Research Article **AJGRR (2018) 1:5**

American Journal of Geographical Research and Reviews
(ISSN:2577-4433)

Role of Geospatial technology in Crime Mapping: A case study of Jharkhand state of India

Firoz Ahmad [1*], Md Meraj Uddin[2], Laxmi Goparaju[1]

[1]Vindhyan Ecology and Natural History Foundation, Mirzapur, Uttar Pradesh, India.
[2]University Department of Mathematics, MCA, Ranchi University, Ranchi, Jharkhand, India

ABSTRACT

Crime is a social stigma which needs to be addressed beyond talks. In developed country Geospatial technology has become well established within the criminology and forensic fields in recent past. In order to achieve this proper database of various crimes (state/ district level) should be available for decision making. The present study was an attempt made to study the district wise crime data (IPC crime registered) for murder, rape, kidnapping, dacoity, burglary, theft and riots of state of Jharkhand for the year 2013 to understand the crime trend. We have generated various maps including crime density map of Jharkhand based on crime types using ARC/ GIS Software and MS EXCEL. The crime density such as murder, rape, kidnaping and riots were found in the range of (2.2 to 17.8), (1.6 to 12.6), (2.3 to 10.4) and (1.0 to 17.5) respectively. Murder crime density was highest in Gumla district whereas it was found to be lowest in Gridih district. Sahebganj district has high crime density for rape and kidnapping. Palamu district had low crime density in rape, whereas Ranchi district recorded low crime density in kidnapping. Crime density for riots was found lowest for district Simdega whereas highest for Koderma. The Indian police and law enforcement departments has not yet exploited the GIS aspect which will fetch better result as far as crime control is considered.

Keywords: Crime Analysis, Geographical Information Systems, Crime Mapping, Jharkhand

***Correspondence to Author:**
Firoz Ahmad
Vindhyan Ecology and Natural History Foundation, Mirzapur, Uttar Pradesh, India

How to cite this article:
Firoz Ahmad, Md Meraj Uddin, Laxmi Goparaju. Role of Geospatial technology in Crime Mapping: A case study of Jharkhand state of India. American Journal of Geographical Research and Reviews, 2018; 1:5.

eSciencePublisher
eSciPub LLC, Houston, TX USA.
Website: http://escipub.com/

Introduction

Crime is an unlawful act punishable by a state. Based on the map of world crime index (http://chartsbin.com/view/39717) the country Venezuela occupied the top with the crime index value 84.44. South Sudan, South Africa and Papua New Guinea occupied 2nd, 3rd and 4th position respectively South Korea occupied in bottom exhibit least crime index value 14.31. Based on this value India occupied 53rd position from top among all 117 countries retaining a value of 46.59.

The traditional criminal record system and its maintenance have become very difficult in the existing crime scenario. Manual processes neither provide accurate, reliable and comprehensive data round the clock nor does it help in trend analysis, prediction and decision support. Geospatial technologies (Remote sensing, GIS and GPS) become worldwide acceptable in society, a wide range of disciplines and professions/scientist/researcher adopt them for collecting, storing, manipulating, updating, analyzing, and displaying spatial data , resulting in the generation of new information and simulation models for policy and decision making. The solution to this ever-increasing problem lies in the effective use of Geospatial tools which provide a unique contribution to forensics. (McKinley et al. 2008; Noond et al. 2002; Wolff and Asche 2009)

Crime mapping and GIS based spatial analysis and modeling in crime is considered as powerful tool for the study and control of crime, because crime maps help police to identify/locate problems at various levels. A growing number of police/law enforcement departments of developed country routinely map and analyze crime data for different purposes (Mamalian and LaVigne 1999 ; Markovic et al. 2006 ; Nelson 1999 ; Wang 2005 ; Wartell 2003). GIS database not only support geocoded thematic layers but also traditional tabular-based data, such as spreadsheets, and additional multimedia based information, such as word processing documents, digital pictures, and video and audio recordings. More recent innovations in spatial tracking device (GPS, Cell phones, Automated License Plate Readers, Unmanned Aerial Vehicles and Radio Frequency Identification devices) have further extended the potential for law enforcement agencies to more easily apprehend offenders and prevent crime while keeping investigation officers safe. Thermal imaging technologies create an image using temperature (Asano et al. 2012) are widely used for marijuana related growing operations (Davenport 2001 ; Schreiber 2009 ; Schultz 2008) whereas Ground-Penetrating Radar has been used successfully by law enforcement agencies to locate a variety of forensic evidence (Schultz 2012).Geographic Profiling (Canter and Hammond 2007) a very common examining methods and one of the more specialized approach of crime mapping and analysis which integrates the theory from criminal investigative analysis, environmental criminology , ethnographic geography and criminal geographic targeting to support law enforcement and investigating agencies in solving difficult serial crimes (Canter 2009).The advancement in information technology and concept of digital India (initiated by Indian government) has tremendous pressure in various department including law enforcement agencies to implement it as the earliest. Although police forces have started using GIS technology which is limited to big cities, the penetration of GIS into every application is relatively low.

Crime mapping basically has three major functions within the crime analysis, firstly it provides cartographical map that helps to manifest the analysis results. Secondly it facilitates the spatial pattern and its nature for visualization with statistical analysis based on crime and other types of event. Thirdly it allows the analysts to link other data sources together based on its geographical location such as census information, socioeconomic condition and historical crime data for a common area.

The study conducted by Ahmad et al. 2017b about the crime of India reveals the crime density in India in the year 2013 was within the range of 61.5 to 527.6 based on the IPC crime registered. The Nagaland state shows the low crime density whereas Kerala state shows the high crime density. The Jharkhand state was the ninth lowest state with value 146.The crime percent increase was noticed in Jharkhand in the year 2013 was 17.8% when compared with the preceding year.

