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**ASSESSMENT OF SPATIO-TEMPORAL DISTRIBUTION OF ROAD ACCIDENTS IN AHMEDNAGAR CITY IN INDIA**

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Yogesh Kadam<sup>1</sup>, Ravindra G. Jaybhaye<sup>2</sup>

<sup>1</sup> Dept. of Geography, New Arts, Commerce and Science College, Ahmednagar, India.

<sup>2</sup> Dept. of Geography, Savitribai Phule Pune University, Pune, India

**Corresponding Author - Yogesh Kadam**

Email- [yogesh.kadam97@gmail.com](mailto:yogesh.kadam97@gmail.com)

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**Abstract:**

The nature of road accident is purely accidental. But such accidents are seen concentrated at particular places obviously along roadways. The current study wanted to seek out the spatio-temporal pattern of road accidents in Ahmednagar city in India. Spatial analysis of road accidents has been done with the help of GIS mapping using the geocoded addresses of road accidents in the study area. The temporal analysis was carried out with the help of simple cartographic techniques. The current study found a high density of road accidents around major transportation nodes along pathways. The heavy traffic density, lack of safety means like traffic signals, speed breakers and absence of traffic controllers led to the occurrence of road accidents in the study area. The temporal analysis explored the monthly and hourly fluctuations in the occurrences of road accidents. The monthly variations in road accidents are seen associated with everyday societal activities like travelling, shopping, and leisure during festivals and holidays. The hourly differences in the occurrence of road accidents are seen related to the routine spatial movement of people in commercial, workplace, recreational and transportation nodes and pathways in the study area. The probable causes of these spatio-temporal patterns of road accidents are in line with the geometric theory of crime, routine activity theory and criminal opportunity theory. The installation of traffic signals, speed breakers, and one-way traffic in vulnerable space-time of road accidents can reduce its level in the study area.

**Keywords:** Spatial Analysis; Temporal Analysis; Crime Mapping; Road Accidents; GIS.

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**Introduction**

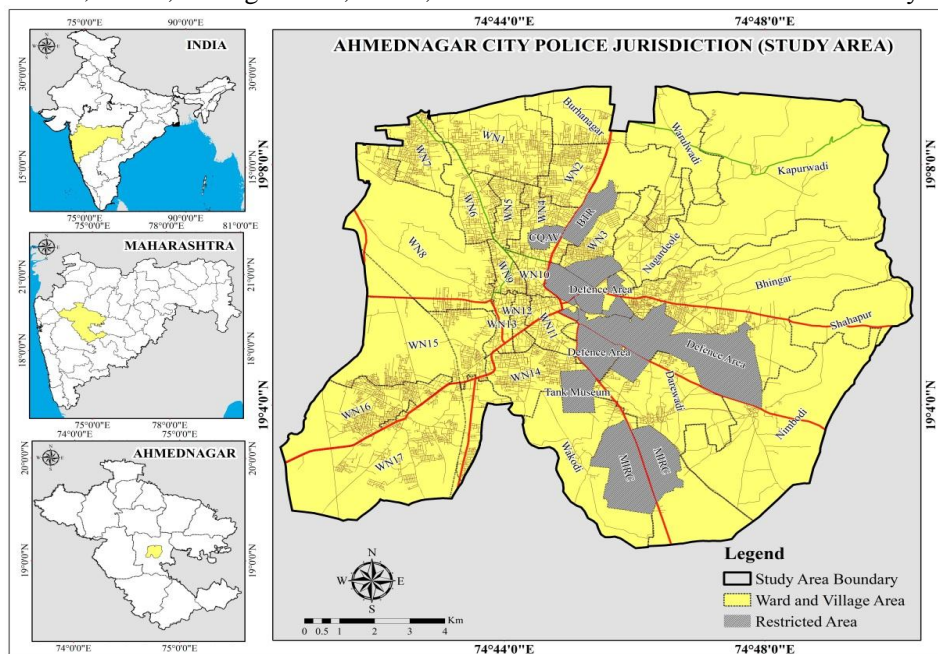
Any act which is against the prevailing law is considered a crime. The study of crime has many facets like sociological approach, psychological approach, behavioural approach and spatial approach. The spatial approach answers the places of crimes and also explores about probable causation of its spatial distribution. It also helps in crime prevention and crime reduction. The spatial aspect of crime is explored by some theories in crime geography and many individual studies over the world. The social disorganization theory (Shaw and McKay, 1969) explain the socio-ecological causation of crimes in an urban area. This theory is based on the work of Park and Burgess (1925) on the socio-spatial structure of city growth. The social disorganization theory explains that the destruction of informal social control among the residents leads to an increase in delinquency in the area. The routine activity theory (Cohen & Felson, 1979) asserts that criminal activities occur only when motivated offenders get potential targets in the absence of a capable guardian. Therefore places of crime are such

