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Comparative Study of Homicide Incidents in Karachi: A GIS Perspective

[1]Imran Khan, [2]Salma Hamza, [1]Farkhunda Burke and [3]Syed Nawaz-Ul-Huda
[1]*Department of Geography, University of Karachi, Karachi Pakistan*
[2]*Department of Earth and Environmental Sciences, Bahria University Karachi Campus, Karachi, Pakistan*
[3]*Dawn GIS, Geospatial Statistical Research and Analysis Division, Dawn Media Group, Karachi, Pakistan*

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Corresponding Author:
Imran Khan
Department of Geography, University of Karachi, Karachi Pakistan

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Abstract: Continuity and severity of homicide incidents in Karachi in actuality is a sign of negligence by administration, one of the components of Routine Activity Theory. Looking at other crimes, like car and motorbike thefts or cell phone snatchings, homicide incidents are much more shocking, having fluctuated from 550-495, 1705, 2258, 2062, 2002, 1820, 918 and 450, respectively between 2009 and 2017. Policy makers and police departments might use GIS to observe trends in criminal activity through geo-coded data and maps may prove significant in solving criminal cases. In this connection, the half square cells configuration has been introduced for evaluation of geographic core of the study area regarding homicides. The study has also sought to reduce the perception that the entire city is enveloped in homicides rather that specific parts of the city are scourged by this heinous crime.

INTRODUCTION

The Routine Activity Theory stated by Cohen and Felson[1] for occurrence of crimes is based on overlapping of a suitable target, a motivated offender along with absence of a proper guardian. All three factors found very persuasively in a cosmopolitan city like Karachi. An analysis of spatio-temporal dynamics of these components is necessary for proper identification of elevated crime risk locations prior to prescribing relevant policing measures. Aspects, geodiversity and biodiversity of crimes[2, 3], being positive as revealed by the variations in spatial behavior and severity of crimes in the study area needs targeted efforts. GIS has proved highly facilitative in deciphering the spatial and temporal aspect along with the human perspectives of homicides, the main component of the Routine Activity Theory.

A dynamic and viable population is an asset for any nation but incompetent governments convert it into a liability due to trust deficit among the multilingual, multiethnic masses[4]. Karachi, the revenue hub and largest city of Pakistan, rightly called Mini Pakistan is facing innumerable issues regarding quality of life. Consequent to high migratory pressure from both rural and less urbanized areas, problems related to ethnicity issues get exacerbated by land encroachment, unplanned housing followed by homelessness as well as immense traffic volumes[5-7], manifested in a yawning hiatus between city incomes and expenditures[8]. Amalgamation of such problems creates a psyche of unpleasantness in society, culminating in crimes[9].

Karachi is the capital of the province of Sindh and the largest and most thickly populated (16 million) city of Pakistan. Located strategically

