc. from GIS can be used on the study area for mapping liable crime prone spots (Olajuyigbe et al, 2016). Geospatial technologies help to capture the spatial heterogeneity of the different types of criminal activities and security resources and thus to start a spatial connection between the events in a specific region of attention (Kaura, et al., 2014). GIS permits police force to plan meritoriously for emergency response, decide mitigation priorities, analyse historical events, and forecast future events (Sangamithra, Kalaikumaran, & Karthik, 2012). Crime is a major issue, where an efficient analyzes of different remote sensing techniques are accomplished for crime investigation by crime investigation agencies (Napoleon & S., 2017). One of the major activities that has to be performed by crime investigation department is mitigation of hot spot locations where the number of crimes are more (Sivaranjani & Sivakumari, 2015). Using hotspot techniques such as spatial analysis, interpolation and spatial autocorrelation the high concentration crime occurring areas can be found (Ansari & Kale, 2014). Such hotspots are small zones that have a great deal of crime or a disorder, even there may be no common criminal; and crime analysis try to link these to underlying social situations (Eck, Chainey, Cameron, Leitner, & Wilson, 2005). Though there is no theoretical basis, hotspots are areas of imaginary boundary where there is recurrence of crime incidents (Divya, Robinson , & Selvan, 2014).

When we discuss clustering from a data-mining point of view, similar kinds of crime in the given crime rate of interest are studied, such clusters are valuable in classifying a crime pattern or a crime fling (Yadav et al, 2017). Crime analysis is the method used by the law enforcing agencies to lessen, avoid and solve crime problems with criteria that determine the potential crime area for decision support (Nurul Hazwani binti, bin Othman, & bin Selamat, 2012). A strong influence of land use is limited to their immediate surroundings – strongly attracting crime spots are alcohol outlets, cultural facilities, commercial buildings, bars and low income housing colonies; in contrast, depots-transports, gardens, grand stands are strongly detracting (Natalia Sypion & Leitner, 2017). Through best path finding which is a situational crime prevention (SCP), pedestrian will analyze the situation first before take any decision path so as lessen chances for criminal to commit crime (Wan, Mohamad & Abdul, 2015).

The present study focuses on to identifying crime prone zones through crime mapping with probability of occurrence based on past incidence of various crimes. Then provide spatial crime hot spots so as police can plan better surveillance and scheduling to minimize crime occurrence and take preventive actions in short time based on Euclidean distance maps. As per the scope it is provided a spatial decision making system to Ajmer city police for better surveillance scheduling of a year.

OBJECTIVES OF THE STUDY

The objectives of the study are based on the scope of the study so as to achive the expected results. They are:

- Crime mapping and identifying clusters and hot spots of crime prone zones of Ajmer city.
- Generate Euclidean distance of crime locations from police stations and major roads.
- Evaluate relationship between sex ratio of Ajmer city and rape incidences.
- Delineate the susceptible picks and pockets of crime in the area on the basis of concerned socio-economic parameters.
- Facilitate and suggest surveillance plan and scheduling with respect to crime prone zones identified.

SCOPE OF THE STUDY

The study was undertaken as a pilot study to understand various Geospatial tool usages in crime analysis by means of primary data collected from all police stations of Ajmer city. Interaction with the major stakeholders of crimes to gather domain knowledge has been used in analysis inference.

LIMITATIONS OF THE STUDY

Though field survey data has been collected for six year (2009-2014) with respect to certain crimes. Many other aspects like suicide, juvenile delinquency, molestation have not been covered in this study. The socio economic

data was available only for one year 2011, thus it has been taken as a base year due to paucity of data for other years. Hence change detection, hotspot transition and directional spread of crime has not been analyzed here.

STUDY AREA: AJMER CITY

As per Census India-Rajasthan-2011, Rajasthan is the largest state in the country, with difficult terrain comprising of desert, forests, mountains, tribal belt, ravines and a long international border. It also has typically hard to reach population groups. Geologically the Aravali hills around Pushkar and Ajmer City are one of the oldest in the world. Ajmer city is head quarter of Ajmer district and is a popular religious and tourist destination. Ajmer is a municipal corporation with 55 wards with an area 219.36 square kilometer. The ownership of type of houses (as shown in Table-1) and other demography details shown in Table-2.

Table 1: House Type

S. No.	Permanent	Semi-Permanent	Temporary
1.	107,438 (97.8%)	1,843 (1.68%)	273 (0.25%)
Permanent - those houses whose walls & roofs are made of Pucca materials. ***Semi-Permanent*** - those houses made of other types of materials. ***Temporary*** - those houses having wall and roofs made of Kutcha materials.			

(**Source:** Census Commissioner, India, 2011)

Ajmer city is surrounded by four national highways namely NH-8, NH-58, NH-79 and NH-89. Ajmer city stretches from 26˚23' North to 26˚23' North and 74˚36' East to 74˚40' east geographically. City has nine Police Stations (PS) and one Women (Mahila) PS have been selected for study (Ravi,Sarvesh, & Parul, 2016).

