

The spatiotemporal analysis of Motor Vehicle Thefts in rural and semi-urban areas of Algiers and its neighboring departments

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Abstract— Motor Vehicle Theft (MVT) is a phenomenon that represents a serious safety challenge for the Algerian public safety services in Algiers and the region of its bordering departments, particularly during the last few years. The highly social and economic costs of this phenomenon make its study and combating among the priorities of public security services.

To strengthen the efforts made in this field, the present research work analyzes the spatial and temporal variations of the MVT crimes, to identify the phenomenon helping factors, and the modus operandi used by criminals activating in this region.

This study is based on the Routine Activity Theory, with the assumption that the spatial-temporal distribution of the MVT crimes in the region of Algiers and its neighboring departments, is not random, but it follows a specific pattern. The data collected from the Algerian public safety services units in rural and semi-urban areas and the Crime Stat IV software have been used to identify and analyze the MVT hotspots. The obtained results show that the main hotspots of this criminality are more likely to occur in the recently inhabited residential area, especially those of social housing type, located along the highways and roads leading to the main EAST-WEST highway, where surveillance measures are generally weak.

Keywords— Motor Vehicle Theft, Spatial-temporal Analysis, Environmental Criminology, Routine Activities Theory, Kernel Density Estimation, Nearest Neighbor Hierarchical Clustering.

I. INTRODUCTION

Almost all countries in the world are facing the MVT (four-wheeled and more) phenomenon, which is becoming more seriously challenging, because of its contribution to the increase of the crime index [1], particularly during the last few years in Algeria. Statistics collected from Algerian public security service units show a significant increase in the number of vehicle thefts as well as the number of people involved in these thefts. The main motivation of these criminals is the significant increase in the prices of vehicles and spare parts.

Effectively, one of the main steps to design a safe living environment, to prevent and to fight against such kind of proprieties offenses, is to understand the crime patterns of such criminality. That is why our research work, in this paper, focuses on the identification of patterns reflected through the spatiotemporal analysis of MVT cases, the understanding of the effect of social and environmental factors associated with such kind of crime, as well as the detection of modus operandi used by perpetrators and types of targeted vehicles.

To attain these objectives, the data related to Motor Vehicle Theft cases, collected through the quotidian activity of the Algerian public safety services in rural and semi-urban areas, between January 2020 and February 2023, has been exploited using the Crime Stat IV software, in order to identify the main MVT hotspots in Algiers and its neighboring departments.

The Routine Activity Theory, generally used to interpret the non-random spatiotemporal distribution of proprieties crimes [2], and some functionalities of the Crime Stat IV software, were used to investigate the validity of the hypotheses of our study, supposing that the presence of motivated offenders, suitable targets such as a large number of vehicles, in places when and where surveillance measures are evaluated to be weak such as the new constructed suburbs of Algiers and its neighboring departments, would facilitates the occurrence of the MVT crimes.

To achieve the expected objectives of this research work, different sources of data generated through the quotidian activities of the Algerian public safety services in rural and semi-urban areas have been used, particularly:

- The statistical data of the judicial police record management system of the Algerian public safety services,
- 197 reports in relation with the MVT cases,
- 10 reports dealing with the dismantling of vehicle theft specialized criminal networks,
- The data collected From the vehicle examination department of the National Institute of Criminalistics and Criminology of the Algerian National Gendarmerie (INCC-GN).

Moreover, different field visits were carried out to many Algerian public safety services units located in rural and semi-urban areas, particularly to those having recorded a significant number of cases, in order to evaluate the effect of the social and environmental factors associated with this kind of crimes.

Regarding the used tools, it is important to mention that the spatial statistics software for the analysis of crime incident locations (Crime-Stat IV) is the main software used in our work. It allows an automatic identification of the areas with high concentration of MVT cases (Hotspots), through different functionalities available on the software, like the Nearest Neighbor Hierarchical Spatial Clustering (Nnh) and the Kernel Density Estimation (KDE) [3].

This paper is organized on four main sections, the first one dealing with some previous related works and the main theories in the field of the Environmental Criminology. The second shows an overview about MVT cases recorded in rural and suburban areas of Algeria, while the third section analyzes the spatiotemporal distribution of MVT cases within the region of Algiers and its neighboring departments using the CrimeStat software, and illustrates the different modus operandi used by criminals activating in this region, targeted vehicles types, and the destiny of non-recovered stolen vehicles. Finally, in the fourth section an attempt to establish the perpetrators profile was given.

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II. LITERATURE REVUE

A. Crime Place Theories

The crime mapping analysis is one of many other fields derived from the Environmental Criminology. It is based on three main theories with common objectives related to the situational aspects of crime which are : the Rational Choice Theory [4], the Crime Pattern Theory [5] and the Routine Activities Theory [2].

The Rational Choice Theory suggests that the decision where and when the crime could occur is the result of a decision-making formula that estimates the expected efforts, benefits, and risk incurred [4]. However, the Crime Pattern Theory suggests that the crime occurs in places where an offender's awareness space intersects with perceived suitable targets [5].

Regarding the Routine Activities Theory, it considers the crime as the outcome of the spatial and temporal convergence of a likely offender and a suitable target in the absence of a capable guardian [2]. In other words, Behavior patterns of the individuals determine where and when crimes are most likely to converge [6].