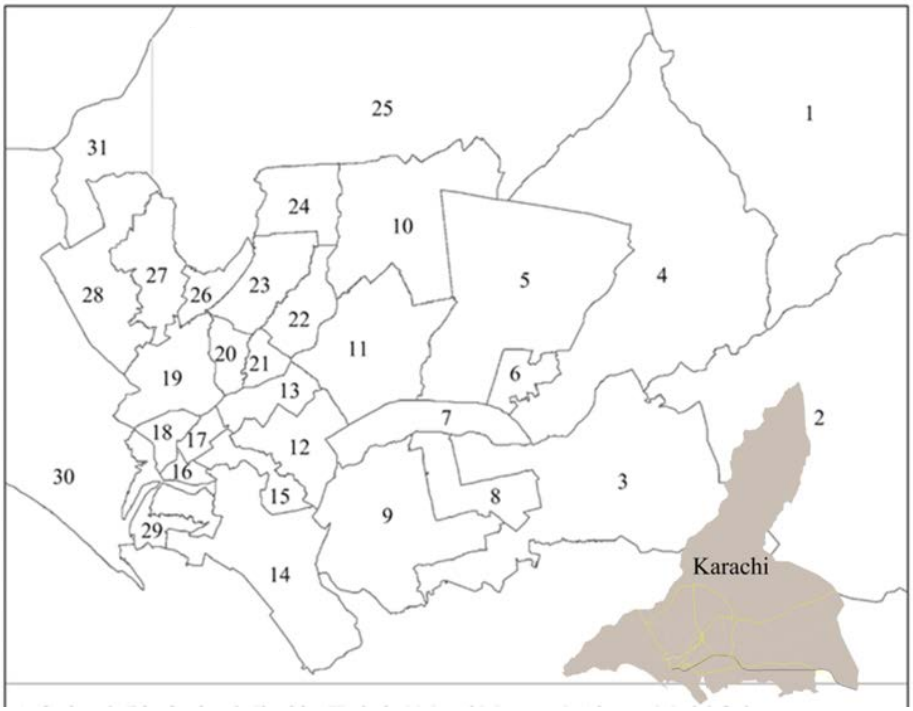

Fig. 1: Karachi sub-divisions;. 1: Gadap, 2: Bin Qasim, 3: Ibrahim Hyderi, 4: Murad Memon, 5: Airport, 6: Model colony, 7: Shah Faisal, 8: Landhi, 9: Korangi, 10: Gulzar-e-Hijri, 11: Gulshan-e-Iqbal; 12: Ferozabad, 13: Jamshed quarters, 14: Civil lines, 15: Saddar, 16: Aram bagh, 17: Garden, 18: Lyari, 19: SITE, 20: nazimabad, 21: Liaquatabad, 22: Gulberg, 23: North Nazimabad, 24: New Karachi, 25: Manghopir, 26: Orangi, 27: Mominabad, 28: Baldia, 29: Harbor, 30: Mauripur, 31: Shah Mureed

between 24.750-25.656'N and 66.653-67.574'E on the coast of the Arabian Sea, Northwest of the Indus river delta, it covers an area of 3600 km^2 (Fig. 1). The Federal Bureau of Revenue (FBR) collects highest share of revenue to the total revenue of Pakistan from the study area[11]. According to the Pricewaterhouse Cooper study of 2009, Karachi's GDP was nearly 78 billion in 2008 and is expected to touch the $120 billion mark by 2020 at a growth rate of 5.9%. Two main sea ports, Karachi and Qasim, play very crucial roles in handling imports and exports of the country.

Karachi by virtue of its revenue contribution, has a pride of place in the economy of Pakistan according to the income based formula defined by National Finance Commission (NFC), Karachi is entitled to a greater share of its earnings but unfortunately the provincial government does not share Karachi's earnings as per its resources. Ethnicity being the reason for non-pursuance of NFC formula, administrators prefers to follow ethnic bias as against merit and credibility leading to disparities among ethnic blocks, resulting in escalation of crimes at intervals. The responsibility being shared by both the ethnically biased administrator as well as negligent supportive guardian such anomalies resulted in political turf wars, state actions against opponent political parties, sectarian killings, ethnic riots, gangwars and terrorism which have been the key causes of homicides in the study area[12].

The ground reality is that the inhabitants of Karachi have been getting scarier with time, as the most worrying crime statistics concern killings or homicides of its citizens, along with other crimes like car and motorbike theft or cell phone snatchings, etc.[12]. The homicides trend have been shocking between 2009-2017, ranging from 550-495, 1705 2062, 2002, 1820, 918, 526 and 450, respectively for the ten years; marked escalations being recorded for the period between 2011 and 2014. Some of the most respected citizen were killed during that period. With 2009 as the base year, killing by gunshot fluctuated with 02, 01, 05, 06, 06, 05, 03, 01 and 01 lives per day for the last 10 years, 2012 and 2013 having witnessed 2258 and 2062 reported killings which amounted to one person having been killed every 4 h[14].

Definitions of crime have been given in different sciences concerning the environment, with variations in their meanings. Study of crime according to law is different from that of social sciences. In order to understand the legal interpretation of crime it is necessary to know that the definition of crime is a relative concept. Crime, simply speaking is breach of law[13] and different

procedures of punishment are entailed. The procedures of punishment and penalty may differ for persons charged of theft, murder, snatching or cyber crime, etc.

Geographic Information System (GIS) offers crime analysts pathways regarding statistical and graphic representations of crime-related issues. An understanding of where and why crimes occur can improve attempts to fight the scourge[14, 15]. Crime mappings help police and policy makers to protect citizens more effectively. Simple maps that display the locations where crimes or concentrations of crimes have occurred can be used to help direct patrols to places they are most needed[16]. Geography provides help to identify geo-demographic role in crime expansion or contraction and give solutions to overcome crime escalation[17].

Geographic computer packages such as MapInfo, ArcGIS etc., spatial tools facilitate in evaluation of crime data and neighborhood impacts[18, 19]. Crime mapping refers to the process of conducting spatial analysis within the range of activities of crime analysis[20, 21]. Crime mapping involves the manipulation and processing of spatially referenced crime data in order to display visually in an output that is informative to the particular user[22].

Policy makers and police departments might use GIS to observe trends in criminal activity through geo-coded data and maps may prove significant in solving criminal cases. Maps can be produced at any geographic level (e.g., police stations, divisions or zones) to aid in the analysis of crime patterns[23]. Each response area can be shaded to represent the number of crimes that occurred in that area during a specific time frame. The darker the shade, greater the indication that more events occurred within the study area. These thematic maps can also be used to show the change in an area's crime rates[24]. The percent change in the number of crime incidents can be displayed by shading each area according to whether there was an increase, decrease or no change.

GIS based study of homicide incidence has been made to provide significant analytical ground for spatial and temporal patterns. Geo-coded data from the perspective of locations describes cross examination of hot spots for study of cause and effects relationship. The main purpose of the present study is to analyze the incidence of homicides under geographical methodologies. In this connection, the study units have been subdivided into smaller areas of Half Square Cells (Grids). This ideology can provide help to find out the actual affected place in the cell with the help of geo-coded data.

