GIS Contribution to Identify Accident Black Spots on National Highway: Case Study of Wilaya of Mascara (Algeria)

R. Oulha., K. Brahimi., A. Boumediene, F. Dali, and M.A. Madouche

Abstract—In Algeria, we attend an exponential increase of the number of road accidents and strong increase of the road traffic. The road risk which becomes very important is concentrated in ten Wilaya(departments) and constitutes the cause of 45 % of the accidents in 2007. There is no universal definition of accident locations on roads, commonly termed hotspots, which means that the definition of hotspot is open to much speculation. The traditional definition considered that the hot spot as a place where a high number of accidents are found. This paper presents two approaches by which hot spots can be identified. The Wilaya of Mascara in Algeria was chosen as the study area. The first approach is based on mobility analysis of persons and goods. This approach allows a comprehensive analysis of factors driving risk and different types of vehicles on the roads studied, but it does not allow the exact location of black spots which the interest in using Geographical Information System (GIS) and spatial analysis. The second approach consists on the use of Kernel estimation approach with ArcGis tool, to improve the analysis and to identify high-risk areas in order to bring specific solutions in planning.

Keywords—road risk, mobility, high-risk areas, geographical Information systems, ArcGis, Mascara, Algeria.

I. INTRODUCTION

ROAD traffic accidents are complicated to analyze as they cross the boundaries of engineering, geography, and human behavior (Sabel et al., 2005). Risk analysis can identify road safety problems on the network to provide security measures to remedy (Zeitouni et al., 2005). The explanation of risk factors associated with the interaction with neighbors is essential to decision-making on road safety. Several studies showed in addition that the composition of the traffic, and in particular the importance of the traffic heavy, have an important influence on the safety of circulation if the geometrical characteristics of the road are bad (Chanut, 2005).

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The issue of road safety is rarely taken into account when dealing with urban management of goods. For years, research has focused on the travel of people at the expense of cargo movements (Fig.1). Since the 1970s there has been a plethora of statistical models applied to the understanding of road accidents (Anderson, 2006). However statistical approach neglect the spatial dimension of risk which the interest in using GIS (Zeitouni et al.,2005).
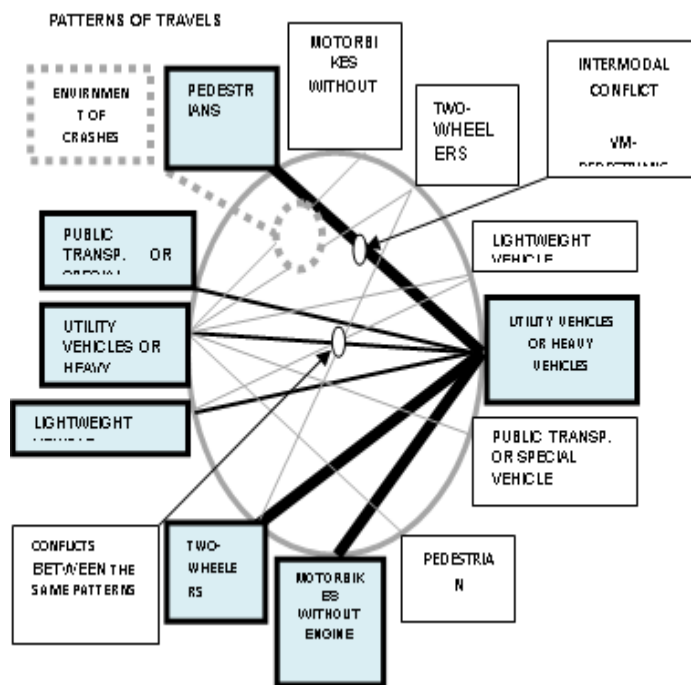

Fig.1. Representation of the intermodal conflicts implying good vehicles (source: Maurelli & Iacovelli in Bouceddour, 2006)

Figure 1 clarify the relationship between the poles of attraction that engender greater mobility of people, shopping areas that attract large flows of goods transport and the inclusion of road safety in the development and highway management. This approach requires attention first to the risk factors related to road elements of National Highway design and traffic conditions (location of commercial areas in relation to roads studied, interaction of different types of vehicles on the same axes road type of town planning, road network characteristics, etc.). GIS aided spatial data and spatial

analysis provides a lot of information to analysts about hazardous locations, hot spots, warm spots etc. Using GIS, the analyst can merge accident and highway data, geocode the accident data and locations, calculate frequency and rate of accidents, select a variable for stratification to calculate mean and standard deviation of accident rates (Liang et al., 2005).