Table 2: Demography details of Ajmer city

Item	Persons	Males	Females	Rate / Percent
Population	542,321	278,545	263,776	947
Literacy	416,511	226,757	189,754	76.8%
Illiteracy	125,810	51,788	74,022	23.2%
Workers (Total)	174,922	143,668	31,254	32.2%
Cultivators	803	629	29	-
Agri. labourers	896	733	163	-
Household industry workers	8104	5419	2685	-
Other workers	152,076	127,707	24,369	-
Non Workers	367,399	134,877	232,522	67.8%

(**Source:** Census Commissioner, India, 2011)

DATA & METHODOLOGY

The crime data falling under all 10 police stations are collected with permission with the categories such as – home breaking, kidnapping, murder, rape, automobile theft, robbery and other crimes. The data collected on ward basis of all 55 wards for six years from 2009 to 2014. The socio economic data of Ajmer city was available for year 2011 only for sex ratio, non-working and illiterate population.

The ward wise total crimes and non-spatial attribute data collected from Police Stations, where nearby suburban areas crime incidences reported are 63. The crimes in different police stations are listed in Table-3 and shown in Figure-1. The 10^{th} police station Mahila Thana crime registration was made at Alwar Gate police station itself, as it is located just opposite to Mahila Thana. This is made as per administrative reasons of police establishment of Ajmer city. The research methodology adopted in the study as flow chart is provided in Figure-3.

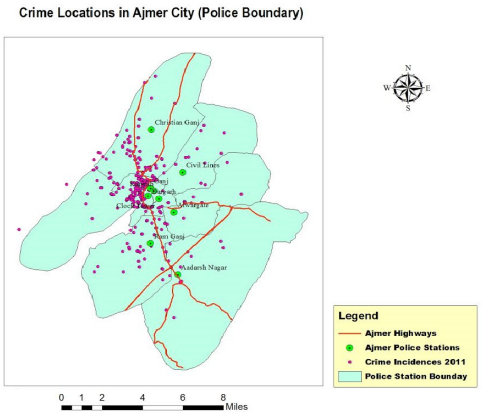


Figure 1: Crime Location with Police boundary

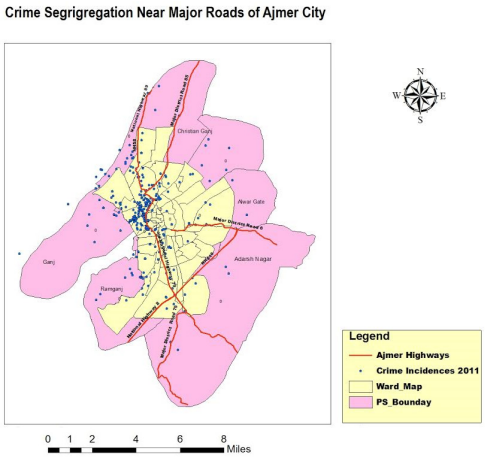


Figure 2: Crime Segregation near Major Roads

GPS was used to collect geographic locations of the crime incidence. Census data was collected from Census department of Ajmer and Ajmer city map were collected from police department. Road network was taken from open street map (as in Figure-2).