The hypothesis of the present study being that continuity and severity of homicide incidents is a sign of negligence by administration, the research question is structured around the identification of half square km geographic cells of consistent occurrences of homicides and its comparison with homicides densities at Sub-division levels. The present study is unique in that it has measured areas affected by killings through creating homicide cells in a geographic background, thus enabling the assessment of administrative performance at unit levels.

MATERIALS AND METHODS

Spatial analyses are the basis of most prominent techniques of geographical studies of crimes. For the present study, crimes data was collected from Karachi Police Office (KPO) which included their spots of occurrence. Subsequent to collection of crimes data in accordance to their addresses provided by the CPO, the authors visited those locations and collected coordinates data (with the help of GPS) for the formation of geo-coded database. Through GPS located cluster, Interpolation technique (IDW) employed for accuracy of the research[16]. For identification of high to low homicides concentration, Spatial Analysis was employed for thematic mapping with the help of MapInfo Professional 15.2.

RESULTS AND DISCUSSION

The present study is based on crimes incidence between 2009 and 2017. Figure 2, depicts crimes concentration scattered in various parts of the study area in 2009, Aram Bagh recording highest, followed by sub-divisions Gulzar-e-Hijri, Korangi, Model Colony, Gulshan-e-Iqbal, SITE, Ibrahim Hyderi, North Nazimabad, New Karachi and Shah Faisal. In 2010, the concentration moved towards the Northern part where Orangi was seriously damaged. Gulshan-e-Iqbal, Civil Lines, SITE, Korangi sub-divisions ameliorated. The 2011 crimes situation was horrifying in comparison to that in 2010. Orangi and adjacent areas recorded highest crimes during the year. The second highly affected long belt extending from Lyari to southern portions of Nazimabad, Liaquatabad and Jamshed Quarters sub-divisions. Crimes intensity is conspicuous in the 2012. Figure 2, depicts 2013 recorded crimes compared to previous years, when the Lyari was continuously active while Gulzar-e-Hijri and Orangi preceded. Lyari and Orangi were continuously facing aftershocks of crimes during 2014. The year 2015, indicates somewhat settling of the volatile situation at the Lyari and its neighborhood but Gulzar-e-Hijri plate faced another upheaval, ensued by horrible homicides due to sectarian terrorism. Overall

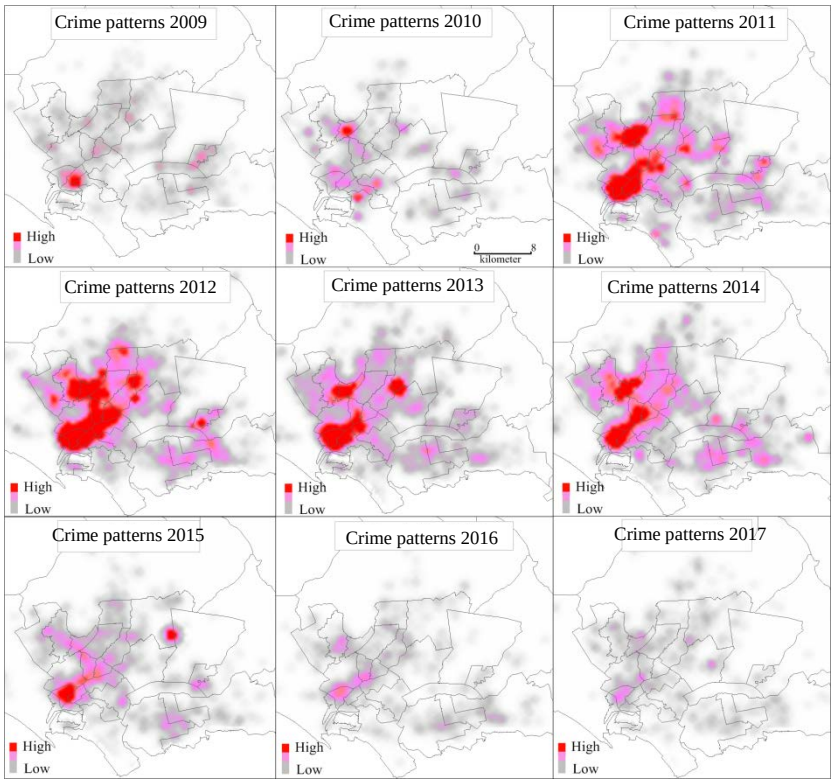

Fig. 2: Spatial concentrations of homicides at Sub-divisions-Karachi

homicides however portrayed decreasing trends in 2015. Figure 2, depicts decreasing in crimes rate due to the Karachi Operation aftershocks during 2016. The year 2017, highlights crimes situation as having reversed with reference to the picture of 2009.