areas of criminal opportunity. The geometric theory of crime (Brantingham & Brantingham, 1981) asserts that crime occurs in the areas where the awareness space of offenders intersects with the spatial distribution of suitable targets. Therefore the distribution of targets, distribution of offenders and their spatial mobility are important factors in the spatial distribution of crimes. The rational choice theory (R. V. Clarke & Cornish, 1985) also asserts that all criminal acts are the rational choice of offenders. Hence the places of crime are the choice of many offenders.

Besides these theories, many individual studies explored the spatio-temporal aspect of crime. Bernasco and Nieuwbeerta (2005) explored the spatial aspects of burglary in Hague city, Netherland. Zulkifli *et al.*, (2015) studied the spatial analysis of vehicle thefts in peninsular Malaysia and found its association with population density. Rey *et al.*, (2012) found the occurrence of repeat victimization in their study. Tarhan and Deniz (2011) in the case study of Izmir-konak municipality used the GIS technique and found the association of spatial

distribution of crimes with population distribution. Even there are some studies in India focused on the spatial aspects of crimes. Jha (2015) found the state-level variations in the distribution of rape in India. Chauhan Ritvik and Baraik Vijay Kumar (2016) observed the increasing offences against women in India. Kumar *et al.*, (2012) revealed the regional variations in the distribution of serious offences in India. Thangavelu *et al* (2013) found the association of crimes with the socio-structural factors in Tamilnadu, India. Even many studies used the GIS for the spatio-temporal analysis of crimes (Chen *et al.*, 2013; Kalinic, 2018; Olajuyigbe *et al.*, 2016; Wang *et al.*, 2013;

Weisel *et al.*, 2006). There are many crime studies over the world focused on the spatial distribution of crimes. But there is a lack of studies exploring the spatio-temporal aspects of road accidents at the micro-level. The increasing means and modes of transportation and increasing traffic surely will increase the road accidents also. There is need of and scope for spatio-temporal study of road accidents in India. Therefore to fulfil this gap, the current study intends to explore the spatio-temporal aspects of road accidents in Ahmednagar city in India. The study is only about road accidents hence hereonwards the word 'accident' is considered as 'road accident' in the current study.



**Figure 1.1: Relative Location Map of ACPJ**

### The Study Area

'Ahmednagar City Police Jurisdiction' (ACPJ) is the study region of this research work (figure 1.1). The ACPJ is composed of both urban and rural areas but the urban population is dominant over the area. Hence it is named as city police jurisdiction. According to the 2011 Census of India, 435,811 people live in the ACPJ within its 86.06 Sq.km area. ACPJ is sub-divided into the three police sub-jurisdictions namely Tophkhana, Kotwali and Camp police sub-jurisdiction. Tophkhana and Kotwali police sub-jurisdictions are urban and the Camp police sub-jurisdiction is rural.

### Objectives of the Study

The objectives of the current study are as below.