The availability of satellite RS data freely has opened up the opportunity for researcher in mapping when coupled with GIS and other thematic vector data (free downloaded) has enhance the capability of mapping for various studies. It has been used widely in study natural resources like, forest/ vegetation mapping (Ahmad and Goparaju 2017a), agroforestry suitability (Ahmad et al. 2017a; Ahmad and Goparaju 2017b), Land use land cover (LULC) analysis (Ahmad and Goparaju 2016), soil and water conservation prioritization (Ahmad and Goparaju 2017c) spatial expansion of mines, natural hazards calamities etc. Little has been done in the field of crime mapping and monitoring.

Developed countries like Canada (Eikelboom et al. 2017), USA (Jefferson 2017; Bunting et al. 2017) and New Zealand (Curtis-Ham and Walton, 2017) have proved the worth of GIS in crime mapping. It is in a nascent stage in a country like India where it will get time to gain momentum.

The location in crime is important and it is spatially identified (Longley et al. 2005). GIS analysis mostly focuses on crime suspect identification and its pattern evaluation in linking their activities with offenses (Groff and La Vigne 1998; LaVigne and Groff 2001).The topology (spatial relationship) of location of crime with other thematic layers such as proximity to roads, schools/colleges, shopping centre, commercial establishment and recreational area, demographical parameter (population density, housing, illiteracy, unemployment and socioeconomic status of the people), are well studied by various researcher (Alves et al. 2013; Anderson and Anderson 1984; Lawrence and Cohen 1979; Cotte Poveda 2012; Cusimano et al. 2010; Hojman 2002; Hojman 2004; Kelly 2000; Levitt 2001). The crime prediction based on its occurrence is new trend and highly useful because of its prospective benefits and utility toward crime identification. (Gerber 2014: Gorr et al. 2003; Liao et al. 2010; Mohler et al. 2011; Wang et al. 2010).

Gupta et al. 2012 have studied crime analysis in Jhunjhunu district of Rajasthan, India and demonstrated the capability of Kriging as well as weighted overlay analysis for identifying crime patterns by integrating socio- economic factor in GIS domain. The study reveals that the social factors have strong correlation with different types of crime. Thangavelu et al. 2013 studied Coimbatore rural area of Tamil Nadu, India. The study highlights the importance of police departments for identifying and detecting rural crime areas based on thematic mapping. Shahebaz and Kale 2014 studied crime mapping in Aurangabad city of Maharashtra state, India. They utilized Kernel Density Estimation, Inverse Distance Weighted and Getis-Ord Gi methods for crime incidence like Murder, Day House Break and Night House Break. They found that the result were satisfactory as crime analysis is concerned and will help a lot to police department if it is effectively used. Malvika (2015) analyzed the scenario of crime of Rajasthan, India at district level. The study shows that the application of GIS, graphical tool and statistics in crime mapping is the need of the hour and should be given preference over the traditional/manual crime recording methods. Karuppannan et al. 2004 evaluated the crime of Chennai city of India in GIS domain. The study reveals that, GIS is a much more compatible application tool of crime pattern analysis than the current processes because of its locational geographic referencing abilities.

The potential aspect of using GIS is its capability to map /analyze/query and hotspot generation. This has not been fully utilized in crime evaluation, identification and prediction in various state of our country therefore it is potential research gap which need to be addressed efficiently such that it can be highly useful for improving the life of citizens. By enforcing strict laws, crime can be controlled and citizen safety be ensured.

The present study aims to evaluate the district wise crime data (IPC crime registered) for murder, rape, kidnapping, dacoity, burglary, theft and riots of state of Jharkhand for the year 2013 to understand the district wise crime trend and produce the crime density map.

The Study area

The study was carried out in one of the states of India named Jharkhand (Figure. 1) which become a state in the year 2000. The geographical coordinates are from latitude 21 º 58' 02'' N to 25 º 08' 32''N and longitude 83º 19' 05''E to 87º 55' 03 '' E. It is surrounded in east by the state West Bengal, on the west by the state Chhattisgarh, on the north by the state Bihar and on the south by Orissa state. Jharkhand is rich in minerals accounts for 40% of the mineral resources of India, but it suffers with poverty as 39.1 per cent of the population is below the poverty line. As per 2011 Indian Census Jharkhand has a population of 32.96 million with literacy rate 67.63% whereas Ranchi district being the most educated at 77.13% when compared to the rural Pakur district being least at 50.17%. The State is primarily a rural state as only 24 percent of the population resides in cities. The overall crime rate for the year 2013 was found lowest in Jharkhand equal to 146 compared to National crime rate average 218(ncrb.gov.in**).**