Being the prime economic hub of the country, Kararchi, a melting pot of ethnicity, displays a variegated combination of languages and cultures, giving the Mini Pakistan an identity of its own. High correlations among variables which reflect essences of ethnicity, income, demography, etc have depicted inequality and injustice in the study area. Interpretation of the extracted factors needs exemplary caution as the relations exhibited are complex and can be understood only in the context of the actual position of the existing demographic scenario of the city as well as its economy. Based on their scores, Factors were classified into five categories employing the equal range technique.

An insight into cell density w.r.t areas affected by homicide incidents in the study area has revealed an extremely frightening scenario. The density of homicide cells reveals the nature of concentration or dispersement. With this end in view, the spider diagrams depicted in Fig. 3 and 4 for the period 2009 until 2017, show the dangerous correlation. In 2009, Liaquatabad subdivision revealed topmost rank w.r.t cells density 61.11%, followed by Model Colony (46.76), Garden 43.75, Lyari (42.86), New Karachi (37.50), S.I.T.E (37.10), North Nazimabad (36.54), Aram Bagh (35.71), Gulberg (32.50) and Nazimabad (31.82)% compared to other sub-divisions of the study area. Five subdivisions fell in the 30-20% category, while six in the 20-10% category and eight in the lowest category below 10%. The highest cell densities for homicide varied from 08.91% in Aram Bagh to 06.91% in Gulzar-e-Hijri and high, i.e., 05.64 and 05.45% in Korangi and S.I.T.E, respectively while density for Ibrahim Hyderi and Manghopir were 04.91 and 04% respectively. Little correlation is visible between cell density and killing density in 2009.

In 2010, Nazimabad had highest rank with 54.55% killings, followed by Garden 50, Orangi 41 and Lyari 33%. According to Fig. 3, seven subdivisions recorded ranges between 30-20% ranges, 08 in 20-10 while 10 in below 10% range. The relationship between homicides and affected cell densities in Orangi subdivision indicates extremely deplorable law and order conditions there with 08.50% life losses to total killings in the city.

In 2011, revealed significant change in homicides cells densities. The densely populated subdivisions of Garden and Lyari recorded 80% while Nazimabad above 70 and Orangi and Liaquatabad above 60%. Only three subdivisions fell in the category of 50-60% killings, 02