A suitable target is defined as any person or object, estimated by an offender, for victimization, as attractive[7]. Capable guardians are persons and/or environmental features that would prevent the execution of a criminal act [7]. Finally, a likely offender is a person who has both the will and the means to execute a crime [7]. This theory has been used as an explanation for spatial distribution of crime in many research works such as [8 - 13].

B. Related works

Many studies show that vehicle theft is not uniformly distributed across space and time. In [12], Sherman et al shows in a study carried out on the Minneapolis American city, to investigating the identification of hotspots in predatory crime, routine activities and the criminology of place, that 2.7% of all addresses and intersections generate emergency calls for vehicle theft to the police. Also, Piza et al confirms in [14], the existence of spatial clusters of vehicle thefts in parking lots located near the American-Mexican borders. This author believes that the reason behind the existence of hotspots in this region is to allow the transfer of stolen vehicles easily over these borders even before they were reported stolen.

Furthermore, Light et al illustrates in [15] that movie theater parking lots in the United States of America (USA), are favorite targets for both car thieves and burglars, because these parking lots are rarely sites of potential activity for witnesses while movies are playing. Vehicle theft crimes, occurring at commercial and public facilities, on roads and streets and in squares, had different peak times that aligned precisely with the times people go to work and return home [16]. The locations of theft tend to cluster along major roads and routes and around some types of socioeconomic activity, such as commercial parking lots and downtown detached houses that have easy access to vehicles and low guardianship against theft [17]. All these findings support the Routine Activity Theory [2].

It is important to mention that facilities, physical situation, and guardianship of parking lots, such as lighting, visibility, and security measures, are other factors which largely affect the likelihood of occurrence of vehicle theft [18,19]. MVT hotspots were also likely to be near expressways, which are convenient for the escape of criminals. Moreover, urban sprawl and higher-density housing construction exerted an influence on the spatial pattern of vehicle theft. This criminality tends to move in accordance with the direction of the development of new residential areas [16].

In addition, the influence of activity nodes, such as comprised of ATMs, payphones, gas stations, bars, bus stops and schools, on single and repeat-victimization MVT locations in Atlantic City (NJ), has been tested by Levy and Tartaro [20]. The obtained results confirm that repeat MVT locations were more likely to be near activity nodes than single theft sites [20].

Finally, it is worth highlighting that the results reported in [21], regarding the study of MVT cases in the Adelaide Central Business District, where it has been shown that MVT did not occur randomly over space but rather was concentrated in hotspots and in the suburbs containing major shopping centers. MVT also displayed variation in time, being higher between 12AM and 8AM than at other times of the day.

III. OVERVIEW ABOUT MOTOR VEHICLE THEFT CASES RECORDED IN RURAL AND SEMI-URBAN AREAS OF ALGERIA

To give an overview regarding the Motor Vehicle theft phenomenon in Algeria, the Fig. 1 below, shows the evolution of the number of stolen vehicles cases recorded by Algerian public safety services units in rural and semi-urban areas, during the period from January 2012 to February 2023.

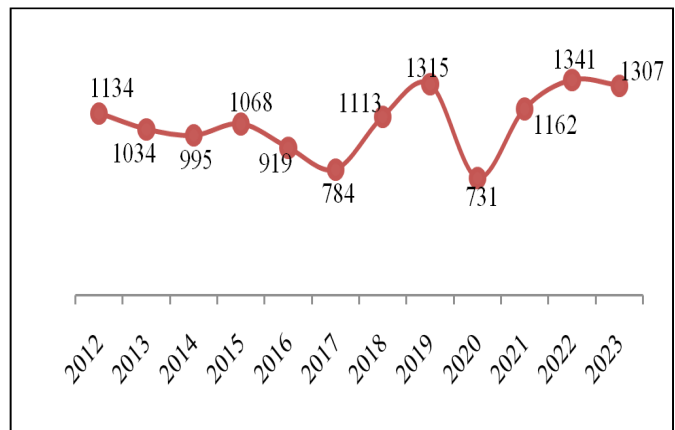


Fig. 1. Evolution of the number of stolen vehicles during the period from January 2012 to February 2023.

Fig. 1 makes clear that the highest numbers of stolen vehicles cases was recorded during the last few years, particularly in 2019, 2021, and 2022. This increase can be explained as a direct consequence of the unavailability of new vehicles on the Algerian market, and therefore, the rise of the price of used vehicles and their spare parts. Regarding the year 2020, the decrease in MVTs recorded during this year is due to the containment measures during the spread of the Corona pandemic (Covid-19).

Fig. 2 shows the most Algerian departments affected by this phenomenon, as well as the number of recorded stolen vehicles cases by year, during the period from January 2012 to February 2023. It is clear in this figure that 43.5% of the MVT cases recorded by the Algerian public safety services units' are concentrated only in four (4) departments which are: Algiers, Boumerdès, Tipaza and Blida. It is important to mention that Algeria is divided into 58 administrative departments. The results above show also a significant increase of the number of cases handled by the units operating in these departments, particularly from 2021.