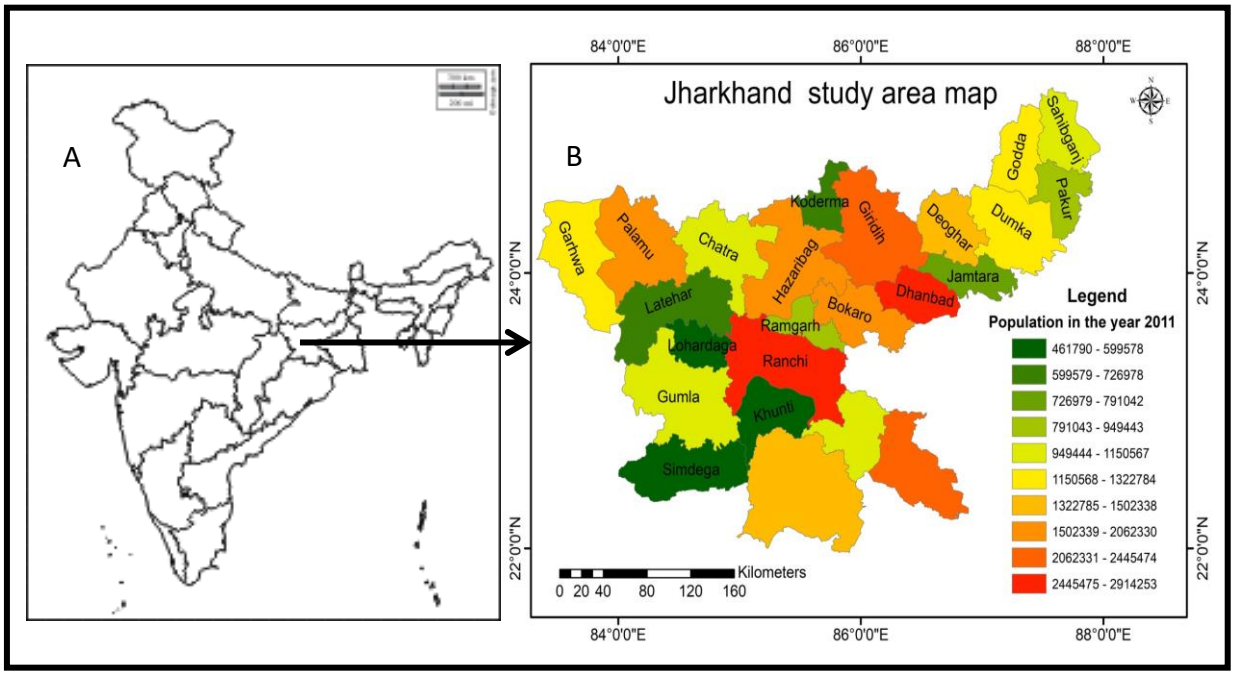


Figure 1. The location of the study area (A: India, B: Jharkhand)

Material and methods

The vector files for the state and all the districts were downloaded from DIVA GIS website (http:// www.diva-gis.org/Data). District wise crime data (murder, rape, kidnapping, dacoity, burglary, theft and riots) for the year 2013 was downloaded from the website (http://www.neighbourhoodinfo.co.in/crime/Jharkhand). The analysis and evaluation was done in ARC/ GIS Software and MS EXCEL. Various district wise attribute columns in polygon vector layer for the crime types murder, rape, kidnapping, dacoity, burglary, theft and riots and for population 2011were created in ARC/

GIS Software. The crime number and population were filled in each respective column. The census data for India is available at an interval of 10 year. In our study we have used Indian census data 2011 (latest) to understand crime density for each district. Based on this data we have created crime map showing various crime type. The crime density (CD) in our study means number of crime per lakh population. Three districts such as West Singhbhum, East Singhbhum and Sarikhela Kharsawan don't have crime data and were left blank in the map.

Result and Discussion

The total number of crime reported in Jharkhand for the year 2013 was 48208. The violence crime number was 7138 whereas the rest was related to property. The violence crime include crime like Murder, rape, robbery, kidnaping and riots whereas crime like dacoity, burglary, theft were kept under property related crime. The evaluation of crime data district wise (IPC registered) for violence (murder, rape, kidnapping and riots) and property (dacoity, burglary and theft) for the year 2013 with crime type are given in figure 2 and figure 3.