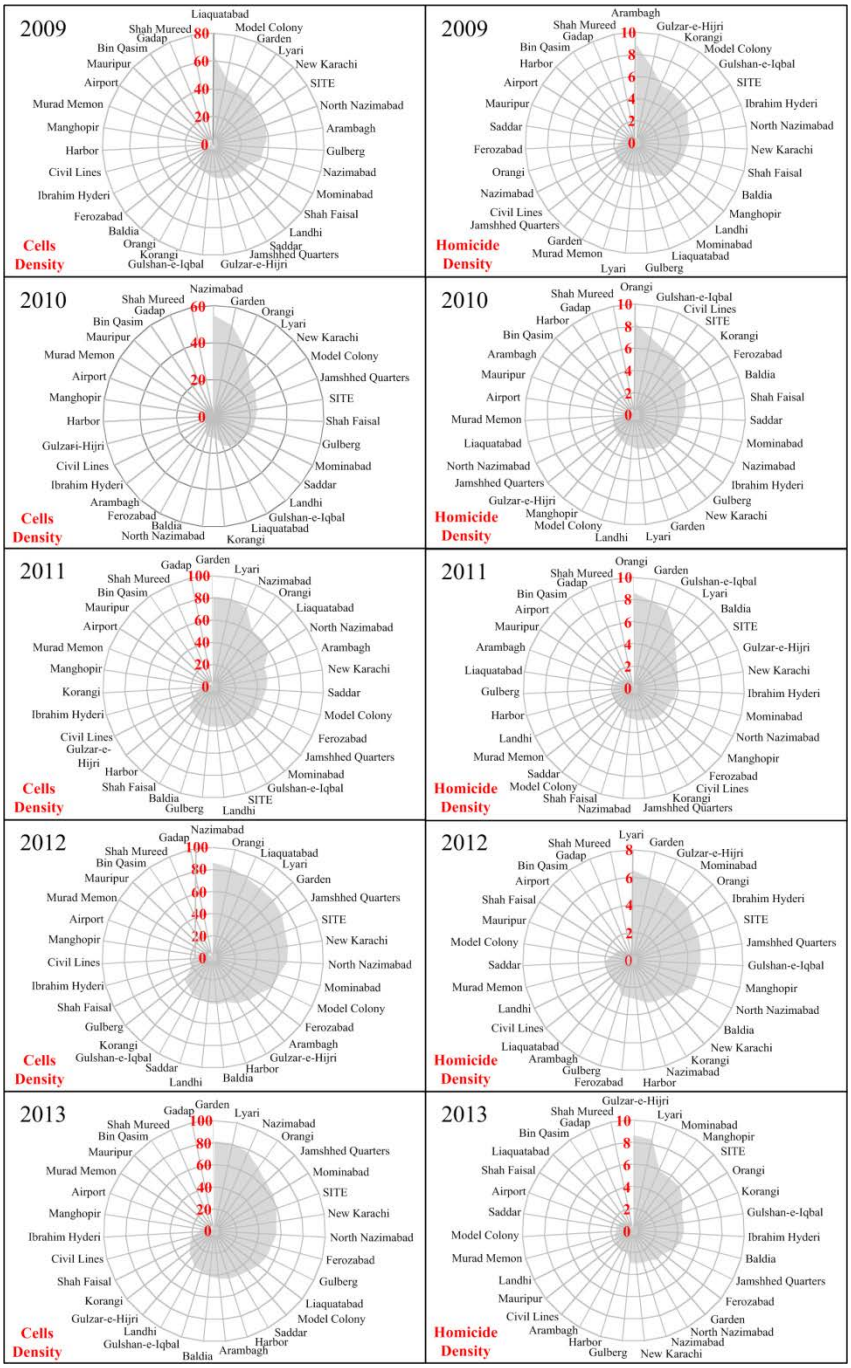

Fig. 3: Comparative study of affected cells and homicides densities at Sub-divisions-Karachi

groups of 06 subdivisions each in categories 40-50 and 30-40%; one between 20-30, three in 20-10 and six in below 10% homicides category. In 2011 was a dangerous year w.r.t homicides in Karachi and Orangi emerged as the worst affected subdivision with 62% of homicide cells, followed by Garden and Lyari which revealed extremely frightening situations w.r.t both density of killings and density of cells. Killing in all these 03 subdivisions were higher in concentration compared to other subdivisions where the incidents were more

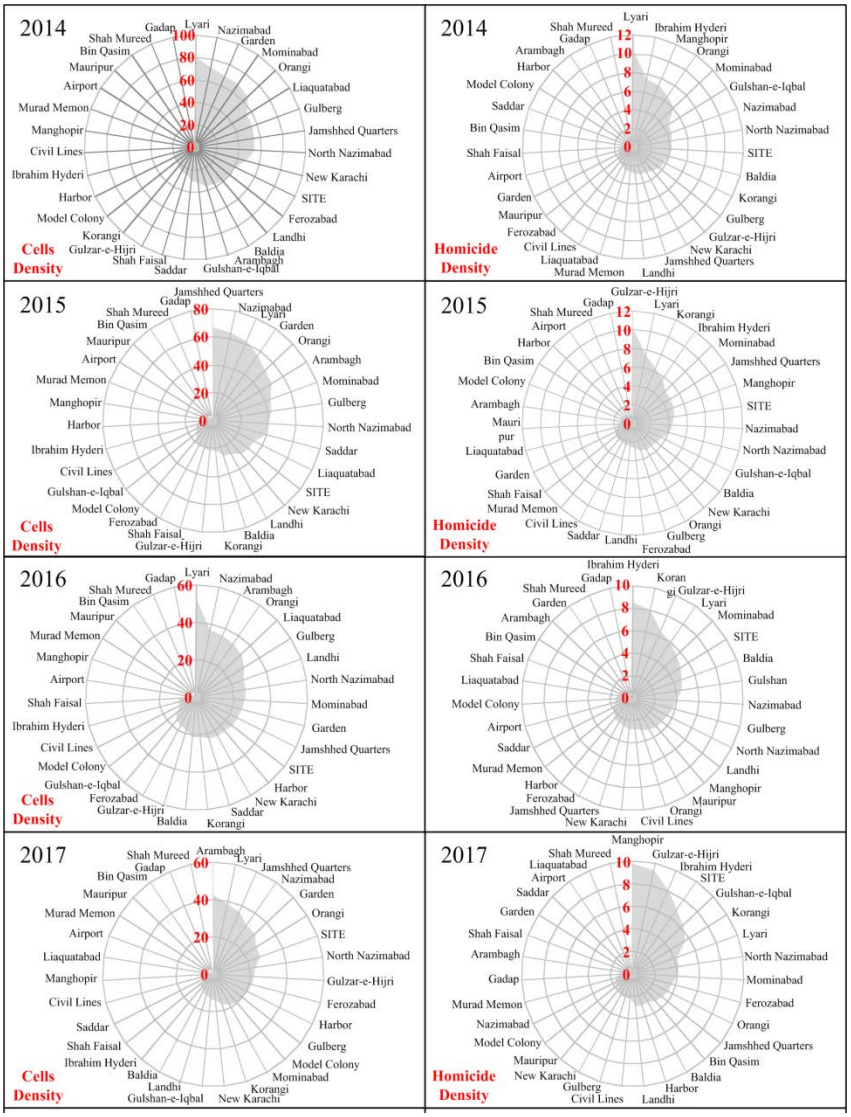

Fig. 4: Comparative study of affected cells and homicides densities at Sub-division-Karachi