1. To visualize the spatial pattern of accidents in the study area
2. To discover the temporal pattern of accidents in the study area

3. To discuss the probable causes of spatio-temporal patterns of accidents in the study area.

### Data

The current study is based on the crime data of the year 2011 to 2018 collected from the three police stations in ACPJ. There are a total of 1031 cases of accidents/rash driving registered in the ACPJ from 2011-2018. Out of these 1031 cases of accidents, nearly 43 % (444) accidents were registered in Kotwali followed by 32 % (328) in Camp and 25 % (259) in the Tophkhana police sub-jurisdiction. On the other hand, out of 1031 cases of accidents, address is absent in 170 cases. Therefore spatial analysis of accidents is carried out with the available data of 861 cases. Besides the temporal analysis, 10 cases of accidents were excluded due to the lack of temporal data (time and date) of these cases. Hence temporal analysis is carried out with the

1021 cases of accidents in the study during the year 2011-2018.

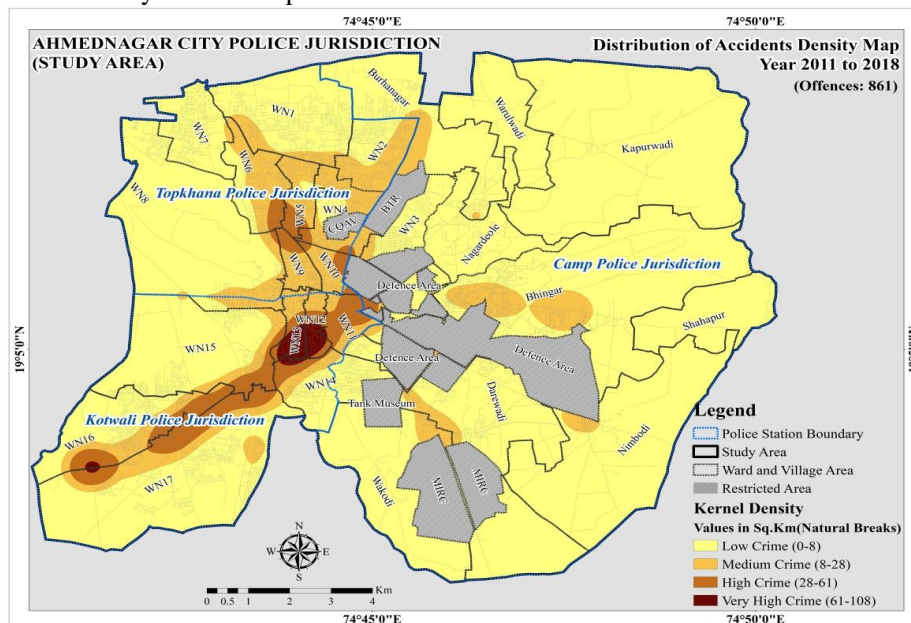
### Methods

The current study used the geospatial and cartographic techniques for the analysis. The crime maps are prepared using advanced techniques in ArcGIS software. The kernel density tool in ArcGIS is used to prepare a density map of accidents. The natural break method is selected to classify degree of density. The cartographic technique like line graph is used to explore the monthly and hourly pattern of accidents in the study area. The patterns are

critically analysed from the various perspectives prevailed in crime geography.

### Spatial Analysis

The crime-type accident has a somewhat different nature than other crimes. The nature of an accident is dominantly accidental while other crimes have a socio-economic origin. Other crimes occur in and around the residential and commercial areas (Kadam, 2022). On the other hand, accidents occur along pathways only. Hence spatial nature of accidents remains confined to the transportation network only.