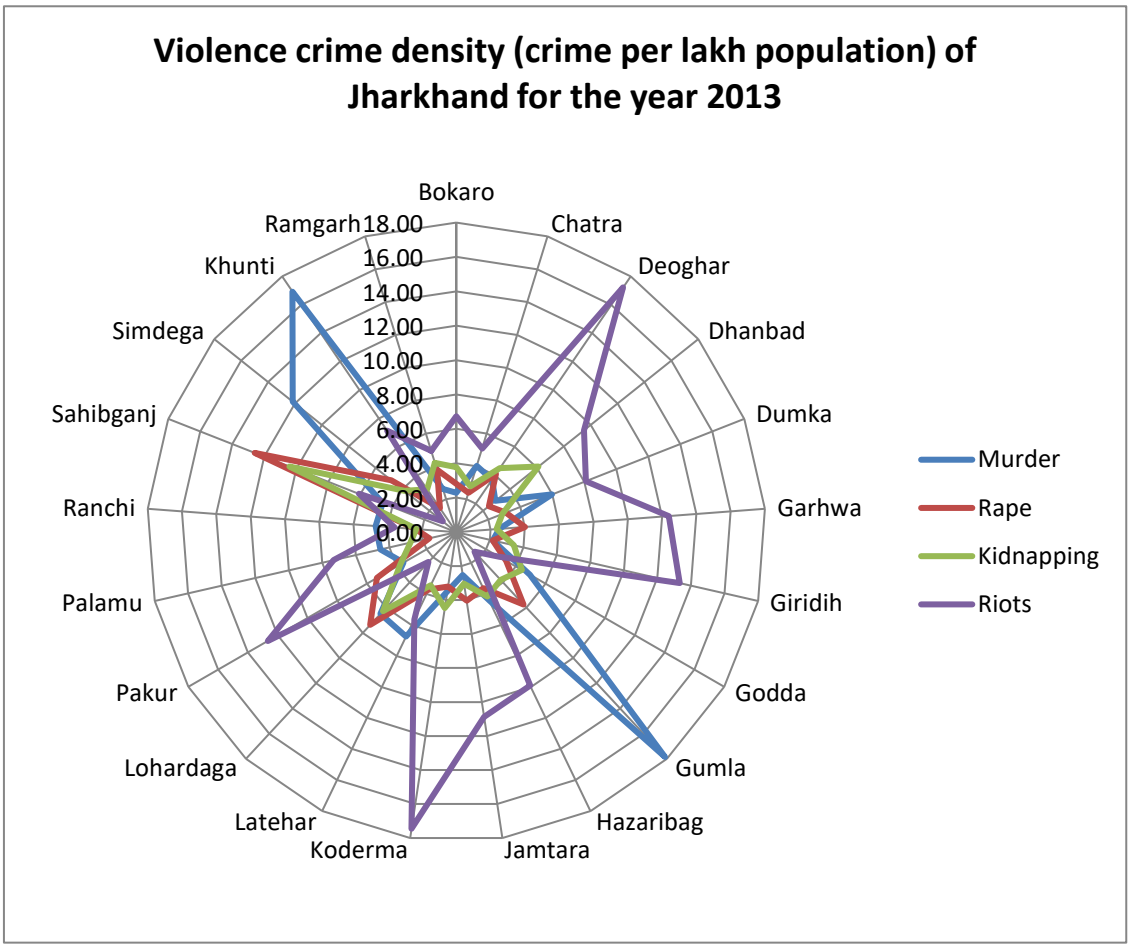


Figure 2: Violence crime density of Jharkhand for the year 2013

The graph representing in figure 2 shows synoptic overall view at a glance. Gumla, Khunti and Simdega district of the Jharkhand shows high crime density in murder whereas Koderma, Deogarh and Gridih are high in crime riots. Rape is more in the district of Sahebganj and Lohardaga whereas Ranchi exhibit least in crime like violence (murder, rape, kidnapping and riots). Similarly figure 3 shows the theft is the major contributor in property crime. The Dhanbad, Bokaro and Ranchi show more crime like theft.

Mapping technology became boon in the recent days for the citizen and administration due to its potentiality to pool various data set which is widely available with them. The advancement

and improvement in computer science and its various user friendly modules/algorithms such as image processing techniques and GIS toward mapping enable a logical conclusion to find out various re-search problems. The ARC/ GIS software was used here to generate, display and compose of map based on the existing data sets are given in figure 4. The crime density (crime per lakh population) of Jharkhand in violence and property were found to be in the range of (14.9 to 34.2) and (7.7 to 52.6) respectively given in the figure 4. Sahebganj district leads in crime like violence whereas Dhanbad district leads in property crime. The crime density such as murder, rape, kidnaping and riots were found in the range of (2.2 to 17.8), (1.6 to 12.6), (2.3 to 10.4) and (1.0 to 17.5) respectively. Murder crime density was highest in Gumla district (roughly 3 times with state average) whereas found lowest in Gridih district. In Gumla, Khunti and Simdega districts the crime density of murder were in double digit with value 17.5, 16.9 and 12.2 respectively. Sahebganj district leads in the crime like rape (roughly 3 times with state average) and kidnapping(roughly 2.5 times with state average) as far as crime density is concern. Lohardaga district occupied 2nd position in rape and kidnapping crime density. Palamu was found lowest in rape whereas Ranchi was found lowest in kidnapping. Riots crime density was found lowest in Simdega whereas highest in Koderma.

The property crime density such as theft, dacoity and burglary were found in the range of (3.1 to 45.1), (0 to 1.6) and (0.9 to 77) respectively. Dhanbad district leads in crime like theft (roughly 2.8 times with state average) and dacoity (roughly 2.4 times with state average) whereas Khunti district exhibit least crime in dacoity and burglary. Gharwa district was found lowest in theft whereas Bokara district occupied highest value in burglary. The similar study on crime mapping was done by Ahmad *et.al.,* 2017b at country level.