scattered (Fig. 3). In 2012 similar to 2010 Nazimabad and in 2011 Orangi emerged as most disturbed subdivisions with 80% of the homicide cells followed by Liaquatabad, Lyari, Garden and Jamshed Quarters with 70% affected cells. S.I.T.E, New Karachi, North Nazimabad, Mominabad and Model Colony recorded above 60% affected cells ranged between 50-60%, followed by four subdivisions Gulzar-e-Hijri, Harbour, Baldia and Landhi between 50-40%. Homicides gripped 40-30% cells of Saddar, Gulshan-e-Iqbal, Korangi and Landhi subdivisions; Shah Faisal recorded between 30-20%, followed by Ibrahim Hyderi, Civil Lines and Manghopir with 20-10%; 10-01% in Airport, Murad Memon Goth, Mauripur and Bin Qasim Least, i.e., <01% were recorded in Shah Mureed and Gadap subdivisions covering a large administrative area but with greater rural jurisdiction and sparse population which recorded less homicide cells in comparison to the highly urbanized subdivisions.

A comparison of homicide cells and homicides densities in Fig. 4, reveals their scattered nature with high density homicide cells being scattered in Nazimabad, Orangi and Liaquatabad while Lyari and Garden which witnessed horrible homicide incidents recorded highly on both accounts, revealing continuity of extremely disturbing law and order conditions highlighting the administrative incompetency specially in the core affected areas, continuously over several years (Fig. 5).

In 2013, the 03 top homicide density cells were alternated by Garden, Lyari and Nazimabad which improved their position from first to third, all of them

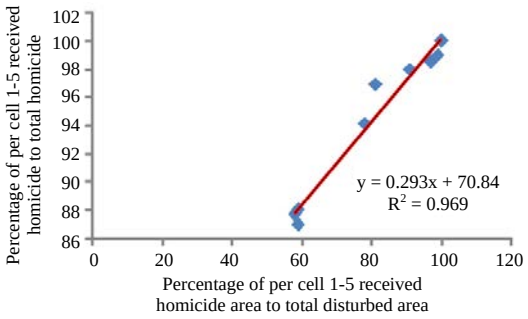

Fig. 5: Parameters of local areas

with 75% homicide cells Orangi, Jamshed Quarters and Mominabad recorded 60% homicide cells, followed by subdivisions S.I.T.E, New Karachi, North Nazimabad, Ferozabad, Gulberg and Liquatabad with 50% cells. Gulzar-e-Hijri rocketed to topmost position w.r.t homicides density, Lyari maintaining its second position followed by Mominabad, Manghopir, S.I.T.E and Orangi.

Figure 4 depicts cells and homicides densities for the decades 2014 until 2017 Lyari topped both w.r.t cells as well as homicides densities at 80%. Nazimabad followed with 70% and Garden third with 60% disturbed cells alongwith Mominabad and Orangi. Four subdivisions i.e Liaquatabad, Gulberg, Jamshed Quarters and North Nazimabad homicide cells ranged between 50-60%, while only 02 subdivisions i.e., New Karachi and S.I.T.E recorded in the 40-50% range. Twenty subdivisions revealed decreasing trends in the ranges 30-40 and 20-30; four recorded in the range of 10-20 and six subdivisions in the 10-01% homicide disturbed cells range. The homicides densities also revealed same scenario except for Ibrahim Hyderi which jumped to the highest segment with second position, after its relatively high position in 2009 until 2013.

A decreasing trend of cell density was categorically revealed in 2015, when only 03 subdivisions showed above 60-70% affected homicide cells, while 03 each were in the 50-60% and 40-50% ranges. Four subdivisions recorded 30-40% while seven 20-30, followed by 11 lesser affected cells in the 01-20% homicide ranges. Homicide density showed a repetition of 2014 scenario, except for Korangi which revealed third position in 2015.

In 2016, revealed some relief with drop in the number of cells, with only 01 subdivision i.e. Lyari showing highest position with 52.38% cells, followed by 05 in 30-40% category, 11 in 20-30; 04 in 20-10% and the remaining subdivisions in below 10% range category of homicide affected cells. Change in density of homicide cells compared to affected cells was visible. Except for some improvement in Lyari the subdivisions Ibrahim Hyderi, Korangi, Gulzar-e-Hijri, Mominabad and S.I.T.E revealed topmost ranks. Lyari was however, considerably dangerous, having occupied topmost rank w.r.t both homicide cells and 04th position w.r.t killing densities.

In 2017, Aram Bagh with 42.86% affected cells topped, followed by 04 subdivisions in 30-40% category, 08 in the 20-30% range, 06 in 20-10% and finally 12 in the lowest category. With reference to homicides density in Manghopir, followed by Gulzar-e-Hijri had topmost ranks, subsequently followed by Ibrahim Hyderi, S.I.T.E and Gulshan-e-Iqbal and then Korangi, Lyari, North Nazimabad, Mominabad, Ferozabad, Orangi, Jamshed Quarters and Bin Qasim in moderate category.

