Accident Prediction Model -Case Study Region of Tangier

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***Abstract*— Road accidents in Morocco cause more than 4,000 deaths each year and about 140 Million Dirhams (equivalent to about $14 million) of property damage. Many researchers have developed models to predict accidents and their causes, but it has not yet been possible to control this phenomenon, where the human factor plays a very important role. The dramatic increase of vehicle travel calls for an effective modeling of accidents prediction and their fatalities. In this paper, we propose an accident prediction model that relates accident frequency to various contributory factors, and is developed using linear regression techniques. In addition, this study investigates road traffic accident using descriptive statistics to compare the different modes of travel and other parameters. We will study particularly the region of Tangier who has known a great economic development in the last decade originating much traffic and displacements.**

***Index Terms*— accident prediction models, road safety, mobility in Tangier (Morocco)**

I. Introduction

Road traffic increased after the Second World War. This increase is therefore reflected in the evolution of road accidents. This fact has suggested scientific discipline that studies accidents, created in France in 1968 by researchers of the National Organization of Road Safety, the accident is considered as an unavoidable unpredictable event it is a product of a system combining individual behavior, transport tool and environment. The World Health Organization (WHO) has predicted that traffic fatalities will be the third leading cause of death worldwide by 2020 [1].

During more than 70 years, several models have been developed to estimate traffic accidents, Smeed has investigated the relationship between the deceased and the number of vehicles and proposed model using data corresponding to one year (1938) [2], this data are not enough and the model cannot be generalized to other countries for several reasons (Andreassen, 1985) [3]. Many authors have been interested in the study of accidents, modeling mathematically, with the aim of estimating their evolution and trying to give solutions [4]. Using Smeed's formula and Andreassen equations, in the work, analyzing data on traffic accidents of 25 years, 1977-2001 to understand the causes of accidents and estimate traffic accidents in seven cities from 2007 to 2010 [5], also has studied the causes of accidents in cities of India according to gender, age, time of day and several factors [6]. In other works, developed mathematical models for number of traffic accident fatalities, authors investigate the causes of accidents in Jordan [7], in developed prediction models for Jordan [8], Qatar and United Arab Emirates. Akıngör and Doğan have used the same equation models to study traffic accidents in Turkeys [9]. Ponnaluri has modeled road traffic fatalities in India [10], Jadaan and al. have studied accidents in Jordan, and elaborated a model for the prediction of fatalities, also evaluated the cost of accidents and tried to give some solutions to reduce accidents in Jordan [11].

Morocco is among the countries where the most traffic accidents occur across the world [12]. According to WHO data published in May 2014 Road Traffic Accidents Deaths in Morocco reached 6,039 or 3.38% of total deaths. The age adjusted Death Rate is 19.98 per 100,000 of population ranks Morocco #70 in the world and the number of people who died from traffic accidents in 2016 exceeded 3,593, rising by 0.79% from 2015, according to the latest numbers of traffic accidents released by the Ministry of Equipment Transport and Logistics [13].

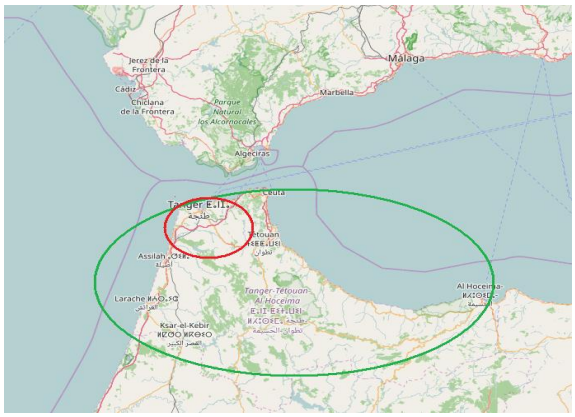

Figure 1. Study area

In this study, we will analyze the traffic accidents in the northern region of Morocco as depicted in Fig. 1. The Tangier-Tétouan region is set to receive an ambitious slate of building projects between 2010 and 2017. In addition, the population has evolved from 762583 in 2004 to 1060302 in 2014 [14], this evolution is reflected in the

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generation of more complex mobility, the CREATION of new bus lines, increased taxis and travel, and a high rate of industrialization as illustrated in Fig. 2. All these factors will contribute to an increase in road accidents as can be observed in Fig. 3.

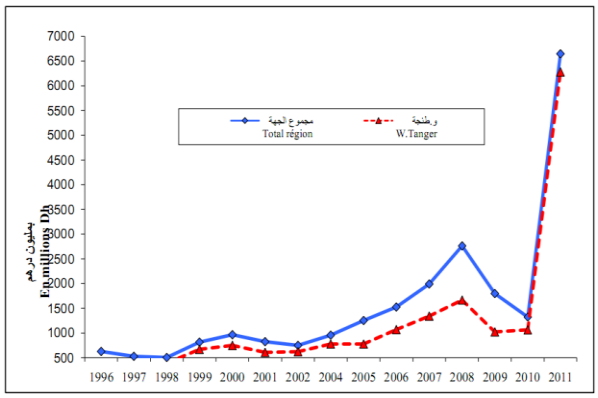

Figure 2. Evolution of industrial investment

The main objectives of this paper are:

- First, we generate a model for the prediction of fatalities and modeling TREND accident developed under Moroccan conditions.