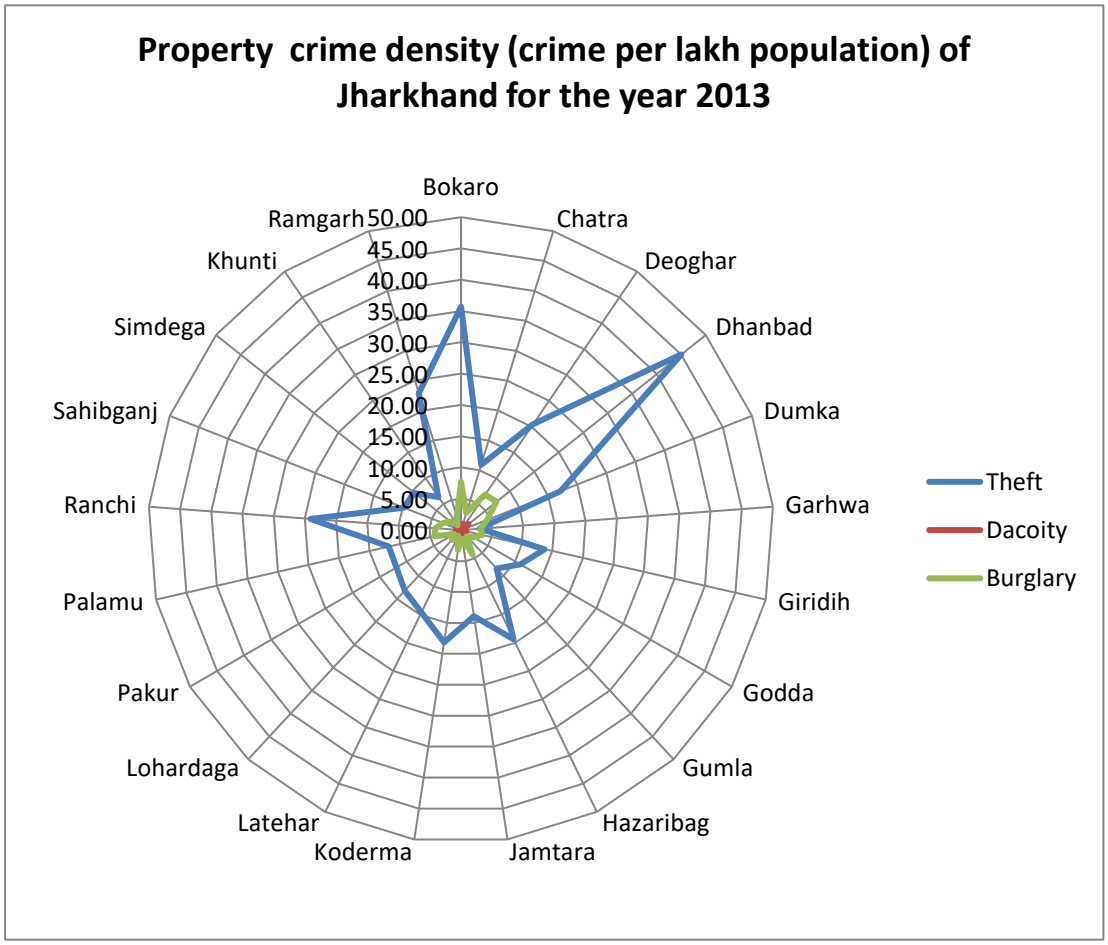
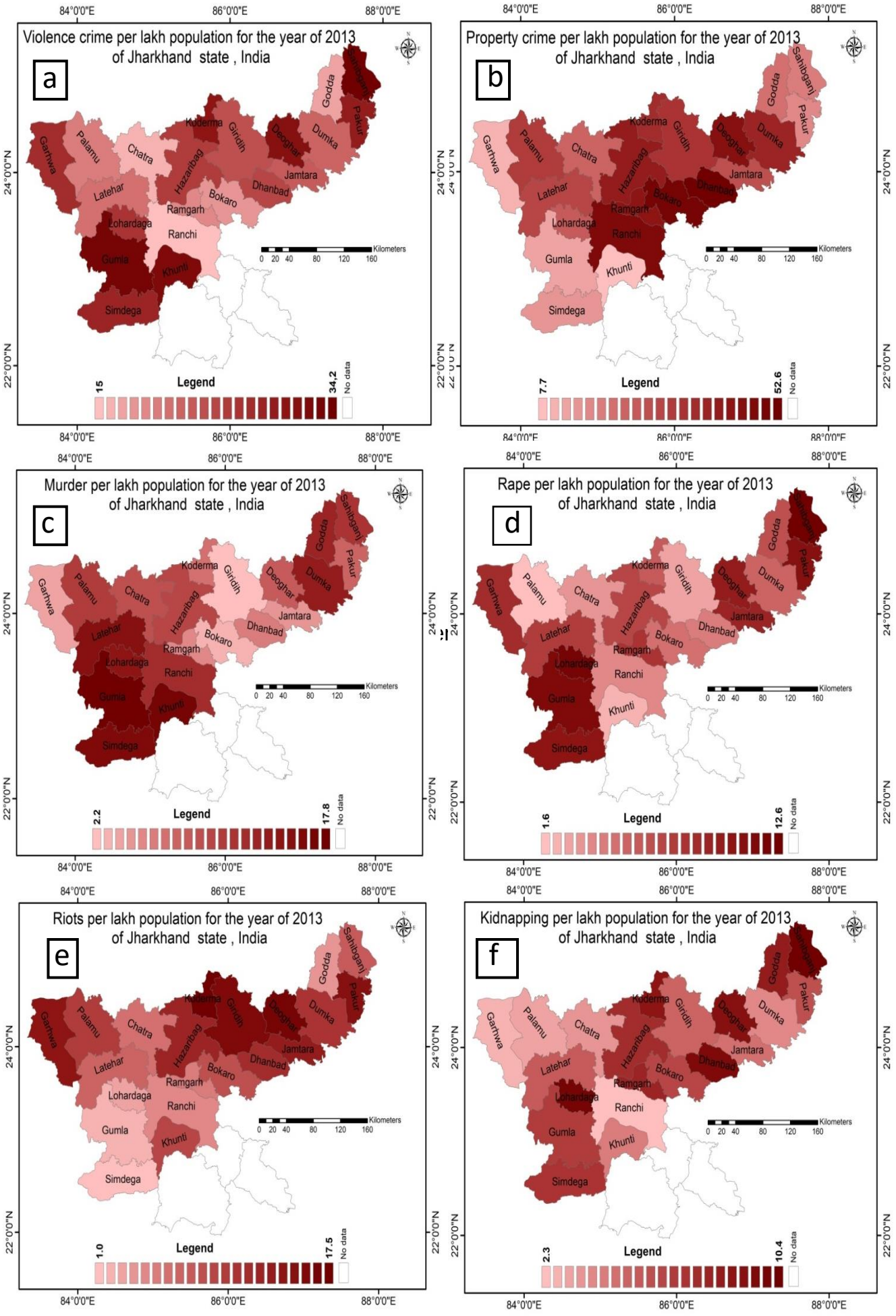


Figure 3: Property crime density of Jharkhand for the year 2013


a
Violence crime per lakh population for the year of 2013 of Jharkhand state , India
Legend
15
34.2
No data
b
Property crime per lakh population for the year of 2013 of Jharkhand state , India
Legend
7.7
52.6
No data
c
Murder per lakh population for the year of 2013 of Jharkhand state , India
Legend
2.2
17.8
No data
d
Rape per lakh population for the year of 2013 of Jharkhand state , India
Legend
1.6
12.6
No data
e
Riots per lakh population for the year of 2013 of Jharkhand state , India
Legend
1.0
17.5
No data
f
Kidnapping per lakh population for the year of 2013 of Jharkhand state , India
Legend
2.3
10.4
No data
Kilometers
0 20 40 80 120 160
84°0'0"E
86°0'0"E
88°0'0"E
24°0'0"N
22°0'0"N
Garhwa
Palamu
Chatra
Koderma
Giridih
Deoghar
Godda
Sahibganj
Pakur
Dumka
Jamtara
Hazaribag
Latehar
Bokaro
Dhanbad
Ramgarh
Lohardaga
Ranchi
Gumla
Khunti
Simdega