The overall scenario of homicides has been summarized in Table 1 and 2 showing ranking of subdivisions w.r.t the variables. Table 1 reveals that Lyari, Gulzar-e-Hijri, Orangi, Ibrahim Hyderi, Gulshan-e-Iqbal, Manghopir, Mominabad and S.I.T.E were most vulnerable subdivisions in Karachi during the last decade in terms of both homicide numbers and their density. The average homicides per cell also being highest in Lyari, followed by Garden, Ibrahim Hyderi, Aram Bagh, Nazimabad etc., Shah Mureed appears least affected by homicides, preceded by Gadap and Bin Qasim which however did record <100 total homicides during the entire study period.

Table 2 provides concrete evidence that Lyari and Nazimabad sub-divisions were consistently scourged by homicides in the last decade with highest position among top 05 ranks. Gulshan-e-Iqbal, S.I.T.E and Ibrahim Hyderi recorded 09 times out of 10 w.r.t this ranking. The table categorically provides proof that Lyari and Nazimabad were under immense pressure of criminals, however, some parts of Gulshan-e-Iqbal, S.I.T.E and Ibrahim Hyderi witnessed more murders among sub-divisions of the study area. The consistently repeated positions of Lyari indicate its high vulnerability and sensitivity in terms of life security.

The absence of Gulshan-e-Iqbal and Ibrhaim Hyderi among the top 05 ranks of cell density indicates that homicides were concentrated in more compact areas. The dominance of Lyari, Noth Nazimabad, Orngi, Mominabad, S.I.T.E and Garden among the top ranks of both cell densities and homicides indicate the presence of pockets inflicted by target killers, gang wars and other criminals under cover of powerful political protection.

Figure 5 showing the correlation between varieties of percentage of per cell homicides to total homicides and percentage of homicide area to total disturbed area reveals a very high positive correlation to the tune of 97%, pointing towards strong evidence of guardian incapability to provide law and order in the presence of culprits and victims who become easy targets of homicides. This correlation lends strong support to the Routine Activity Theory in Karachi.

Table 1: Ranking of sub-divisions

Sub-divisions	Total homicides	Density 2009-2017	Average affected cells 2009-2017	Average homicides per cell
Lyari	780	7.06	12	62.90
Gulzar-e-Hijri	686	6.21	32	21.78
Orangi	619	5.60	14	44.86
Ibrahim Hyderi	614	5.55	33	18.55
Gulshan-e-Iqbal	582	5.26	27	21.32
Manghopir	581	5.26	33	17.61
Mominabad	566	5.12	21	26.82
SITE	553	5.00	22	24.69
Korangi	499	4.51	28	18.08
Baldia	477	4.31	23	20.65
Garden	435	3.93	8	53.05
North Nazamabad	430	3.89	20	21.08
Jamshed	403	3.65	14	28.38
New Karachi	376	3.40	18	20.43
Nazimabad	370	3.35	12	30.08
Ferozabad	324	2.93	17	19.52
Gulberg	318	2.88	14	23.04
Civil Lines	288	2.61	17	17.25
Landhi	266	2.41	14	18.73
Murad Memon	229	2.07	13	17.89
Shah Faisal	213	1.93	11	19.02
Aram Bagh	203	1.84	5	39.80
Harbour	203	1.84	9	21.83
Liaquatabad	199	1.80	8	26.18
Saddar	199	1.80	9	22.61
Model Colony	195	1.76	9	21.20
Mauripur	185	1.67	12	15.29
Airport	137	1.24	9	15.22
Bin Qasim	98	0.89	7	14.20
Gadap	25	0.23	2	15.63
Shah Mureed	2	0.02	2	1.18

Table 2: Affected homicide

Top five rank repetition due to homicide affected cells density 2009-2017		Top five rank repetition due to homicides 2009-2017	
Sub-divisions	Rank	Sub-divisions	Rank
Lyari	10	Gulshan-e-Iqbal	9
Nazimabad	10	SITE	9
Garden	9	Ibrahim Hyderi	9
North Nazimabad	9	Gulzar-e-Hijri	8
Orangi	9	Lyari	8
New Karachi	7	Mominabad	8
Jamshhed Quarters	7	Korangi	7
Liaquatabad	6	Baldia	6
Gulberg	6	Manghopir	6
Mominabad	6	North Nazimabad	5
SITE	5	Orangi	5
Arambagh	5	Garden	2

CONCLUSION

The present research focusing on Routine Activity Theory proves that escalation of crimes in Karachi is a reflection of incompetency of government authorities. The configuration of half square meter cells of the study area identified the actual affected pockets of crimes. This technique facilitated in achieving ranking at sub-division levels relative to the areas affected by the homicides. The study also sought to reduce the perception that there are often problems of law and order in certain parts of the city but that it is disseminated as if the entire city is in a mess. This study also, identified cells that were persistently foci of murders, coupled with the police and the administration's lack of attention to resolve law and order situation. These phenomena were attributed to competent authorities at the legal background. Hence, its rectification was partly possible through the General Elections 2013 whereby the newly elected federal government approved paramilitary operation against criminals and their perpetrators in the city. Targeted actions against crimes resulted in decrease of crime volumes gradually from 2014 until 2015.