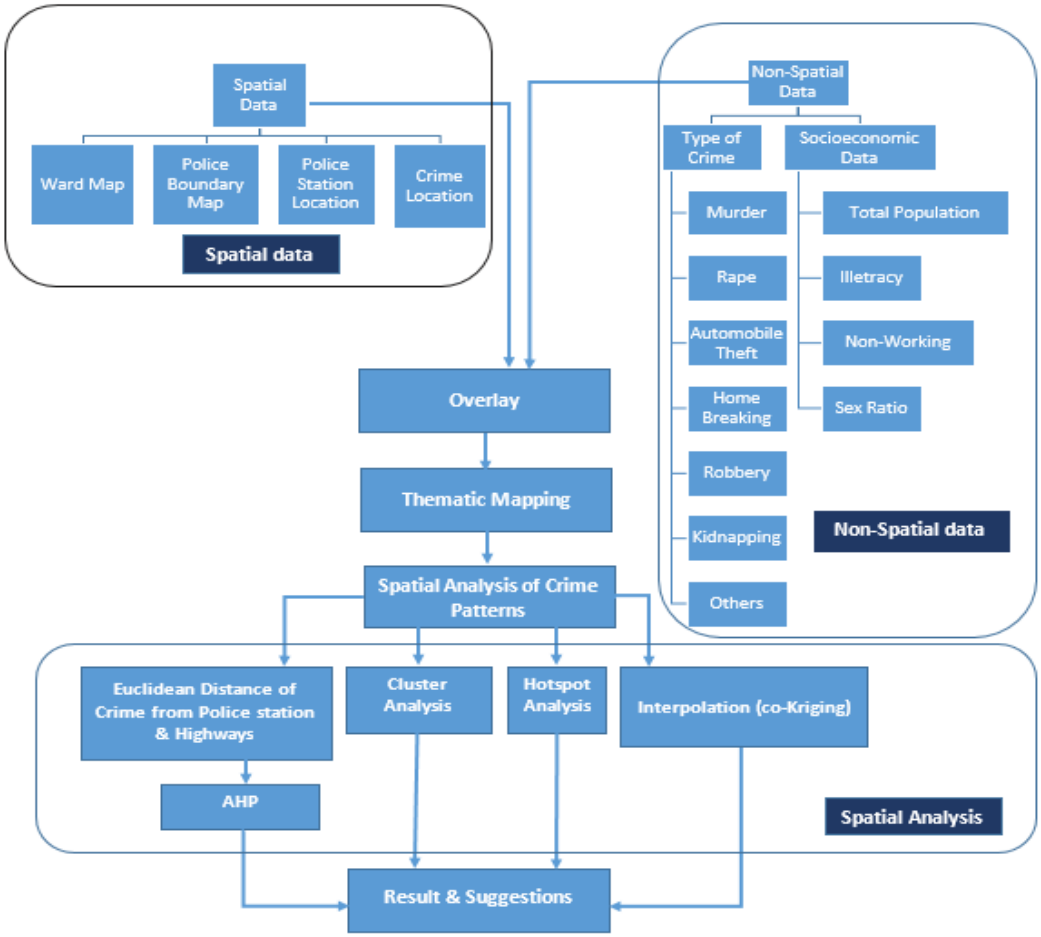


Figure 3: Research Methodology adopted in the Study

In the Figure-2, the maximum crimes spots are lying nearest to the minor and major roads in the Euclidean distance map. The densest network of roads in Ajmer city is in wards 3, 7, 8, 9, 15, 16, 22, 23, 25, 27, 28, 29 and 37. The major concentration for crime with respect to distance is noticed along the major district road 85. National Highway nos. 89, 79, 58, 48 and 8 passes through the city and maximum concentration of crime is near 58 and 79. The major district roads prone to crime are 79, 85 and 6.

Table 3: Various Crimes within Police Station limits of Ajmer city

S. No.	Police Stations	Automobile Theft	Home Breaking	Kidnapping	Murder	Rape	Robbery	Others	Total Crimes
1.	**Adarsh Nagar**	4	7	0	4	0	0	5	**20**
2.	**Ram Ganj**	9	7	1	1	2	1	4	**25**
3.	**Christian Ganj**	21	19	8	8	3	0	16	**75**
4.	**Kotwali**	41	4	3	1	4	4	21	**78**
5.	**Ganj**	4	0	2	0	3	0	1	**10**
6.	**Dargah**	7	2	1	8	3	1	0	**31**
7.	**Clock Tower**	16	5	1	3	2	0	3	**30**
8.	**Civil Lines**	14	2	0	2	1	3	20	**42**
9 & 10	**Alwar Gate** (including ***Mahila Thana***)	12	11	1	4	5	2	9	**44**
	Total:	**128**	**57**	**17**	**31**	**23**	**11**	**79**	**355**

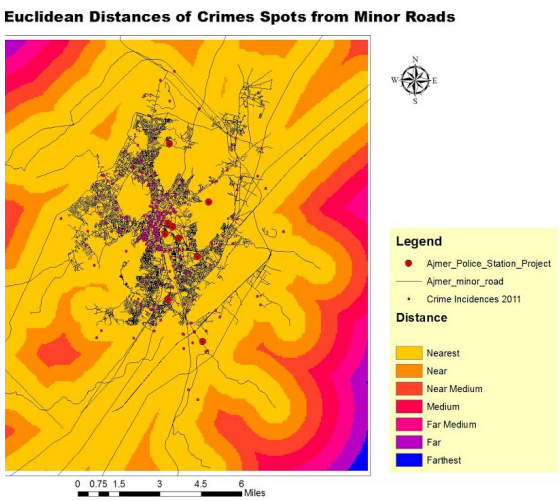


Figure 4: Euclidean distances of Crimes from Minor Roads

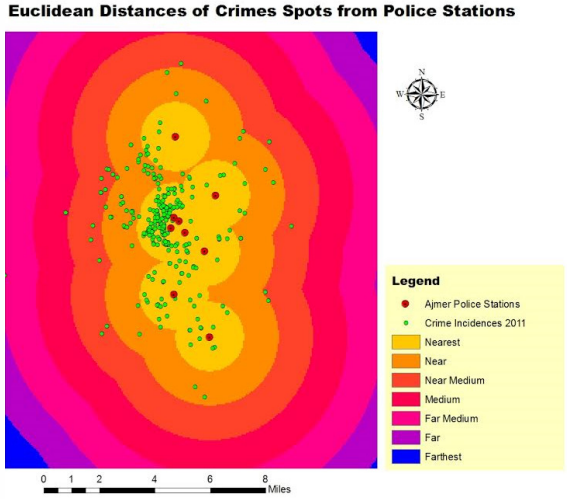


Figure 5: Euclidean distance of Crimes from PS

The Figure-4, 5 and 6 indicates that major crime occurrence is very close the Kotwali, Dargah, Clock Tower and Ganj Police Stations. This old city region is densely populated, has very narrow lanes, and is the overcrowded commercial zone of the area. It can be referred as the CBD (Central Business District) of Ajmer city in the urban terminology. Though police stations are located in the vicinity, still the crime occurrence is frequent here is observed.