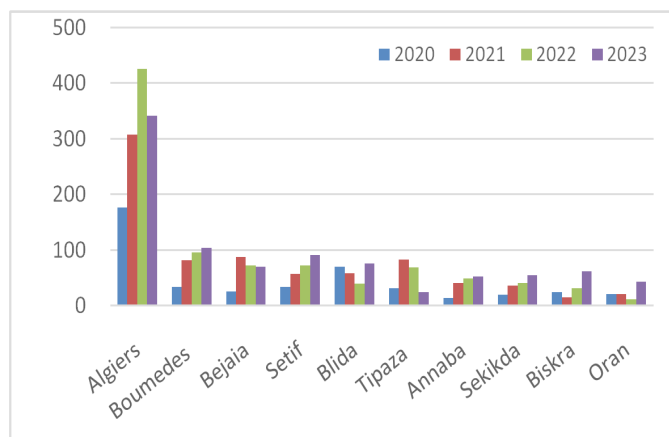


Fig. 2. Number of MVT cases recorded by department during the period from January 2020 to February 2023.

Based on the results obtained in this section, and by taking into account that approximately half (43.5%) of the MVT cases handled by the Algerian public safety services units', between 2020 and 2023, have been recorded in four departments only, the next sections of our study will focus only on these departments (i.e. Algiers, Boumerdès, Tipaza and Blida).

IV. SPATIAL DISTRIBUTION AND CRIME PATTERNS OF MVT

Hierarchical clustering methods, such as the nearest neighbor hierarchical clustering function (or Nnh for short), are among the oldest cluster routines used to investigate the spatial distribution of crimes [3]. This repeated process groups data points together based on the proximity and the connectivity of their attributes [22]. It determines clusters based on how close data points are to one another across all of the dimensions [22].

This function (Nnh) available on the CrimeStat software has been used to investigate the spatial distribution of MVT cases in our study.

Another technique used to examine the spatial distribution of crimes in a specific area, is the Kernel Density Estimation (KDE). This technique involves applying function (known as a kernel) to each data points, which averages the location of that point with respect to the location of other data points [7]. Whereas the spatial distribution and hot spot statistics provide statistical summaries for the data incidents themselves, interpolation techniques generalize those data incidents to the entire region [3]. In other terms, the KDE technique provides density estimates for all parts of the investigated region (at any location in this region). The obtained density is an intensity variable, a Z-value, that is estimated at a particular location. Consequently, it can be displayed by either surface maps or contour maps that show the intensity at all locations [3].

A. Nearest Neighbor Hierarchical Clustering

In our experimental study, the Nnh function and the KDE technique were applied to the MVT cases recorded, during the period from January 2020 to February 2023, in each investigated departement (Algiers, Boumerdes, Tipaza and Blida). A default one-tailed probability level of 0.05 (or 5%) was selected as the threshold distance and each cluster was required to include at least 10 points.

By applying this criteria to 554 MVT cases recorded in Algiers, CrimeStat returned 15 first-order clusters for this departement. The most important one includes 41 incidents and the last contains 10 incidents only. Fig. 3 shows the first-order clusters displayed as 1.5 standard deviational ellipses, and Kernel Density Estimation (KDE) for MVT cases in Algiers.

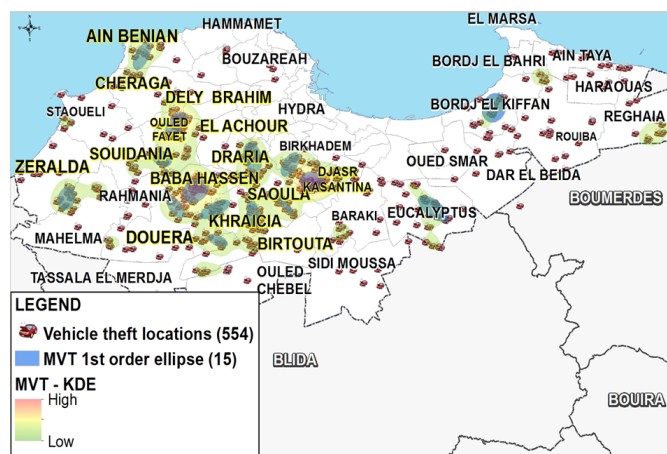


Fig. 3. Map of 1st order hotspots and Kernel Density Estimation produced by Nnh and KDE CrimeStat functions for MVT cases recorded in Algiers during January 2020 and February 2023.

Regarding Boumerdès, the Nnh function was applied to 174 MVT that had been recorded in this departement during the same period, where it has been required that each cluster should contains 7 points at least.

The obtained results are shown in Fig. 4, where the CrimeStat software returns 6 first-order clusters (the clusters are displayed as 1.5 standard deviational ellipses), one second-order cluster and the KDE for MVT incidents in Boumerdès.

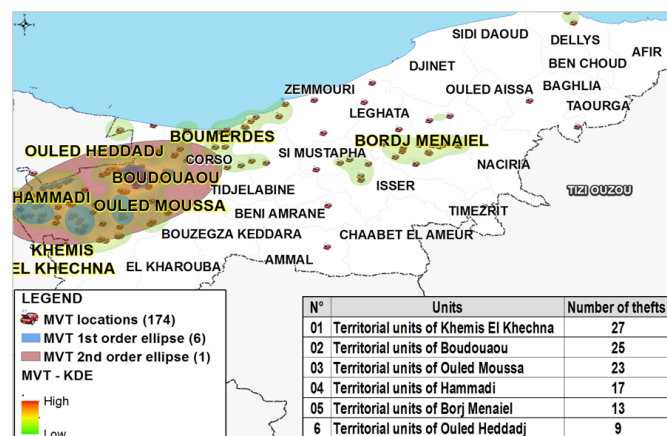


Fig. 4. Map of 1st order hotspots and Kernel Density Estimation produced by Nnh and KDE CrimeStat functions for MVT cases recorded in Boumerdès during January 2020 and February 2023.