The study has strongly proved the validity of Routine Activity Theory in Karachi. Very persuasively, the incompetency of guardian thus being proved through linguistic, racist, nationalist bias perpetrating unequal rights by power wielding authorities, lends strong support to the Routine Activity Theory as the valid justification of crime magnification in Karachi megapolis and the positive role of guardian in its control.

REFERENCES

01. Cohen, L.E. and M. Felson, 1979. Social change and crime rate trends: A routine activity approach. Am. Sociol. Rev., 44: 588-608.
02. Marcus, F. and L.E. Cohen, 1980. Human ecology and crime: A routine activity approach. Hum. Ecol., 8: 389-406.
03. Wiles, P. and A. Costello, 2000. The road to nowhere: The evidence for travelling criminals. Home Office Research Study, London, UK.
04. UN-Habitat, 2003. The Challenge of Slums: Global Report on Human Settlements, 2003. Earthcan Publications Ltd., London, ISBN-10: 1844070379.
05. Hasan, A., 2015. Land contestation in Karachi and the impact on housing and urban development. Environ. Urbanization, 27: 217-230.
06. Ali, Z., 2012. Violence in Karachi; Is it political, ethnic or religious conflict?. Pakistaniaat: J. Pak. Stud., 4: 78-83.
07. Ali, M.S., M. Adnan, S.M. Noman and S.F.A. Baqueri, 2014. Estimation of traffic congestion cost-a case study of a major arterial in Karachi. Procedia Eng., 77: 37-44.
08. Ellis, P.D., J.S. Friaa and J.K. Kaw, 2018. Transforming Karachi into a livable and competitive megacity: A city diagnostic and transformation strategy. No. 123628, The World Bank, Washington, USA.
09. Braithwaite, J., 2013. Inequality, Crime and Public Policy. 1st Edn., Routledge, Abingdon, UK., Pages: 344.

10. PBS., 2017. Census 2017-Pakistan. Pakistan Bauru of Statistics, Islamabad, Pakistan.
11. GOP., 2019. Pakistan economic survey 2018-2019. Economic Adviser's Wing ic Adviser's Wing, Finance Division, Government of Pakistan, Pakistan.
12. Khan, I., F. Burke and S. Nawaz-ul-Huda, 2019. Spatiotemporal concentration of homicides in Karachi. Pak. J. Criminol., 11: 68-83.
13. Sen, R. and S. Borle, 2015. Estimating the contextual risk of data breach: An empirical approach. J. Manage. Inf. Syst., 32: 314-341.
14. Schaaik, V.J.G. and V.D.J.J. Kemp, 2009. Real Crimes on Virtual Maps: The Application of Geography and GIS in Criminology. In: Geospatial Technology and the Role of Location in Science, Scholten H.J., V.D.R. Velde and V.N. Manen (Eds.). Springer, Dordrecht, Netherlands, pp: 217-237.
15. Caplan, J.M., L.W. Kennedy and J. Miller, 2011. Risk terrain modeling: Brokering criminological theory and GIS methods for crime forecasting. Justice Q., 28: 360-381.
16. Wang, F., 2012. Why police and policing need GIS: An overview. Ann. GIS., 18: 159-171.
17. Deslauriers-Varin, N. and E. Beauregard, 2013. Investigating offending consistency of geographic and environmental factors among serial sex offenders: A comparison of multiple analytical strategies. Criminal Justice Behav., 40: 156-179.
18. Kalinic, M., 2017. Combining open-source programming languages with GIS for spatial data science. Master Thesis, Technical University of Munich, Munich, Germany.
19. Azzam, T. and D. Robinson, 2013. GIS in evaluation: Utilizing the power of geographic information systems to represent evaluation data. Am. J. Eval., 34: 207-224.
20. Masho, S.W., K.W. Zirkle, D.C. Wheeler, T. Sullivan and A.D. Farrell, 2019. Spatial analysis of the impact of a school-level youth violence prevention program on violent crime incidents in the community. Prev. Sci., 20: 521-531.
21. Curtis, A., J.W. Curtis, J. Ajayakumar, E. Jefferis and S. Mitchell, 2019. Same space-different perspectives: Comparative analysis of geographic context through sketch maps and spatial video geonarratives. Int. J. Geog. Inf. Sci., 33: 1224-1250.
22. He, J., H. Chen, Y. Chen, X. Tang and Y. Zou, 2019. Diverse visualization techniques and methods of moving-object-trajectory data: A review. ISPRS Int. J. Geo-Inf., Vol. 8, No. 2. 10.3390/ijgi8020063
23. Onat, I., 2019. An analysis of spatial correlates of terrorism using risk terrain modeling. Terrorism Political Violence, 31: 277-298.
24. Asongu, S.A. and P.N. Acha-Anyi, 2019. The murder epidemic: A global comparative study. Int. Criminal Justice Rev., 29: 105-120.