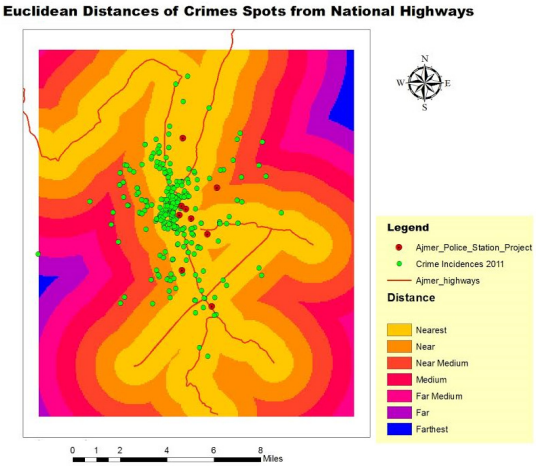


Figure 6: Euclidean distance of Crimes from National Highways (NH)

The cluster/outlier type (COType) field distinguishes between a statistically significant cluster of High values (HH) as in wards of Ajmer city 2, 21, 22, 23, 24, 25 and 47, outlier in which a High value is surrounded primarily by Low values (HL), and outlier in which a Low value is surrounded primarily by High values (LH) (as in Figure-7). The surrounding region is not significant to the occurrence of crime in this case.

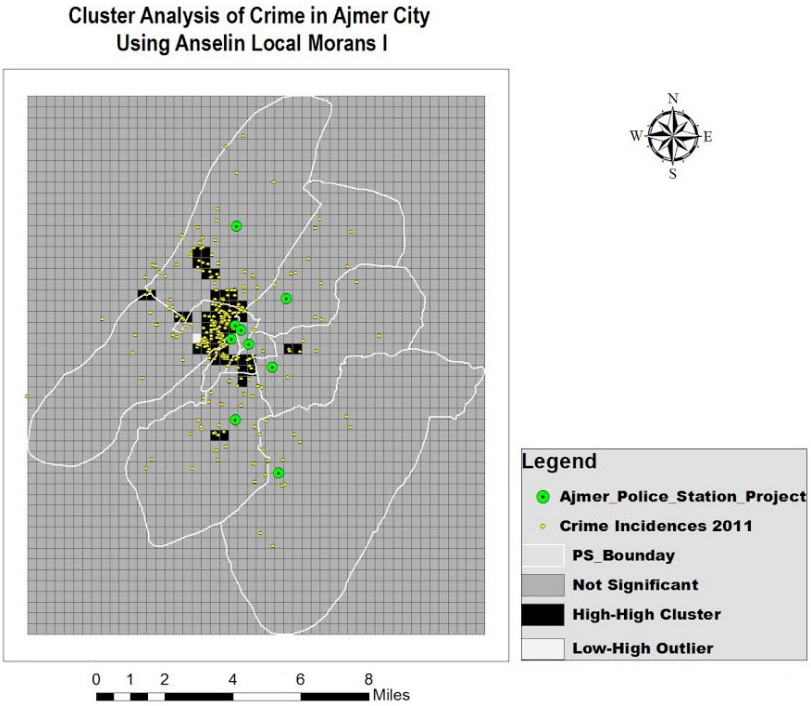


Figure 7: Cluster Analysis of Crime using Anselin Local Moran

The objective of using ordinary *Kriging* here is to predict a value based on the crime locations within the police boundary using a fish net. As it is a best linear unbiased indicator (BLUE) to predict the crime value based map for crimes location in the neighborhood of a police boundary. A strong correlation with primary variable is seen so *Co-Kriging* was used with crimes as primary variable and the socio-economic indicators as secondary to study the problem to make the region into susceptible regions. By which police force can plan better crime prevention strategy to contain crime.

The correlation coefficient of *Total crime* with *non-spatial attributes* such as population, illiteracy, non-working population and sex ratio was found out. Table-4 depicts that illiteracy, non-working population and population are highly correlated. Sex ratio obviously negatively correlated which is quite fine to undertake the study.

Table 4: Correlation Coefficient between Crime vs non-spatial data

S. No.	Non-spatial Attribute	Correlation Coefficient
1.	Illiteracy	0.991974628
2.	Non-Working Population	0.938512548
3.	Sex Ratio	-0.979543878
4.	Population	0.964581285

The results of interpolation technique states that the crimes are more susceptible in the north western and central part of the city in wards 2, 3, 5, 6, 20, 22, 24 and 25. There is a gradual decrease of probability of occurrence in the neighboring wards 15, 16, 26 and 55. It further becomes very low in the periphery region (as in Figure-8).