The same method was applied on the MVT data collected by the Algerian public safety services units' of Tipaza and Blida, and the results are displayed, respectively on Fig. 5 and 6.

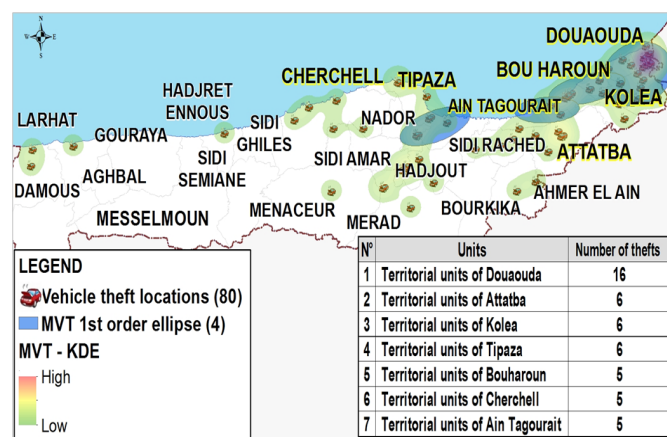


Fig. 5. Map of 1st order hotspots and Kernel Density Estimation produced by Nnh and KDE CrimeStat functions for MVT cases recorded in Tipaza during January 2020 and February 2023.

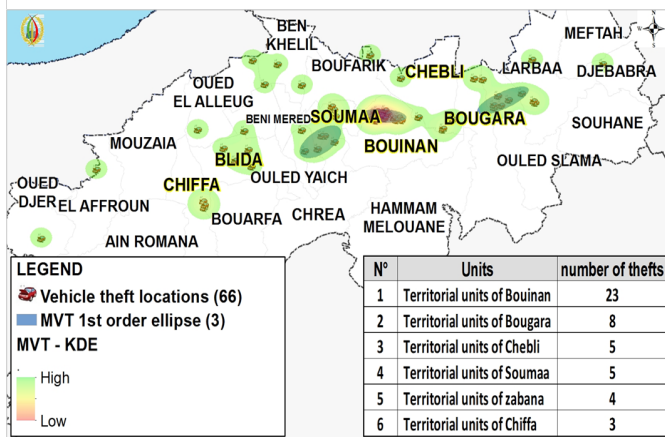


Fig. 6. Map of 1st order hotspots and Kernel Density Estimation produced by Nnh and KDE CrimeStat functions for MVT cases recorded in Blida during January 2020 and February 2023.

To examine the particularities of the hotspots obtained in the previous section, their geographical features and the geographic position of these places where vehicle theft incidents generally occurs, several field visits had been carried out to visually inspect these regions in presence of the local police officers of the Algerian public safety services units’.

The geographic localizations of some of the most important hotspots obtained in Algiers (Ouled Fayet), Boumerdès (Boudouaou), and Tipaza (Douaouda), are shown as examples respectively in Fig. 7, 8 and 9.

The combination of the results obtained through the spatial analysis of the MVT cases recorded in Algiers and its neighboring departments, during the period from January 2020 and February 2023, from one side, and the results of the inspection field visits carried out to some of these regions, from another side, reveals that the most:

- MVT cases hotspots are located in the recent constructed residential areas, especially of social housing type.
- Areas targeted by MVT thieves are not designed in a way that allows the prevention of crimes, in addition to the absence of secure parking spaces and surveillance installations such as CCTV cameras (absence of capable guardian).
- MTV hotspots are located along the highways and roads, close to exits not far from the main “East-West” highway (the distance between the crime scenes locations and the exits to the Algerian East-West highway varying from 300 to 1500 meters).

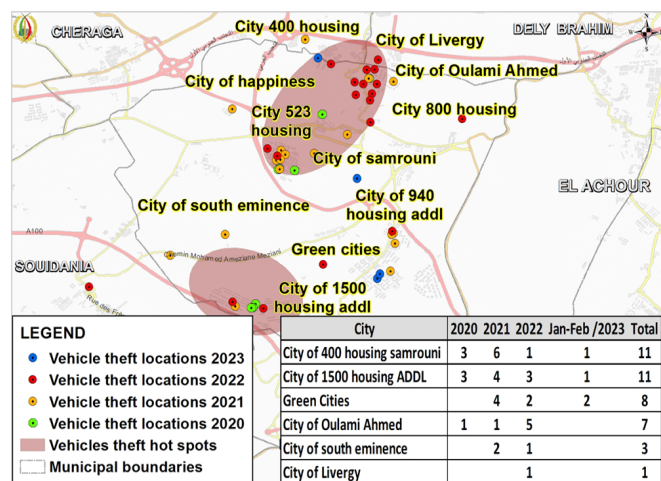


Fig. 7. Map of 1st order hotspot produced by CrimeStat Nnh function for MVT cases occurred in the region of Ouled Fayet (Algiers), during the period from January 2020 to February 2023