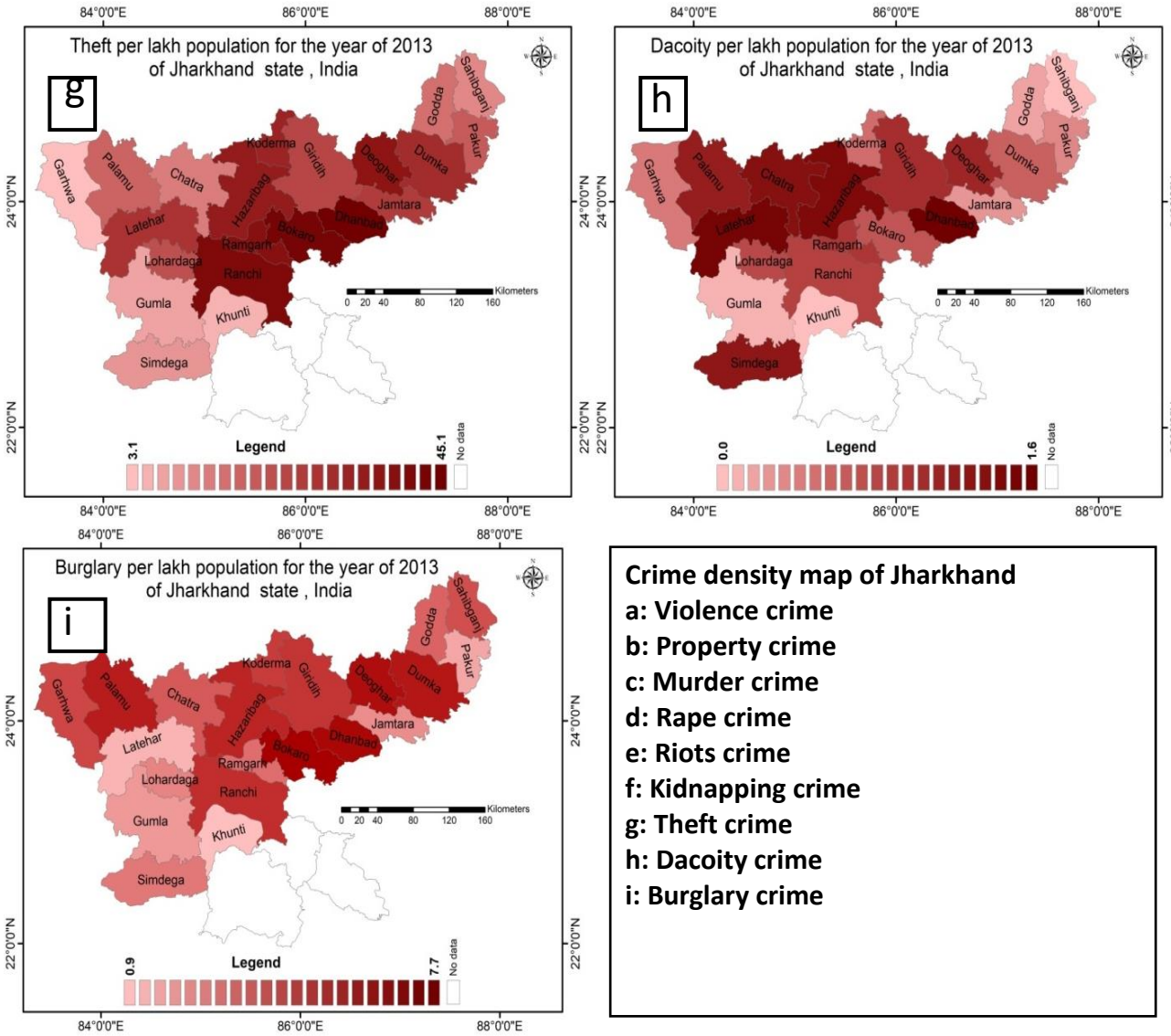


Figure-4 (a, b, c, d, e,f, g, h, i): Crime density map with respect to crime types of Jharkhand

Conclusion

Remote sensing data, GIS and GPS can be potentially used to harness in variety of applications in crime mapping, prediction and identification. Historical crime data and its location when analyzed with other thematic data sets such as location of police station, road network, shopping malls, buildings, bus stand, recreational centre with urban sprawl and girls school and colleges, mobile police van location and installed camera location etc manifest several logical clues which can be highly useful for crime identification and prevention. Furthermore data of various hotspot of crime can be potentially utilized to install new CCTV camera, establishing the new police station post and mobilizing the police patrolling.

Jharkhand retain abundant natural and mineral resources, hardworking human population of tribal origin with a rich cultural heritage and traditional knowledge but is one of the most poverty dominated state in India and well identified by World Bank (Singh et al. 2012). Several district of the state Jharkhand are affected and are under the influence of naxal movement and poverty. Poverty is both a cause and consequence of the exclusion and discrimination. Several innocent people including political leader, police officers has been reported killed in past due to this, although most of the rural area dominated by

tribal people is highly innocent and peace loving. Gladson Dungdung is a general secretary of Jharkhand Human Rights movement of India and one of leading human rights defender and writer spoken internationally on human rights issues, including atrocities, violence against women and gross violation of the rights of indigenous peoples of Jharkhand. He believes “In the name of development, the State is taking resources from poor people and handing it over to the rich. Government policies are creating more and more disparity.”(https://www.frontlinedefenders.org/en/profile/gladson-dungdung) Antonio Maria Costa an Executive Director of the United Nations Office on Drugs and Crime (UNODC) and Director-General of the United Nations Office in Vienna, quoted “Crime was both the cause and consequence of poverty, insecurity and underdevelopment” in one of the debate on crime prevention and criminal justice and international drug control (https://www.un.org/press/en/2005/gashc3817.doc.htm).

The Jharkhand coal mines activity especially in the Dhanbad district was the first areas in India witnessed organized crime. Mafia (organized groups) run parallel economy has developed with involving local population employed by the mafia in manually transporting the stolen coal for long distances for sake of money is the major cause of crime in Dhanbad.