**Figure 1.2: Spatial Distribution of Accidents in ACPJ**

Results revealed the spatial distribution of accidents/rash driving in ACPJ (figure 1.2). Spatial variation has been observed in the distribution of accidents. The very-high density of accidents (6 to 108 crimes per km<sup>2</sup>) is found in one big and one small chunk. A big chunk of the very-high density of accidents is found in wards no.12 and 13. This is the same area where there are many transportation nodes and pathways intersect each other. It includes two big state transportation bus stations, one internal transportation bus stand and many private vehicle stands. All these transportation nodes are lies along the Pune-Aurangabad state highway and many internal roads are merging into it. Hence this area experienced heavy traffic not only in the daytime but also in the nighttime. Besides this area also experienced the diurnal transitory population gathers here mainly for work, recreation, shopping. Therefore this area has a high degree of pedestrians and all types of vehicles too. Hence congregation of the transitory population with vehicles on the highway and internal roads increases the chances

**Yogesh Kadam Ravindra G. Jaybhaye**

of accidents/rash driving incidents. Along with this, there is an absence of traffic signals and guards in many places experiencing a traffic jams. As well as road divider and speed breaker are also absent at various places where they are needed. The absence of these safety measures is like an absence of capable guardian to deter crime (Cohen and Felson, 1979). All these causes might have resulted in a very-high density of accidents in this area. These assertions are consistent with the opportunity perspective in crime study (R. Clarke, 2012) suggesting that the existence of criminal opportunities reflects in the actual commission of crimes. The second small chunk of the very-high density of crime is observed on the verge of ward no. 16 and 17. This small chunk is the square where there is a convergence of the Pune-Aurangabad highway with the link road of Ahmednagar city. This square also experiences heavy traffic density. Therefore this area also has a high chance of accidents which resulted in a very-high density of accidents in this area during the year 2011-2018.

An elongated high-density area of accidents (28 to 61 crimes per km<sup>2</sup>) is found along the Pune-Aurangabad state highway passing through the midst of Ahmednagar city. Many internal roads merge into the Pune-Aurangabad highway in this area. Hence it experiences many local and non-local vehicles over this highway and internal roads. Hence this might have resulted in the high density of accidents in this area. Among the other two extensions of a high-density area of accidents, one small area was found close to the former area on the verge of ward no. 16 and 17. As discussed earlier this is the square where the Pune-Aurangabad highway and link road of Ahmednagar city merge. Hence it has a high chance of accidents which resulted in an actual high density of accidents in this area. The second distant chunk of high-density an accident is found in the north-eastern quadrant of the study area. Ahmednagar-Manmad highway has connected through this area and there are many commercial enterprises along with it. As well as many internal roads merge into this highway in this area. Therefore this area experiences high vehicle traffic which might have resulted in a very-high density of accidents in this area. The remaining medium-density area has more internal roads and less traffic than former areas. Hence there is a medium density of accidents.

The low-density area is occupied either by rural-agricultural areas in adjacent villages or barren land in the outer wards of Ahmednagar city. Hence there is very low traffic in this area which might have resulted in the low density of accidents in this area. All results regarding spatial distribution and density are consistent with the routine activity approach (Cohen and Felson, 1979) and opportunity perspective (R. Clarke, 2012) in the crime study.

#### Temporal Analysis

Moderate to low fluctuations have been observed in the month-wise frequency of rash driving/accidents (figure 1.3 and 1.1). Though rash driving/accidents have moderate temporal fluctuations in the frequency by month but such incidents do not depict a particular temporal pattern of occurrence because accidents can occur at any time. Even though January (116) experienced the highest incidents of rash driving/accidents followed by October (103), November (94), April (92) and December (82). This might be particularly due to these are months of either winter, summer or Diwali vacations during which is it observed that degree of vehicle traffic increases and in turn, which might have increased the incidents of rash/driving along the transportation routes in the ACPJ.