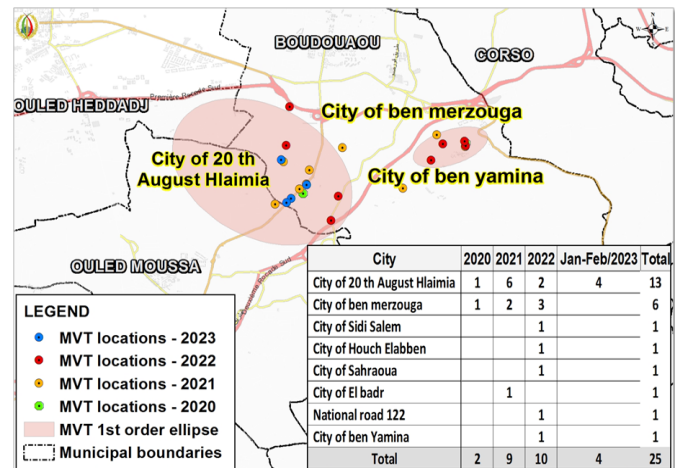


Fig. 8. Map of 1st order hotspot produced by CrimeStat Nnh function for MVT cases occurred in the region of Boudouaou (Boumerdès), during the period from January 2020 to February 2023.

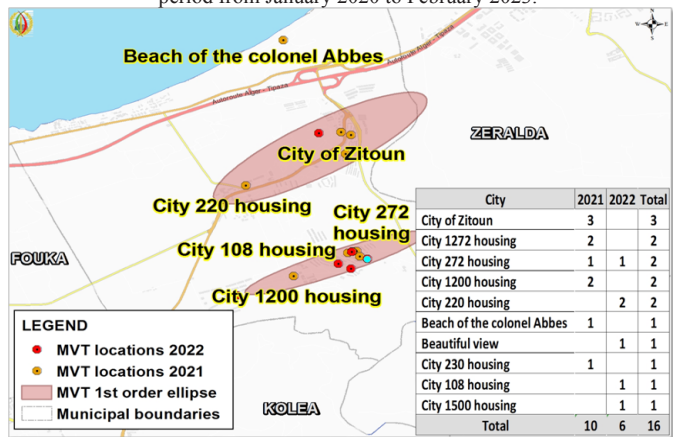


Fig. 9. Map of 1st order hotspot produced by CrimeStat Nnh function for MVT cases occurred in the region of Douaouda (Tipaza), during the period from January 2020 to February 2023.

B. Type of targeted vehicles, Used modus operandi and routes taken to transfer stolen vehicles

An other important result is revealed in this study is related to the type of stolen vehicle. “RENAULT SYMBOL” and “DACIA STEPWAY” are the most targeted types of vehicles in Algiers and its neighboring departments, especially those locally assembled in Algeria. They represent the first category of the stolen vehicles with a rate equal to one third (1/3) of the total number of stolen vehicles during a period of 3 years approximately. The second category includes vehicles from the brand HYUNDAI, especially: HYUNDAI i10 and HYUNDAI ACCENT, manufactured during the period from 2011 to 2015.

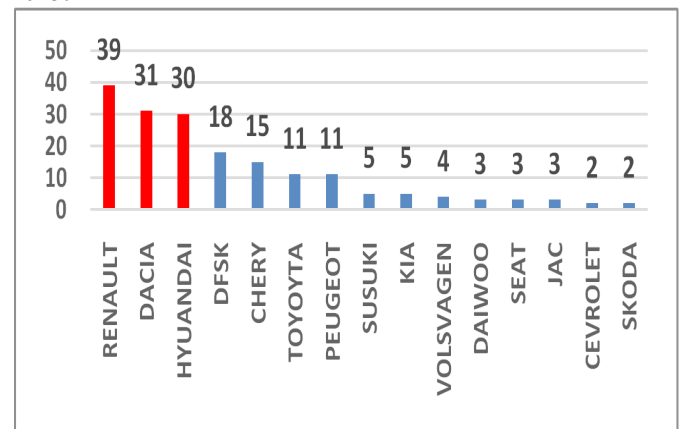


Fig. 10. Types of vehicles stolen in the department of Algiers and its neighboring departments, during the period from January 2020 to October 2022

Fig. 10 shows that 57% of the stolen vehicles in Algiers and its neighboring departments are the vehicles most likely to be stolen are branded “RENAULT”, “DACIA” and “HYUNDAI”. Moreover, it has been noted that 96% of the “RENAULT SYMBOL” and “DACIA STEPWAY” stolen vehicles in this region, were locally assembled in Algeria during the period from 2016 to 2020. It should be noted that these brands are among the most used in Algeria.

Regarding the mini trucks, the analysis conducted in this study shows that DFSK and CHERY, are the most targeted vehicle in their category with a percentage more than 68% of the total number of the stolen mini trucks.

One of the common particularities between the previous targeted stolen vehicles is related to the unreliability and the existence of vulnerabilities in the system of protection against theft, which makes these vehicles suitable targets.

About the modus operandi used to perpetrate such kind of crimes; it is important to mention that the percentage of stolen vehicle cases without resort to violence and threats represents 82% of the total recorded cases. These criminal acts take place mostly in the vicinity of the victim's residence, between 03:00 and 05:00 o'clock AM.

Regarding the remaining cases, it has been noted that:

- 10% of the stolen vehicles were robbed with use of violence against the victim, during its presence outside of the vicinity of its residence. These crimes targeting illegal private transporters, occurs generally between sunset and midnight.
- 8% from the total number of stolen vehicle concerns victims of breach of trust.