Safety and security of people is vital for the peaceful loving business, education and overall development. Some of the measures that need to addressed are better policing, inclusive adequate urban planning to counter the risk of spreading crimes, technological advancement in security, and socio-economic up gradation and development of overcrowded slum areas that are prone to criminal acts and violence. This is the duty of every citizen of the state to be aware of their role in ensuring the safety and security of society at large. By and large unemployment, poverty, illiteracy, poor socioeconomic condition and slow disposal of court case are the reason of crime in society.

Acknowledgement

The authors are grateful to National Crime Records Bureau, Ministry of Home Affairs, India portal for providing the crime data and DIVA GIS website for vector data.

Conflict of Interest:

The authors do not have any competing interest.

Funding source: No funds have been provided for this study.

References

Ahmad, F. & Goparaju, L. (2016) Analysis of Urban Sprawl Dynamics Using Geospatial Technology in Ranchi City, Jharkhand, India. J. Environ. Geogr. 9 (1–2): 7–13. DOI: 10.1515/jengeo-2016-0002

Ahmad, F., Meraj Uddin, M & Goparaju, L. (2017b) Role of Geospatial technology in Crime Mapping: a perspective view of India. World Scientific News. 88(2):221-226

Ahmad, F., Goparaju, L. & Abdul Qayum, A. (2017a) Agroforestry suitability analysis based upon nutrient availability mapping: a GIS based suitability mapping. AIMS Agriculture and Food. 2(2): 201-220. doi: 10.3934/agrfood.2017.2.201

Ahmad, F. & Goparaju, L. (2017a) Long term deforestation assessment in Jharkhand state, India: A grid based geospatial approach. Biological Forum 9(1):183-188.

Ahmad, F. & Goparaju, L. (2017b) Land Evaluation in terms of Agroforestry Suitability, an Approach to Improve Livelihood and Reduce Poverty: A FAO based Methodology by Geospatial Solution: A case study of Palamu district, Jharkhand, India Ecological Questions 25, 67-84 DOI: http://dx.doi.org/10.12775/EQ.2017.006

Ahmad, F. & Goparaju, L. (2017c) Soil and Water Conservation Prioritization Using Geospatial Technology – a Case Study of Part of Subarnarekha Basin, Jharkhand, India. AIMS Geosciences, 2017, 3(3): 375-395. doi: 10.3934/geosci.2017.3.375.

Wang, D., Ding, W., Lo, H. et al. (2013) Crime hotspot mapping using the crime related factors—a

spatial data mining approach. Appl Intell. 39: 772. https://doi.org/10.1007 /s10489-012-0400-x

Malvika, P. (2015) Crime Mapping of Rajasthan (2013): A District-level Analysis. Asian Journal of Research in Social Sciences and Humanities 5(6):139-152. DOI : 10.5958/2249-7315.2015.00141.0

Karuppannan, J., Shanmugapriya,S., and Balamurugan,V. (2004) Crime Mapping in India: A GIS Implementation in Chennai City Policing. Geographic Information Sciences. 10:20-34. http://dx.doi.org/10.1080/10824000409480651

Brantingham, P.J. and Brantingham, P.L. (1991), Environmental Criminology (eds.). Prospect Heights, IL: Waveland Press. Weisburd, D., & McEwen, T. (1997). Introduction: Crime Mapping & Crime Prevention. In D. Weisburd & T. McEwen (Eds), Crime Mapping & Crime Prevention (Vol. 8, pp. 1-21). Monsey New York: Criminal Justice Press.

Eikelboom, A ., Martini ,E., Luisa Ruiz,L. et al (2017) Public Crime Mapping in Canada: Interpreting RAIDS Online. Cartographica: The International Journal for Geographic Information and Geovisualization Summer. Vol. 52, No. 2, pp. 108-115. https://doi.org/10.3138/cart.52.2.5101

Jefferson, B. J. (2017). Predictable Policing: Predictive Crime Mapping and Geographies of Policing and Race. Annals of the American Association of Geographers, 1-16. DOI: 10.1080/24694452.2017.1293500

Bunting, R. J., Chang, O. Y., Cowen, C., Hankins, R., Langston, S., Warner, A., ... Roy, S. S. (2017). Spatial Patterns of Larceny and Aggravated Assault in Miami–Dade County, 2007–2015. Professional Geographer, 1-13. DOI: 10.1080/00330124.2017.1310622

Curtis-Ham, S.; Walton, D. (2017) Mapping crime harm and priority locations in New Zealand: A comparison of spatial analysis methods. Appl. Geogr. 2017 DOI: 10.1016/j.apgeog.2017.06.008

Alves, L,G., Ribeiro, H,V., Lenzi, E.K., Mendes, R.S. (2013) Distance to the scaling law: a useful approach for unveiling relationships between crime and urban metrics. PLoS One. 8(8):1–8. pmid:23940525

Gerber, M.S. (2014) Predicting crime using Twitter and kernel density estimation. Decision Support Systems. 61:115–125.

Gorr, W., Olligschlaeger, A. and Thompson, Y. (2003) Short-term forecasting of crime. International Journal of Forecasting. 19(4):579–594.

Liao, R., Wang, X., Li, L.and Qin, Z. (2010) A novel serial crime prediction model based on Bayesian learning theory. In: Proceedings of the 2010 IEEE International Conference on Machine Learning and Cybernetics. vol. 4. p. 1757–1762.

Mohler, G,O., Short, M,B., Brantingham, P.J., Schoenberg, F,P. and Tita, G.E. (2011) Self-Exciting Point Process Modeling of Crime. Journal of the American Statistical Association.106(493):100–108.