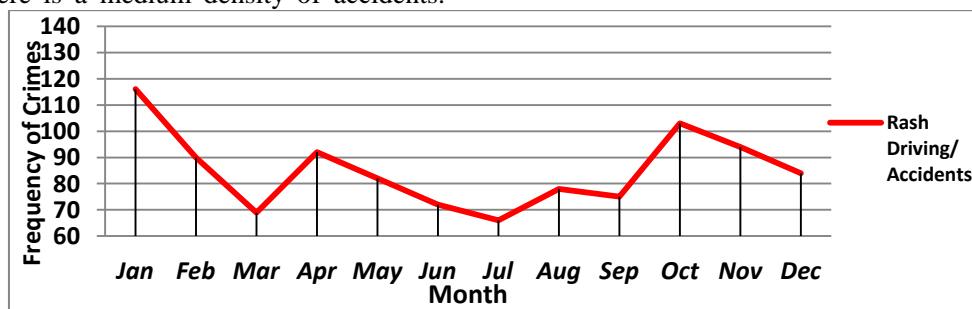


Figure 1.3: Monthly Frequency of Accidents in ACPJ

Table 1.1: Frequency of Rash Driving/Accidents by Month and Year in ACPJ

Year	Months												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2011	11	6	7	11	10	6	6	8	7	14	18	10	114
2012	18	15	10	12	10	9	9	8	7	13	13	14	138
2013	17	6	15	8	10	7	7	15	12	16	17	9	139
2014	13	12	10	13	12	11	12	9	5	12	9	6	124
2015	18	7	4	9	5	10	7	12	10	10	7	13	112
2016	13	11	4	15	10	9	6	10	10	15	11	13	127
2017	8	18	8	13	12	9	9	9	12	8	12	13	131
2018	18	15	11	11	13	11	10	7	12	15	7	6	136
<b>Total</b>	<b>116</b>	<b>90</b>	<b>69</b>	<b>92</b>	<b>82</b>	<b>72</b>	<b>66</b>	<b>78</b>	<b>75</b>	<b>103</b>	<b>94</b>	<b>84</b>	<b>1021</b>

(Source: Ahmednagar City Police Department)



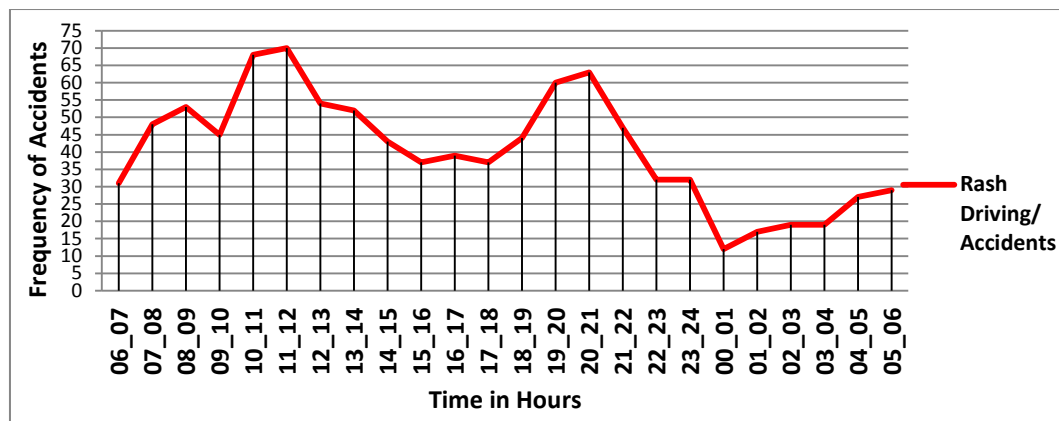


Figure 1.4: Hourly Frequency of Accidents in ACPJ

Results revealed the hourly trend of occurrence of rash driving/accidents in the ACPJ from the year 2011 to 2018 (figure 1.4). High temporal fluctuations have been observed in the hourly occurrence of rash driving/accidents. During the hours 10.00 to 12.00 and 19.00 to 21.00 ACPJ experienced the highest frequency of rash driving. Hours of 10.00 to 12.00 are rush hours for the majority population because during these hours people travel to the workplace, shopping and other places through pathways. Again from 19.00 to 21.00 hours, people travel through pathways to come back home as well as for shopping, sports and leisure purpose. Hence these two temporal zones might have experienced the higher incidents of accidents along pathways and this possibility is consistent with the routine activity theory (Cohen and Felson, 1979) which exclaimed that criminal incidents occur beside the legal routine activities of people. The routine life of majority people remain immobile during the night hours hence the accidents are also experienced less in these hours.