II. AN EVALUATION OF THE ROAD INSECURITY: THE CASE OF WILAYA OF MASCARA

The choice of the Wilaya of Mascara as area study,was justified by the particular context of the Wilaya, in comparison with the carriages of goods and its agricultural vocation and by our knowledge of the accidents on this territory.

III. ACCIDENTOLOGY IN ALGERIA AND MASCARA, SOME FIGURES

Statistics of road accidents in Algeria and their interpretations show a very alarming fact (fig.2). In 2008, Algeria had 35,1 million inhabitants and had a fleet of 5 million vehicles running on a road network of 109452 kilometers. The same year, the security services recorded 40481 road crashes that have resulted in 4422 fatalities and 64708 injured. The total cost of road accidents is estimated at over 1 billion U.S $ per year (Ministry of Transportation, 2009).
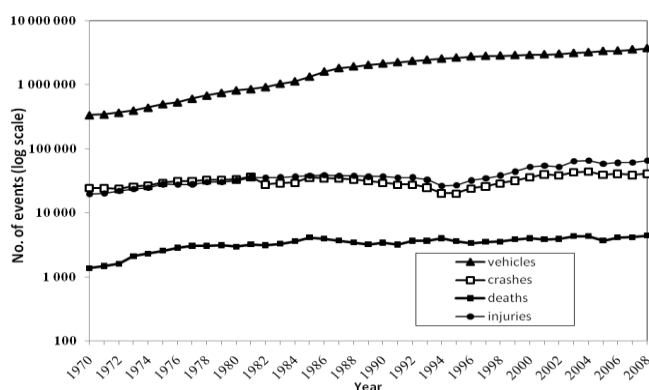

Fig. 2 Total number of registered vehicles, crashes, deaths and injuries in Algeria (1970-2008)

The problems arising from the road traffic, in Algeria, became at the present time a serious subject of concern. The road risk which become very important, is concentrated on ten Wilayas, on a total of 48 Wilayas, and constitute the cause moreover 35% of the accidents in 2008 (National Center for Prevention of Road Safety, 2008).

Mascara is located in a strategic position; it's the junction point of agricultural, industrial and tourism areas in the Western Algeria with a dense highways network (fig.3). It is 100 kilometers from Oran, the capital of West Algeria, which is a pole of attraction, which favors greater mobility between them. Hence, traffic accidents have become more common.

In term of road mortality, Mascara is classified in 2nd rank into 2008 in rural area with a gravity of 175 for 100 crashes. According to the statistics provided by Civil Protection services in 2010, 68% of accidents occurred on National

Highways and the section of the East-West motorway recently introduced in the Wilaya of Mascara. The 32% remaining of crashes occurred on urban roads (Civil Protection services, 2010) (fig.3).
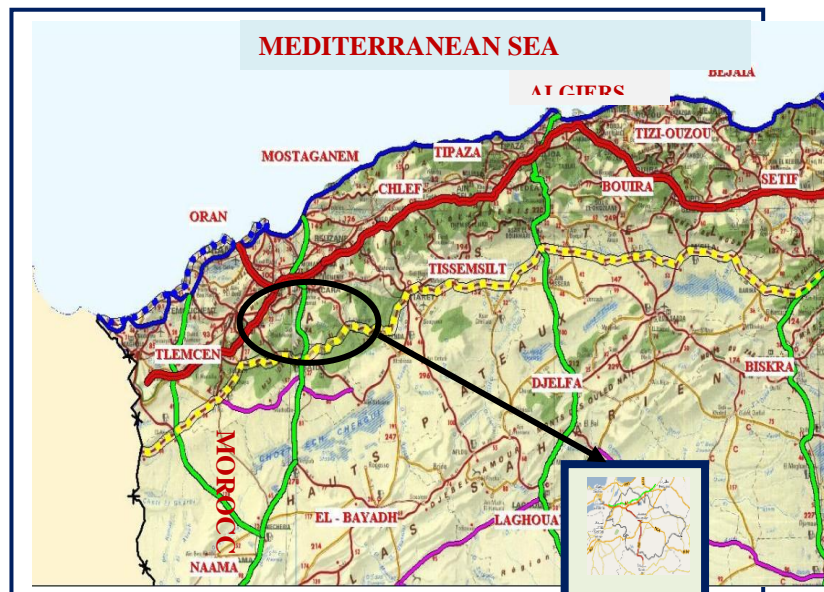

Fig.3 Location of Mascara in Algeria.