Wang, P., Mathieu, R., Ke, J. and Cai, H.J. (2010) Predicting Criminal Recidivism with Support Vector Machine. In: Proceedings of the 2010 IEEE International Conference on Management and Service Science. p. 1–9

Anderson, C,A. and Anderson, D,C.(1984) Ambient temperature and violent crime: Tests of the linear and curvilinear hypotheses. Journal of Personality and Social Psychology. 46(1):91–97. pmid:6694060

Lawrence, E. and Cohen, M,F. (1979) Social Change and Crime Rate Trends: A Routine Activity Approach. American Sociological Review.44(4):588–608.

Cotte Poveda, A.(2012) Violence and economic development in Colombian cities: a dynamic panel data analysis. Journal of International Development. 24(7):809–827.

Cusimano, M., Marshall, S., Rinner, C., Jiang, D. and Chipman, M. (2010) Patterns of urban violent injury: a spatio-temporal analysis. PLoS One.5(1):1–9. pmid:20084271

Hojman, D,E. (2004) Inequality, unemployment and crime in Latin American cities. Crime, Law and Social Change.41(1):33–51.

Hojman, D,E(2002). Explaining crime in Buenos Aires: the roles of inequality, unemployment, and structural change. Bulletin of Latin American Research. p. 121–128.

Kelly, M.(2000) Inequality and crime. Review of Economics and Statistics.82(4):530–539.

Levitt, S,D. (2001) Alternative strategies for identifying the link between unemployment and crime. Journal of Quantitative Criminology.17(4):377–390.

Gupta, R. , Rajitha, K., Basu, S. and Mittal, S.K. (2012) Application of GIS in Crime Analysis: A Gateway to Safe City. 14th Annual International Conference and Exhibition on Geospatial Information Technology and Application. Indian Geospatial Forum 7th to 9th February 2012.http://www.indiageospatialforum.org/2012/proceedings/ppt/Prof%20Gupta,%20Development.pdf

Thangavelu, A. , Sathyaraj S.R. and Balasubramanian S. (2013) Assessment of Spatial Distribution of Rural Crime Mapping in India: A GIS Perspective. International Journal of Advanced Remote Sensing and GIS, 2(1): 70-85

Shahebaz, M. A. and Kale, K. V. (2014) Mapping and Analysis of Crime in Aurangabad City using GIS Journal of Computer Engineering, 16(4): 67-76

McKinley J., Ruffell A., Harrison M, Meier W, Kemp H, Graham C. Barry L (2008) Spatial thinking in search methodology: a case study of the "No body murder enquiry". West of Ireland. In:Ritz K, Dawson L, Miller D (eds) Criminal and environmental soil forensics. Springer.New York, pp 285-302

Noond, J., Schoficld, D., March, J. (2002) Visualising the scene: computer graphics and evidence presentation. Sci Justice 42(2):89-95

Wolff, M., Asche, H. (2009) Towards geovisual analysis of crime scenes - a 3D crime mapping approach. Bi HH. Chen. 11C (2003) Collaborative workflow management for interagency crime analysis. In: Intelligence and security informatics, proceedings. Lecture notes in computer science, vol 2665. Springer, Berlin, pp 266-280

Longley, P., Goodchild, M.F., Maguire, D.J., Rhind, D.W. (2005) Geographical information systems and science, 2nd edn. Wiley, New York

Groff, E.R., Vigne. N.G.L. (1998) The use of geographic information systems (GIS) for state and local crime analysis. Paper presented at the conference of European statisticians. Ottawa, 5-7 Oct 1998

La Vigne, N.G., GrolT ER (2001) The evolution of crime mapping in the United Slates: from the descript tive to the analytic. In: Hirschfield A. Bowers K (eds) Mapping and analysing crime data: lessons from research and practice. Taylor & Francis, New York, pp 203—222

Singh. K. M., Singh, R. K. P., Meena, M. S., Kumar, A., Jha, A. K. and Kumar, Anjani. (2012). Rural poverty in Jharkhand: an empirical exploration of socio-economic determinants. MPRA Paper No.44811. ICAR Research Complex for Eastern Region, Patna.

Mamalian, C.A., LaVigne, N.G. (1999) The use of computerized crime mapping by law enforcement: survey results. National Institute of Justice Journal Research Preview, January, Washington, DC

Markovic, J., Bueermann, J., Smith, K. (2006) Coming to terms with geographical information systems.Police Chief 73(6):60–73

Nelson, L. (1999) GIS. A powerful weapon for law enforcement. ArcUser, Jan–Mar 1999

Wang, F. (2005) Geographic information systems and crime analysis. Idea Group Publishing, Hershey, p 345

Wartell, J. (2003) Crime mapping and data sharing. In: Leipnik MR, Albert DP (eds) GIS in law

enforcement: implementation issues and case studies. Taylor & Francis, New York

Asano CH, Rogers T, McGuire G, Juck D, Jacobs J (2012) Application of infrared photography for the detection of hidden evidence at the crime scene: passive and active thermography techniques through drywall. [Studies/research reports]. Identif Can 35(2):40–55

Davenport, G.C. (2001) Archaeologists as forensic investigators: defi ning the role. Hist Archaeol 35(1):87–100

Schreiber, S. (2009) Seeing through to the hot spots: amid falling costs and improved features, law enforcement may be able to fi nd a few more reasons to pick up a thermal imaging camera.

Law Enforc Technol 36(7):35–40

Schultz, P.D. (2008) The future is here: technology in police departments. Police Chief 75(6):19–27

Schultz, J.J. (2012) Detecting buried remains using ground penetrating radar. Department of

Anthropology, University of Central Florida, p 235

Canter, D., Hammond., L. (2007) Prioritizing burglars: comparing the effectiveness of geographical profiling methods. Police Pract Res 8(4):371–384. doi: 10.1080/15614260701615086

Canter, D. (2009) Developments in geographical offender profiling: commentary on Bayesian

journey- to-crime modelling. J Invest Psychol Offender Profi ling 6(3):161–166