Co-Kriging requires much more estimation, including estimating the correlation for each dependent variable with the independent variable (Environmental Systems Research Institute, 2017). A very high positive correlation was observed between crime and illiterate and non-working population. Whereas a very high negative correlation was noticed between sex ratio and the registered rape incidences (as in Table-4).

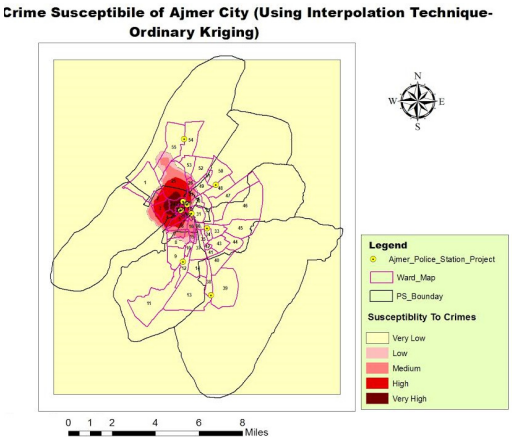


Figure 8: Crime Susceptibility - Ordinary Kriging

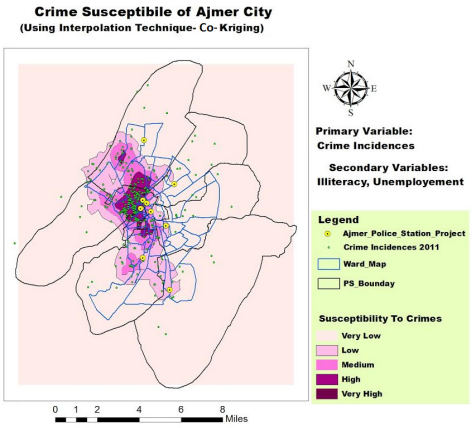


Figure 9: Crime Susceptibility - Co-Kriging

The Co-Kriging technique results into formation of three '*High Crime Susceptible Regions*' in the area spread in Dargah, Ganj, Christian Ganj, and Clock Tower. It is a religious center with hundreds of pilgrims move in and out of this region which is in ward 55 in the north, 15 and 16 in the south central and rest concentrated in 3, 5, 21, 22, 23, 24 and parts of 25, 26 wards. '*Medium Crime Susceptibility*' is observed mainly in wards 55, 2, 8, 10, 36, 17, 18, 29, and 27. The surrounding regions have low and very low susceptibility of crimes (as in Figure-9).

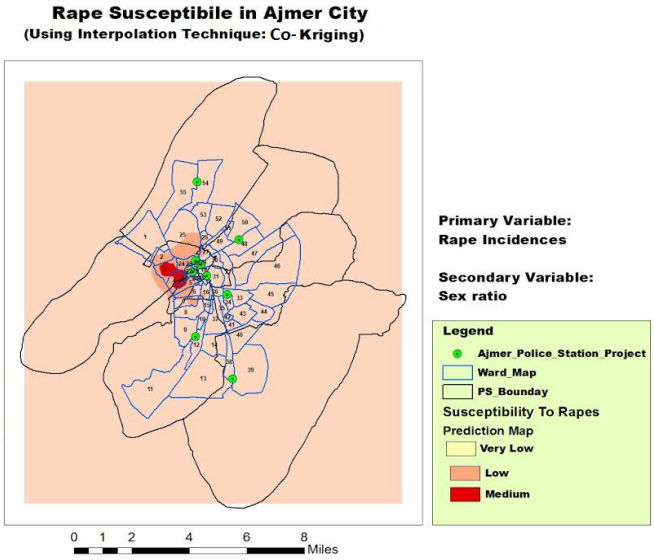
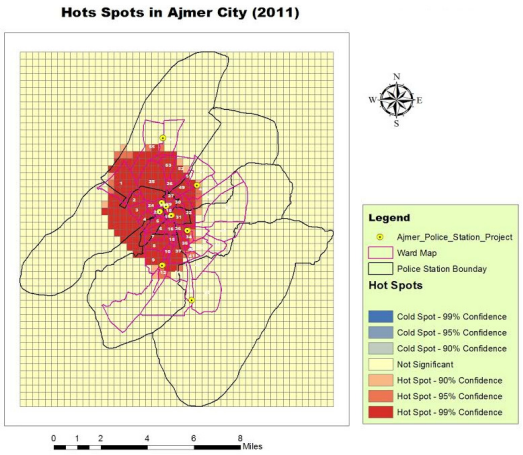


Figure 10: Rape Susceptibility - Co-Kriging

In case of Rape incidences, maximum crimes were reported in the Alwar gate and Kotwali police stations, which lie in the least sex ratio area of the city (as in Figure-10).