These elements make Wilaya of Mascara a famous Wilaya on a national scale by his fatal crashes. National Highways in particular the NR4, between Oued Tlelat (Oran) to El Ghomri (Mascara) and NR6, connecting Mascara Oued Taria, are the moust deadliest axes of the wilaya of Mascara. So, it is an urgent task to reduce these accidents by performing analysis and taking precautions. The aim of this study is to determine hot spots and factors contributing to accidents in these locations and to determine how, what, and where accident countermeasures can be implemented using a GIS.
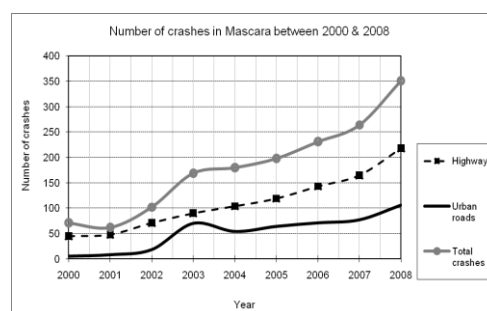

Fig. 4 Number of crashes in Mascara Between 2000 and 2008

IV. METHODOLOGY

The first method relies on estimating the risk from the return experiment on traffic accident, listed by different services. Data from accidents are files of the National Gendarmerie, Civil Protection services for accidents involving the 4 wheels and insurance of the Wilaya of Mascara for accidents involving two-wheelers for the period 1996 to 2008, 13 years.

To determine the types of vehicles on the N6 and N4 segments and the volume of daily traffic, we made a count on several points and on different days of the week. Results were compared to statistics provided by the Management of Public Works.

Since the quality of statistics provided by the Police is subject to criticism, the search for another source of data is shown to be essential. This has, indeed we have done the part of road users including taxi drivers who use this National Highways daily. Participation of road users is intended to bring their practices, their experiences of the accident and their feelings in relation to road safety. We undertook this especially with taxi drivers (Mascara-Oran-Mascara) which tracks these axes on average 16 times a week.

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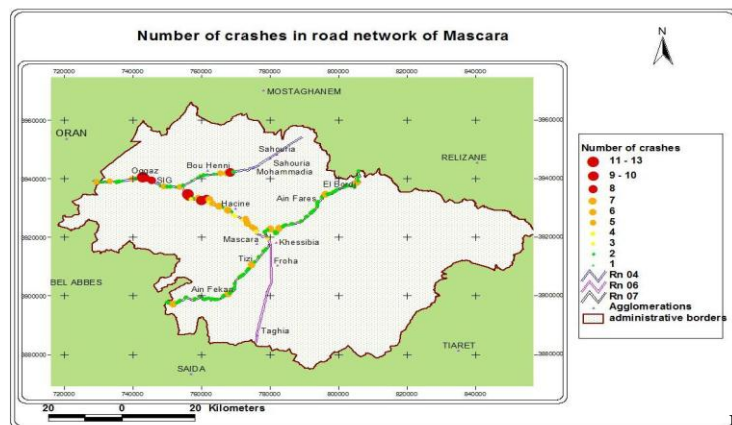
hotspot threshold approach based on kernel density estimation.

V. RESULTS AND DISCUSSION

Counts carried out on the site have shown that there is a complexity of traffic over the N4 and N6 (Fig. 6). The agricultural character of the Wilaya of Mascara has found that daily on these roads, vehicles carrying agricultural products toward the city of Oran. The geographical position of the Wilaya of Mascara axis between the north and south and east and west of Algeria supports the presence of the bus carrying passengers to the capital Algiers in particular via the N4 (fig.6). In addition, major construction works of the East-West Motorway and other penetrating favored the presence of heavy trucks carrying construction materials. The flat morphology of Sig and Mohammadia villages located on the axis N4 and poor quality of public transport has encouraged the use of both wheels of all kinds. This mode of transport is much responded particularly in these villages and is used as a means of transport by all categories of age.
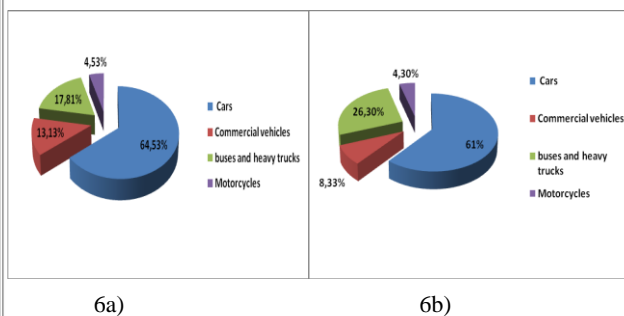

Fig.5.Number of crashes in road network of Mascara

6a) 6b)

Fig. 6 traffic daily composition: 6a) on the section of Highway-N6, 6b) on the section of Highway-N4.