Generally, and for security reasons, recently stolen vehicles are firstly hidden in residential areas chosen by the criminal organization to remain under the surveillance of a some members of this organization until making sure that there is no tracking devices installed on it.

Later, the vehicle will be transported to its intended destination using camouflage, by making some alterations on it, such as providing the vehicle with a registration plate identical to a pre-prepared forged driving document or with driving document for a vehicle that has been legally dismissed by qualified administrative authorities.

During the transfer of a stolen vehicle, a rental car is generally used by the criminal organization members to ensure that the way is clear and to check the existence of any imposed vehicle theft countermeasures.

In this context, it is important to note that the majority of vehicles stolen from Algiers department, during the period from January 2020 to October 2022, have been transported to the southern and south-eastern suburbs of this department, especially for the localities of “Meftah”, “Larbaa”, “Bougara” and “Sidi Hammad”. The intention of the criminal organization members behind this choice is to bypass the fixed security safeguard imposed by the Algerian public safety services units’, by taking the south-western bypass route, which is not secured using surveillance cameras (highway surveillance camera network), to attend to the EAST-WEST main highway, as shown in Fig. 11.

As regards to the vehicles stolen from the department of Tipaza, especially from the localities of “Douaouda” and “Kolea”, they are transported via the National Road N° 67 leading to the South of the capital towards BOUFARIK and TASSALA EL-MERDJA, as shown in Fig. 12.

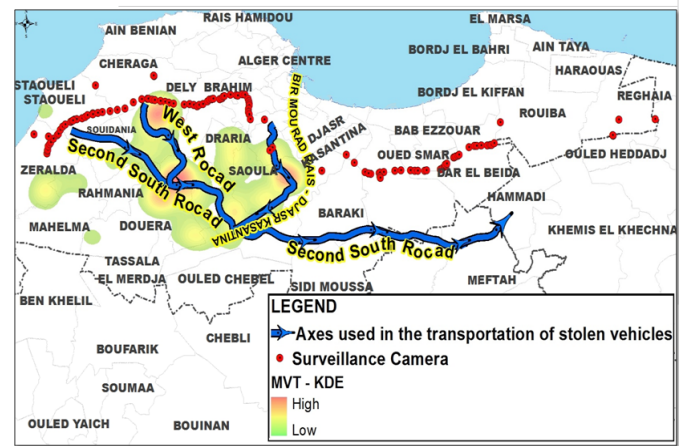


Fig. 11. Main axes used to transport vehicles stolen from Algiers department during the period from January 2020 to October 2022.

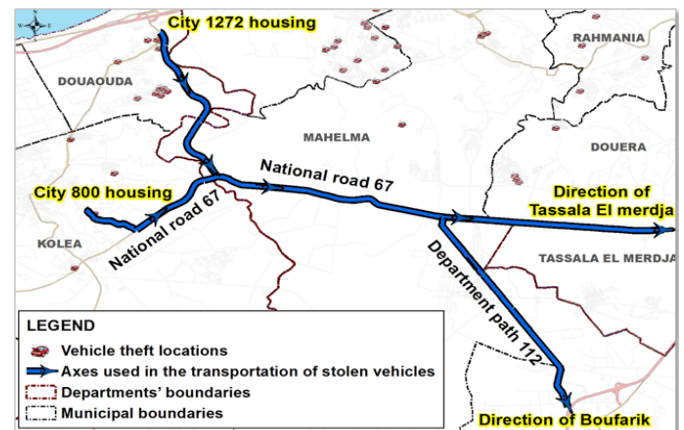


Fig. 12. Main axes used to transport vehicles stolen from Tipaza department during the period from January 2020 to October 2022.

C. Recovery of stolen vehicles and the destiny of those non-recovered

The analyze of the data collected by the Algerian public safety services units' regarding the phenomenon of MVT, shows that the chance of retrieving a stolen vehicle decreases over time, especially after the first seven (7) days of committing the theft. This chance increase when these units' are notified in earlier time (less than 4 hours after the theft crime has occurred), as shown in Fig. 14. It is useful to note that:

- 72% of the total numbers of recovered vehicles were found within a radius of no more than 50 km from the place where the vehicle has been stolen, as illustrated in Fig. 13.
- All stolen vehicles fitted with tracking device installations were recovered in a period of time not exceeding 24 hours.

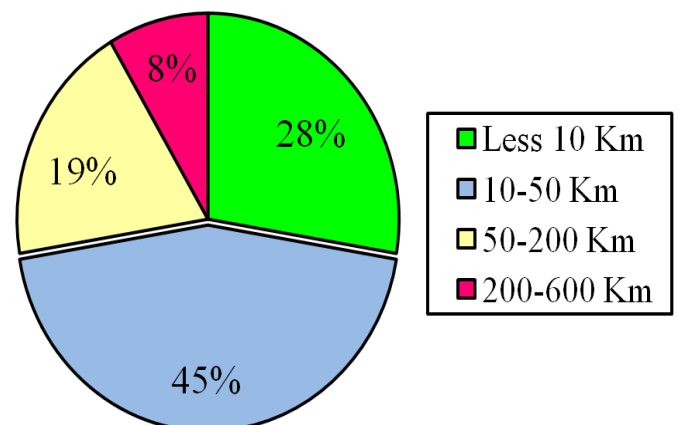


Fig. 13. Distances between the recovery places of the stolen vehicle and where the thefts were occurred.