Hot Spot tool works by looking at each feature within the context of neighboring features. A feature with a high value is interesting but may not be a statistically significant hot spot. To be a statistically significant hot spot, a feature will have a high value and be surrounded by other features with high values as well. The local sum for a feature and its neighbors is compared proportionally to the sum of all features (Environmental Systems Research Institute, 2017).

The hotspot concentration is confined in the north-central part of the city. It has high value concentration in the old city region with 99 percent confidence and has 95 percent and 90 percent confidence in the surrounding region. The results are further validated here by using hot spot analysis because in the Dargah, Ganj, Kotwali, Purani Mandi, Madar gate, Nala Bazar, Kutchery Road areas are having very high intensity of crimes occurrence. The major reasons behind such crime occurrences are possibly the high non-working population, illiterate people of daily wage jobs, and street/ footpath vendors of low per-capita. The other supporting field observation is that intake of locally made liquor and drugs and vicinity to major roads (as in Figure-11 & Figure-12).



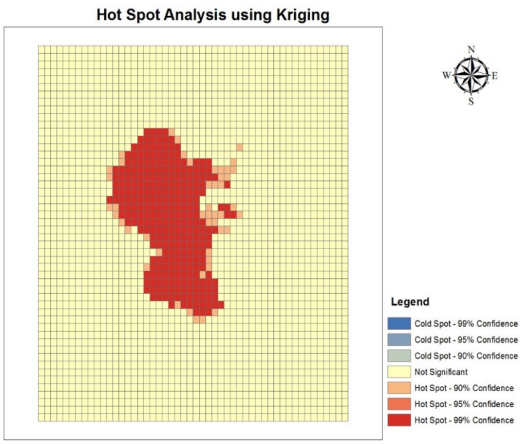


Figure 11 and 12: Hot Spots of Crimes in Ajmer City

To validate the study using multiple variable like population, illiteracy, non-working etc to demarcate the most crime prone zones with others by overlaying separate raster classified images by using AHP. This *Weighted Overlay* (AHP) tool applies one of the most used approaches for overlay analysis to solve multi-criteria problems. In weighted overlay analysis, we must define the problem first, then break the model into sub-models, and identify the input layers (Environmental Systems Research Institute, 2017).

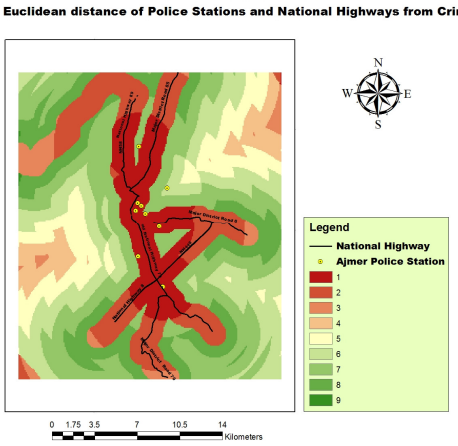


Figure 13: Weighted Overlay -ED of PS from NH

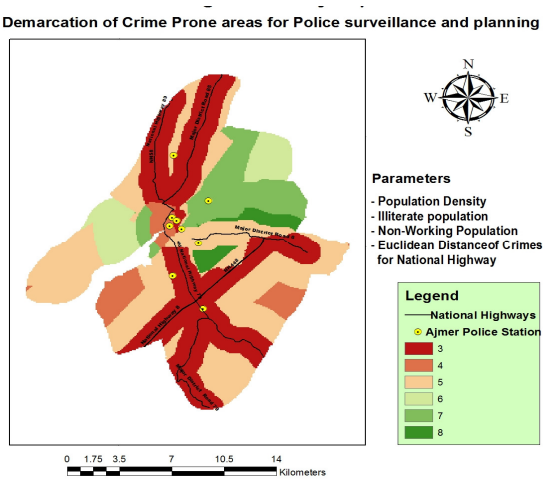


Figure 14: Weighted Overlay- Areas demarcation

Since the input criteria layers will be in different numbering systems with different ranges, have to combine them into a single analysis, each cell for each criterion must be reclassified into a common preference scale such as 1 to 10, with 10 being the most favorable.

For analysis firstly Euclidean distance of crimes from National Highways and Police Stations was used for overlay as the crimes occurrence was close to the two. But, the results were not effective because crime definitely has an association with road network but with respect to police stations, it is segregated only around the police stations in the central old city area. Whereas the map output (as in Figure-13) has uniformly distributed them around all police stations.

Later, another weighted overlay analysis was performed using raster reclassified layers of population density, Illiterate and non-working populations and Euclidean distance from national highways. The final output (as shown in Figure-14) showed impressive results and demarcated zones for policing considering all the input parameters.

Figure-15 gives an illustrative depiction of the four different layers overlaid for Analytical Hierarchical process. The most suitable areas for surveillance are shown in red. Orange areas are next, followed by light brown. Shades of Green follow in that order. Modifying the suitability values or the influence percentages will produce different results. It is a remarkable tool for police for execution of surveillance and planning in the specified crime prone

areas. As it clearly delineates the tensile and unsafe pockets in a region, it definitely benefits the investigation and patrolling activities by the law enforcers.