Secondly, the determination of black areas in Algeria is via the service of the National Gendarmerie services in charge of traffic with traditional methods, that is to say, a place where the number of accidents is repeated during the year (3 to 5 accidents) is considered as a black hot. Which can lead to misdiagnosis when making decisions for the development of these places? It may even aggravate the situation or move items to another location. To this end, we used GIS is a powerful tool for the representation and analysis of discrete events such as accidents on road sections. Recent studies have shown the effectiveness and importance of using GIS for analysis of hotspots. The most promising of these tools is Kernel Estimation, whereby a distribution of discrete point 'events' is transformed into a continuous raster surface (Sabel et al., 2005). Kernel Density analysis method was used to calculate the density of accidents in a search radius of 0.5 km area along highways. Kernel Density calculates a magnitude per unit area from point or line features using a kernel function to fit a smoothly tapered surface to each point or line (Saffet Erdogan et al.,2007). (Fig.8) shows the results of this

Figure 6 present that portion of a flow of heavy traffic including trucks passing through this section og highway from beginning to end . It is obvious that this situation represents a potential risk in road safety for the people.

When we determined the hotspots, most of these points are located at intersections between N6 and N4 with villages and small cities (khessibia, Hassine, Oggaz, Sig). The most important causes of these accidents are dangerous overtaking and speeding (20%) at road sections uncontrolled, reckless pedestrians and users of two-wheelers (13%) levels in urban areas such as the city of Sig and the City of Mohammedia and disregard of traffic signs including stop at intersections (15%). Stretch of 6 km (between PK26 and PK32) of N6 is composed of dangerous curves with a slope of 10%. This place is an accident-prone area during rainy seasons because of the slippage of the pavement. The slow movement, made more dangerous by the discomfort of heavy goods vehicles over very long distances is increasing impatience of the drivers of other vehicles. Another risk factor lies in the speed differences between passenger cars and trucks that can reach on certain categories of roads, 40 km / h. This situation poses

considerable problems in controlling the passive safety of heavy trucks.
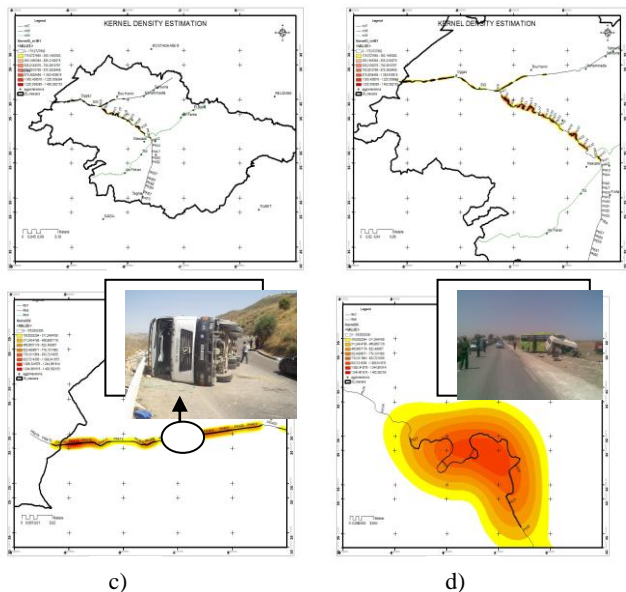

c)   d)

Fig.7 Location of accident hot spots in sections of National Highways N4 and N6: (a) and (b) Total Kernel Density Estimation, (c) hotspots in section of N6 between PK26 and PK32 (d) hotspots in section of N4 between PK401 and PK414

VI. CONCLUSIONS

Road traffic accidents are complicated to analyze as they cross the boundaries of engineering, geography, and human behavior. Road safety requires taking into account the general problem posed by the heterogeneity of the traffic mix different categories of vehicles. Cycles, the cycles, motorcycles, passenger cars, trucks and buses must share the roadway.The survey method with road users and the use of GIS are two complementary methods for the determination of black spots. The participation of road users is also a good alternative in developing countries like Algeria, where data quality is subject to criticisms. This study may have application in other wilayas of Algeria. The main advantage of using this approach for identifying accident black spots on National Highways is that it can easily be used for planning road safety measures. Also these can be supplemented with the results obtained by using other approaches. Moreover the results can act as a quick guideline for road planners and the authorities concerned with accident mitigation measures.

ACKNOWLEDGEMENTS

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