### Conclusion

The current study revealed the spatio-temporal patterns of accidents in Ahmednagar city. The spatial pattern of accidents in the study area is seen associated with the distribution of transportation routes and nodes and the frequency of mobility of vehicles. The crowded areas in the city along transportation routes and nodes experienced the highest frequency of accidents. Besides the absence of traffic controllers and safety means like traffic signals, speed breakers are also concerned with the spatial distribution and density of accidents in the study area. This suggests that it is an opportunistic crime which can be controlled by installing safety means where there is a need. Monthly fluctuations are possibly due to the temporal variations in the everyday societal activities like travelling, shopping and leisure in

**Yogesh Kadam Ravindra G. Jaybhaye**

the course of the festivals and holidays. Hourly differences are possibly due to the daily routine movement of the people in definite areas, for instance, commercial, workplace, recreational and transportation nodes and paths within these nodes. The possible causes discussed regarding the trend of accidents are nearly similar to causes explored in the theories of crime geography. This suggests that crimes can be analysed efficiently from a geographical perspective to reduce and prevent crimes in various space-time zones.

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### References

1. Bernasco, W., & Nieuwbeerta, P. (2005). How Do Residential Burglars Select Target Areas?: A New Approach to the Analysis of Criminal Location Choice. *The British Journal of Criminology*, 45(3), 296–315. <https://doi.org/10.1093/bjc/azh070>
2. Brantingham, & Brantingham. (1981). Notes on The Geometry of Crime. In M. A. Andresen, P. J. Brantingham, & J. B. Kinney (Eds.), *Classics in Environmental Criminology* (pp. 231–255). Canada: Simon Fraser University Publications.
3. Chauhan Ritvik and Baraik Vijay Kumar. (2016). Mapping crime against women in India : Spatio-temporal analysis, 2001-2012. *International Journal of Law and Political Sciences*, 10(6), 2243–2254. Retrieved from <https://waset.org/publications/10005985/mapping-crime-against-women-in-india-spatio-temporal-analysis-2001-2012>
4. Chen, P., Yuan, H., & Li, D. (2013). Space-time analysis of burglary in Beijing. *Security Journal*, 26(1), 1–15. <https://doi.org/10.1057/sj.2011.4>