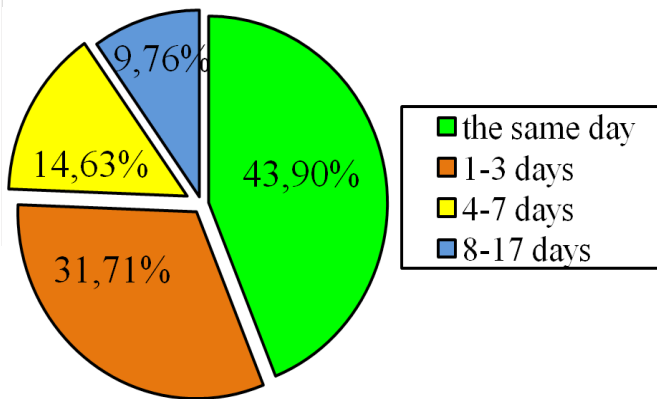


Fig. 14. the average period of time taken before the recovery of stolen vehicles (resolved cases).

Furthermore, it is important to mention that the percentage of non-recovered stolen vehicles is estimated at about 82% of the total number of stolen vehicles (18% only of the stolen vehicles are recovered), which is a result that raises many questions related to the destiny of these stolen vehicles.

In this context, we believe that the destiny of the majority of stolen vehicles in Algeria is associated to one of the following alternatives:

- Selling the vehicle after subjecting it to different falsification process.
- Disassembling the vehicle and selling it as spare parts, especially in the absence of laws regulating the market of used spare parts of vehicles in Algeria.

Regarding the first alternative, the forgery process could be carried out by making partial or total alterations to the vehicle identification number engraved on the chassis (VIN) and to the manufacturer's license plate, through cutting the original ones for example, and welding others belonging to another old vehicle or to a vehicle that has been damaged after an undeclared accident.

The achievement of the forgery process requires also the falsification of the administrative papers of this stolen vehicle according to its new identity (VIN and the manufacturer's license plate), before selling it later.

V. PROFILE OF THE MVT PERPETRATORS IN ALGIERS

To investigate the profile of the MVT perpetrators in the region of Algiers, criminals involved in the MVT resolved cases have been identified in order to verify the criminal records of these persons and to determinate the distance between the criminal activity region where they operates and their residential addressees. The obtained results show that 71% of these perpetrators have been previously prosecuted for different types of crimes. Also, two categories of thieves operating in Algiers had been identified in the present study:

A. First category

It concerns approximately 45% of the thieves involved in the MVT cases occurred in this department. These criminals come from the suburbs located between the region South-East of Algiers and the region North-East of Blida, as shown in figure 15. They have been previously involved in cases related to vehicle theft. They target particular types of cars ("RENAULT SYMBOL" and "DACIA STEPWAY") which are locally assembled and they use quite advanced techniques to bypass the protections integrated on the electronic control unit (UCE) of the vehicle.

It should be noted that a limited number of stolen vehicle cases have been recorded by the Algerian public safety services units', during the last three years, within the regions where these criminals living (their localities of residence). It is about 7 cases in 2020, 4 cases in 2021 and one case in 2022, which confirms the determination of those criminals to operate outside the borders of their residences. Fig. 15 shows the Residence Geoprofile of the perpetrators involved in the MVT cases occurred in Algiers.

B. Second category

Besides the previous category, the investigation reveals that most of the rest of MVT cases recorded in Algiers were committed by criminals living in the same municipalities where those thefts have been occurred. These criminals generally targeting vehicles equipped with security systems easily breached using simple manual methods (the possibility to easily starting the vehicle engine), such as the "i10" and "ACCENT" cars from the "HYUNDAI" brand, especially those manufactured during the period from 2011 and 2015, as well as small mini trucks. In other word, when it comes to the stealing of a vehicle that requires an advanced techniques to operate it, these criminals resort to the use of violence.

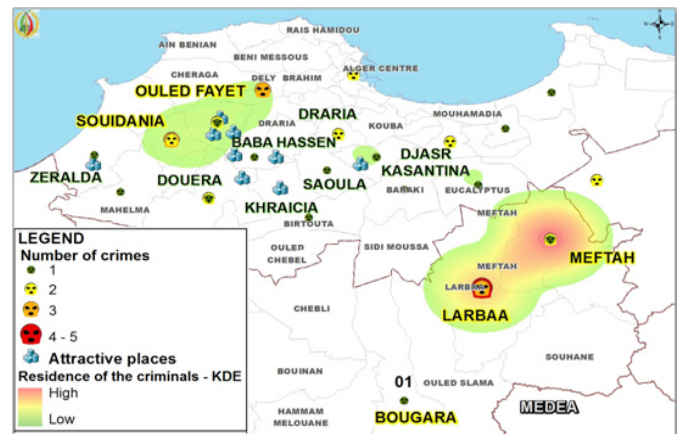


Fig. 15. Residence Geoprofile of the perpetrators involved in the MVT cases occurred in Algiers.

VI. CONCLUSION

In this research work, the Routine Activity Theory was used to examine the MVT data cases of Algiers and its neighboring departments in rural and semi-urban areas. The obtained results confirm that:

- The presence of motivated offenders and a large number of vehicles with significant financial value (suitable targets), in recently inhabited residential area which are not designed in a way that allows the prevention of crimes,
- The absence of secure parking spaces and surveillance installations such as CCTV cameras (absence of capable guardian), in these inhabited residential area which are located along the highways and roads leading to the main EAST-WEST highway, where and when surveillance measures are generally weak.