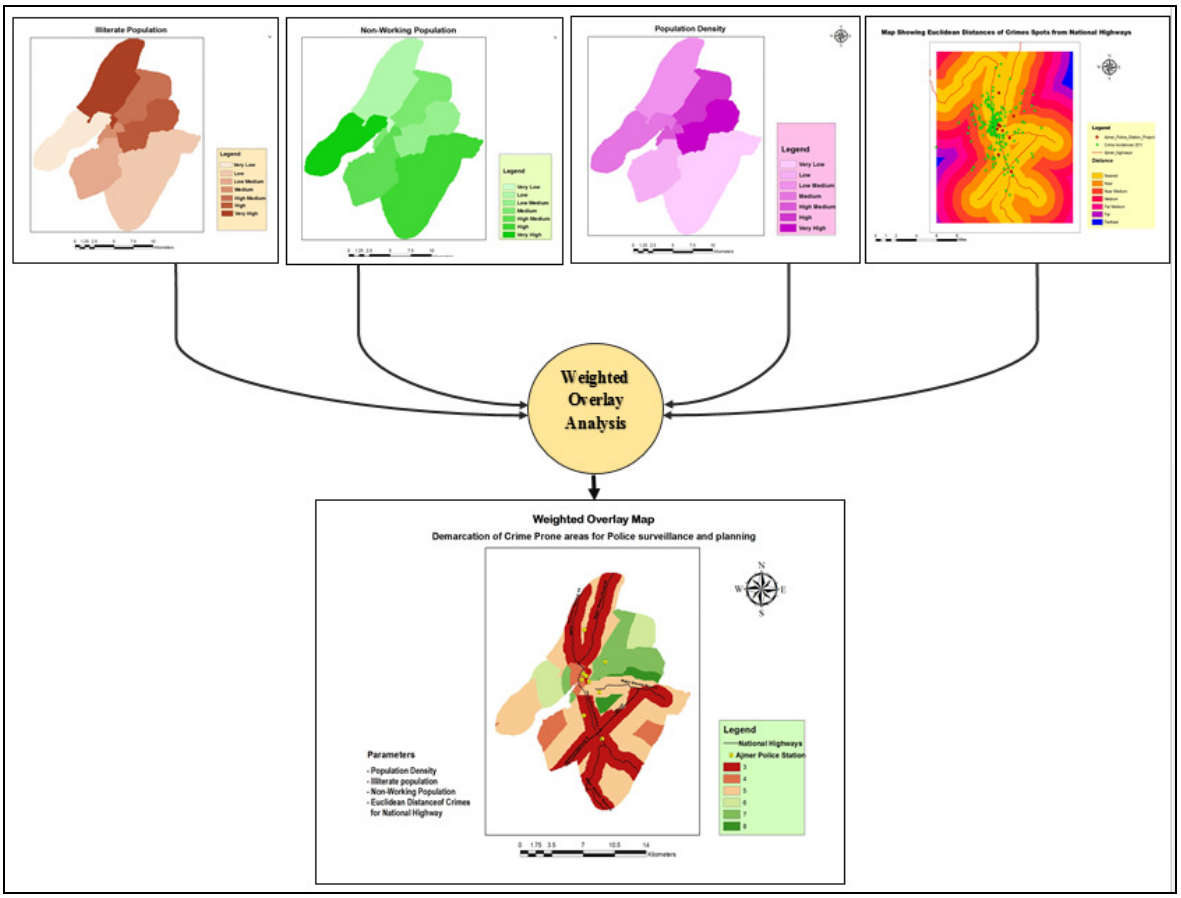


Figure 15: Weighted Overlay Analysis (AHP)

CONCLUSION

The objective of crime mapping and identifying high crime prone zones using various parameters has been met. The objective of facilitating better surveillance planning so as to control crime effectively by police authorities is achieved well within the scope set. The research has generated the crime hot spots distance from the police stations so as police force can have a plan to put a third eye on criminals. As the crime spots have a strong association along roads, the scheduled patrolling can definitely check the crime occurrence in the region. The Ajmer administration also gets an insight about the relationship of criminal offences and socio-economic indicators and can work towards suppressing them. The study can be extended further by forecasting the shift in hot spots with respect to various crime investigation using machine learning or the other techniques. It would definitely ensure safety and security in the area and work towards social welfare. Action, reaction and prevention can effectively be planned using Geospatial Techniques for crime eradication.

REFERENCES

Ansari, S. M., & Kale, K. V., 2014. Mapping and Analysis of Crime in Aurangabad City using GIS. IOSR Journal of Computer Engineering, pp. 67-76.

Ansari, S. M., & Kale, K. V., 2014. Methods for Crime Analysis Using GIS. International Journal of Scientific & Engineering Research, *5*(12).

Census Commissioner, India. 2011. District Census Handbook - Ajmer. Directorate of Census Operations Rajasthan.