5. Clarke, R. (2012). Opportunity makes the thief: Really? And so what? *Crime Science*, 1(Article 3). Retrieved from <https://link.springer.com/content/pdf/10.1186/2193-7680-1-3.pdf>
6. Clarke, R. V., & Cornish, D. B. (1985). Modeling Offenders' Decisions: A Framework for Research and Policy. In B. Andresen, M., Brantingham, P., Kinney (Ed.), *Classics in Environmental Criminology* (pp. 311–340). Canada: Simon Fraser University Publications.
7. Cohen, L. E., & Felson, M. (1979). Social Change and Crime Rate Trends: A Routine Activity Approach. In B. Andresen, M., Brantingham, P., Kinney (Ed.), *Classics in Environmental Criminology* (pp. 187–216). Cambridge: Simon Fraser University Publications.
8. Jha, D. K. (2015). Geography of rape crime in India: A spatial analysis of official data. *International Journal of Research in Social Sciences*, 5(5), 262–274. Retrieved from [https://www.researchgate.net/profile/Darshan\\_Jha/publication/301301828\\_Geography\\_of\\_Rape\\_Crime\\_in\\_India\\_A\\_Spatial\\_Analysis\\_of\\_Official\\_Data/links/572efb4a08ae3736095b1b5d/Geography-of-Rape-Crime-in-India-A-Spatial-Analysis-of-Official-Data.pdf?origin=publ](https://www.researchgate.net/profile/Darshan_Jha/publication/301301828_Geography_of_Rape_Crime_in_India_A_Spatial_Analysis_of_Official_Data/links/572efb4a08ae3736095b1b5d/Geography-of-Rape-Crime-in-India-A-Spatial-Analysis-of-Official-Data.pdf?origin=publ)
9. Kadam, Y. (2022). Crime Mapping and Crime Analysis of Ahmednagar City: A Geographical Perspective. Savitribai Phule Pune University, Pune.
10. Kalinic, M. (2018). Kernel Density Estimation (KDE) vs. Hot-Spot Analysis - Detecting Criminal Hot Spots in the City of San Francisco. 21st International Conference on Geographic Information Science (AGILE 2018), (June), 1–5.
11. Kumar, J., Mishra, S., & Tiwari, N. (2012). Identification of Hotspots and Safe Zones of Crime in Uttar Pradesh, India: Geo-spatial Analysis Approach. *International Journal of Remote Sensing Applications IJRSA IJRSA*, 2(1), 15–19.
12. Olajuyigbe, Omole, Bayode, & Adenigba. (2016). Crime Mapping and Analysis in the Core Area of Akure, Nigeria. *Journal of Remote Sensing & GIS*, 05(04). <https://doi.org/10.4172/2469-4134.1000178>
13. Park, & Burgess. (1925). *The City* (M. Janowitz, Ed.). Retrieved from [http://shora.tabriz.ir/Uploads/83/cms/user/File/657/E\\_Book/Urban\\_Studies/park\\_burgess\\_the\\_city.pdf](http://shora.tabriz.ir/Uploads/83/cms/user/File/657/E_Book/Urban_Studies/park_burgess_the_city.pdf)
14. Rey, S. J., Mack, E. A., & Koschinsky, J. (2012). Exploratory Space–Time Analysis of Burglary Patterns. *Journal of Quantitative Criminology*, 28(3), 509–531. <https://doi.org/10.1007/s10940-011-9151-9>
15. Shaw, C. R., & McKay, H. D. (1969). Juvenile Delinquency and Urban Areas: A Study of Rates of Delinquency in Relation to Differential Characteristics of Local Communities in American Cities. In M. A. Andresen, P. J. Brantingham, & J. B. Kinney (Eds.), *Classics in Environmental Criminology* (pp. 87–123). Canada: Simon Fraser University Publications.
16. Tarhan, C., & Deniz, D. (2011). Evaluation of an Integrated Gis-Based Crime Analysis & 3D Modelling for Izmir-Konak Municipality. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XXXVIII-4/(Udms), 73–78. <https://doi.org/10.5194/isprsarchives-xxxviii-4-c21-73-2011>
17. 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*, 2(1), 70–85.
18. Wang, D., Ding, W., Lo, H., Stepinski, T., Salazar, J., & Morabito, M. (2013). Crime hotspot mapping using the crime related factors - A spatial data mining approach. *Applied Intelligence*, 39(4), 772–781. <https://doi.org/10.1007/s10489-012-0400-x>
19. Weisel, D. L., Smith, W. R., Garson, D., Pavlichev, A., & Wartell, J. (2006). Motor Vehicle Theft: Crime and Spatial Analysis in a Non-Urban Region. Retrieved from <https://www.ncjrs.gov/pdffiles1/nij/grants/215179.pdf>
20. Zulkifli, M., Masseran, N., & Noriszura, I. (2015). Statistical Analysis of Vehicle Theft Crime in Peninsular Malaysia using Negative Binomial Regression Model. *Sains Malaysiana*, (Septembe). <https://doi.org/10.17576/jsm-2015-4409-20>