Are the main helping factors which facilitating the spatiotemporal convergence of the MVT offenses to a specific places in the region of Algiers and its neighboring departments.

These results confirm the validity of the Routine Activity Theory in our case study, where 85% of vehicles theft crimes recorded in the previous mentioned region, are committed in specific places, between 03:00 AM and 05:00 o'clock AM, within the victim's vicinity, and without using violence against

victims.

The study reveals also two main profiles for MVT criminals operating in Algiers. Those living in the southern suburbs localities this department, and which are targeting vehicles equipped with quite advanced anti-theft protection, and those targeting vehicles equipped with security systems easily breached using simple manual methods and living in the same municipalities where those thefts have been occurred.

REFERENCES

- [1] N. Jubit, T. Masron, M. N. Nordin, A. H. Jamian, and A. Yusuf, "Spatial Analysis of Vehicle Theft in Kuching, Sarawak," *Malaysian J. Trop. Geogr.*, vol. 47, no. 1 and 2, pp. 46–66, 2021.
- [2] L. E. Cohen and M. Felson, "Social change and crime rate trends: A routine activity approach (1979)," in *Classics in environmental criminology*, Routledge, 2010, pp. 203–232.
- [3] S. C. Smith and C. W. Bruce, "CrimeStat III user workbook," Natl. Inst. Justice, Washingt. DC, 2008.
- [4] D. B. Cornish and R. V. Clarke, "The reasoning criminal: Rational choice perspectives on offending," 2014.
- [5] P. L. Brantingham and P. J. Brantingham, "Environment, routine, and situation: Toward a pattern theory of crime," in *Routine activity and rational choice*, Routledge, 2017, pp. 259–294.
- [6] L. Anselin, J. Cohen, D. Cook, W. Gorr, and G. Tita, "Spatial analyses of crime," *Crim. justice*, vol. 4, no. 2, pp. 213–262, 2000.
- [7] M. E. Hollis, M. Felson, and B. C. Welsh, "The capable guardian in routine activities theory: A theoretical and conceptual reappraisal," *Crime Prev. Community Saf.*, vol. 15, pp. 65–79, 2013.
- [8] A. M. Bossler and T. J. Holt, "On-line activities, guardianship, and malware infection: An examination of routine activities theory," *Int. J. Cyber Criminol.*, vol. 3, no. 1, 2009.
- [9] D. W. Osgood, J. K. Wilson, P. M. O'malley, J. G. Bachman, and L. D. Johnston, "Routine activities and individual deviant behavior," *Am. Sociol. Rev.*, pp. 635–655, 1996.
- [10] D. W. Roncek and P. A. Maier, "Bars, blocks, and crimes revisited: Linking the theory of routine activities to the empiricism of 'hot spots,'" *Criminology*, vol. 29, no. 4, pp. 725–753, 1991.
- [11] P. W. Rountree and K. C. Land, "Perceived risk versus fear of crime: Empirical evidence of conceptually distinct reactions in survey data," *Soc. forces*, vol. 74, no. 4, pp. 1353–1376, 1996.
- [12] L. W. Sherman, P. R. Gartin, and M. E. Buerger, "Hot spots of predatory crime: Routine activities and the criminology of place," *Criminology*, vol. 27, no. 1, pp. 27–56, 1989.
- [13] M. S. Tillyer and J. E. Eck, "Getting a handle on crime: A further extension of routine activities theory," *Secur. J.*, vol. 24, pp. 179–193, 2011.
- [14] E. Piza, S. Feng, L. Kennedy, and J. Caplan, "Place-based correlates of motor vehicle theft and recovery: Measuring spatial influence across neighbourhood context," *Urban Stud.*, vol. 54, no. 13, pp. 2998–3021, 2017.
- [15] R. Light, C. Nee, and H. Ingham, *Car theft: The offender's perspective*. HM Stationery Office, 1993.
- [16] Y. Mao, S. Dai, J. Ding, W. Zhu, C. Wang, and X. Ye, "Space-time analysis of vehicle theft patterns in Shanghai, China," *ISPRS Int. J. Geo-Information*, vol. 7, no. 9, p. 357, 2018.
- [17] Y. Lu, "Spatial choice of auto thefts in an urban environment," *Secur. J.*, vol. 19, pp. 143–166, 2006.
- [18] R. V. Clarke and D. B. Cornish, "Modeling offenders' decisions: A framework for research and policy," in *Crime Opportunity Theories*, Routledge, 2017, pp. 157–195.
- [19] G. Suresh and R. Tewksbury, "Locations of motor vehicle theft and recovery," *Am. J. Crim. Justice*, vol. 38, pp. 200–215, 2013.
- [20] M. P. Levy and C. Tartaro, "Auto theft: A site-survey and analysis of environmental crime factors in Atlantic City, NJ," *Secur. J.*, vol. 23, pp. 75–94, 2010.
- [21] B. A. Bryan and L. M. Henry, "Visualising the spatio-temporal distribution of motor vehicle theft in Adelaide, South Australia," 2000.
- [22] IBM, "What is clustering?" <https://www.ibm.com/topics/clustering>.