Divya, G., Robinson , R. R., & Selvan, K., 2014. Suitability of Clustering Algorithms for Crime Hotspot Analysis. International Journal of Computer Science Engineering and Technology, *4*(7), 231-234.

Eck, J. E., Chainey, S., Cameron, J. G., Leitner, M., & Wilson, R. E., 2005. Mapping Crime: Understanding Hot Spots. Washington: National Institute of Justice (NIJ).

Environmental Systems Research Institute., 2017. ArcGIS Pro Desktop. (ESRI) Retrieved June 16, 2017, from ArcGIS Pro Desktop: https://pro.arcgis.com/en/pro-app/.

Johnson, C. P., 2000. Crime Mapping and Analysis Using GIS. Geomatics 2000: Conference on Geomatics in Electronic Governance, Pune.

Kaura, A., Ghawanaa, T., Khandurib, P., Taruna, N., Garg, C., & Nayak, B., 2014. Crime mapping using Geospatial technologies: A case study of NCT Delhi. 15thEsri India User Conference 2014.

Mitchell, S. E., 2011. Using GIS to Explore the Relationship between Socioeconomic Status and Demographic Variables and Crime in Pittsburgh, Pennsylvania. Papers in Resource Analysis*, 13*.

Napoleon, D., & S., D. S., 2017. Effected Crime Exploration Implements and Developments with Remote Sensing: Survey. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 115-119.

Natalia Sypion, D., & Leitner, M., 2017. Land Use Influencing the Spatial Distribution of Urban Crime: A Case Study of Szczecin, Poland. International Journal of Geo-Information.

Nurul Hazwani binti , M., bin Othman, M., & bin Selamat, M., 2012. Identification of Potential Crime Area Using Analytical Hierachy Process (AHP) and Geographical Information System (GIS). International Journal of Innovative Computing, 15-22.

Olajuyigbe, A., Omole, K., Bayode, T., & Adenigba, A., 2016. Crime Mapping and Analysis in the Core Area of Akure, Nigeria. Journal of Remote Sensing & GIS*, 5*(4).

Pramod Kumar, G. R., Ravikumar, P., & Soma, R. K., 2012. Based Crime Mapping and Analysis: A Case Study of Mudugiri Town Police Station Jurisdiction. First International Research Conference on Humanities and Social Sciences*. 1*, pp. 170-176. Nugegoda: Faculty of Humanities and Social Sciences, University of Sri Jayewardenepura, Retrieved from http://journals.sjp.ac.lk/index.php/IRCHS/article/view/2354/1326.

Ravi, S., Sarvesh, P., & Parul, B., 2016. Crime mapping analysis of Ajmer city -A GIS approach. Journal of Geomatics, *10*(1), 96-101.

Sangamithra, V., Kalaikumaran, T., & Karthik, S., 2012. Data mining techniques for detecting the crime hotspot by using GIS. International Journal of Advanced Research in Computer Engineering & Technology*, 1*(10), 228-231.

Saravanakumar, S., & Revathy, S., 2016. Crime Mapping Analysis: A GIS Implementation in Madurai City. International Journal of Science and Research*, 5*(3), 1894-1897.

Shahebaz , M. A., & Kale, K. V., 2014. Methods for Crime Analysis Using GIS. International Journal of Scientific & Engineering Research*, 5*(12).

Sivaranjani, S., & Sivakumari, S., 2015. GIS Based Crime Hotspot Mapping and Analysis using Radial Base Function (RBF) and Interpolation Method. International Journal of Remote Sensing & Geoscience*, 4*(5), 43-49.

Thangavelu, A., Sathyaraj , S. R., & Balasubramanian, S., 2013. Assessment of Spatial Distribution of Rural Crime Mapping in India: A GIS Perspective. International Journal of Advanced Remote Sensing and GIS, 70-85.

Wan Nawawi, W. F., Mohamad Nor, N. M., & Abdul Jalil, M., 2015. Identification of Potential Crime Tactical Path-Finding Using Analytical Hierarchy Process (AHP) in Situational Crime Prevention. ICIT 2015 The 7th International Conference on Information Technology, (pp. 672-678).

Yadav, S., Kushwaha, U., Choudhary, S., & Yadav, S., 2017. Security Analysis in Different Areas using Crime Data. Global Research and Development Journal for Engineering*, 2*(5), 346-349.

Acknowledgement: We acknowledge our sincere thanks to ALL who created interest, support and guided us to come out with this research work as a pilot project under National Natural Resource Management Systems (NNRMS-2017) program for University Faculty at IIRS, Dehradun. We thank all faculty who taught us RS, GIS and its Applications. Our special thanks to Dr.Senthil Kumar, Director-IIRS, Dr. Suresh Kumar, Program Coordinator-NNRMS, Dr. Saran, GID-Head and entire Faculty of GID group. Our sincere thanks to Mr. P. Alok Verma, Supervisor of this pilot project under whose guidance we can achieve our first step in RS-GIS technology usage in a short time.

***