- Second, quantify the accident problem in the region, estimate the socio-economic impact and suggest guidelines for improving road safety to accomplish our objectives.

Data were collected from the annual statistics report of the Tangier-Tétouan region (2000 to 2013) [14].

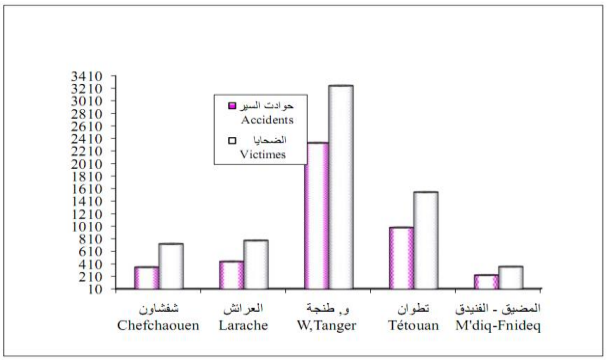

Figure 3. Accidents and traffic victims by province

II. TRAFFIC ACCIDENT MODELS

As we observed in Fig. 3, the city of Tangier expresses a high degree of traffic accidents in comparison with the other cities OF the region; therefore, we have seen that it will be interesting to study traffic accidents and their causes in this specific city.

The first attempts to develop an accident prediction model, was introduced by Smeed, using 1938 data related to population, motorized vehicles and deaths, this model was tested by the author for 20 countries [15].

$$\frac{D}{V} = 0{,}0003\left(\frac{V}{P}\right)^{-0{,}67} \quad (1)$$

where P, D and V are the population, number of deaths and vehicles, respectively.

This model is represented by Eq (1) where the quotient between the number of death and vehicle is

Smeed's law Eq. 1 is criticized for having the number of vehicles on BOTH sides of the equation and that there is a considerable deviation between the expected and actual number of road fatalities.

A model for the prediction of fatalities was developed under Moroccan conditions between 2000 and 2013, the model has the following form:

$$F = 7063{,}595 + 0{,}041.V - 0{,}01.P \quad (2)$$

With:

$R^2 = 0{,}642$ (The higher the R-squared, the better the model fits our data; R-squared is always between 0 and 100%)

Fisher-Snedecorsig.variation=0,038 (Sig.variation must be <0, 05)

Durbin-Watson=2,065 (1, 5<D-W<2, 5)

F, is the predicted number of fatalities

We have generated a linear model across the data from 2000 to 2013. Now with the data provided by the statistical yearbook of the city of Tangier, we can generate a linear model that relates the number of vehicles that circulate around the city of Tangier and the years, and we generate the following model:

$$V = Y.6407{,}338 - 12750000 \quad (3)$$

where,

V, is the number of vehicles

Y, is the year

In addition, we can generate a linear model that relates the population and the years:

$$P = 17543{,}8596.Y - 3{,}429975.10^7 \quad (4)$$

where,

P, is the population

Y, is the year

Ones Eq. (2), (3) and (4) are established, future fatalities can be predicted for the next ten years as shown in Table I:

TABLE I. PREDICTED FATALITIES

Year	Predicted Fatality
2017	2186
2018	2255
2019	2342
2020	2430
2021	2517
2022	2604
2023	2691
2024	2779
2025	2866
2026	2989
2027	3040

as you can see the number of fatalities increases over the years, which can be concluded that the accident rate continues to increase, this may be an indicator that the

measures taken are not enough to reduce accidents in the region of Tangier.

III. Accidents, Rates and Characteristics

The new 2016-2025 security strategy is expected to reduce traffic deaths considerably, with its long term and more demanding vision to adopt a safer and more responsible behavior on our roads. This new security strategy aims to reduce traffic mortality by 50% by 2025. According to the Ministry of equipment and transport, three main factors are the cause of traffic accidents: poor infrastructure, inadequate vehicles, and the human factor. Such that the human factor is the most dominant with 90 percent of the accidents.

We have performed a statistical study to quantify the accidents in the city of Tangier, dividing into accidents by day, means of transport and victims in the period between 2000 and 2013.

We represent the average number of accidents per day during the period between 2000 and 2013 as depicted in Fig. 4.

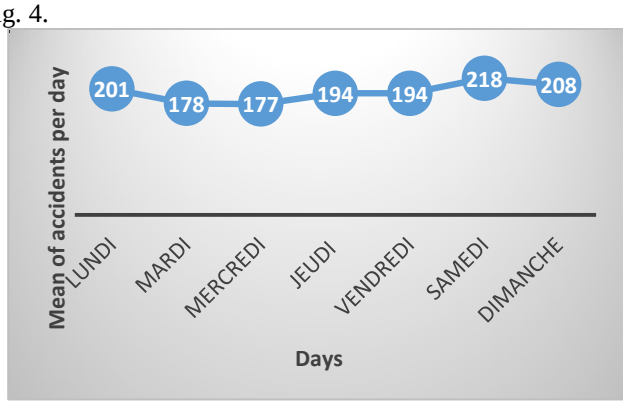

Figure 4. Accidents by day between 2000 and 2013

According to Fig. 4, there is a slight growth in the number of accidents during the first and the lasts days of the week, and in the rest of the days this number remains constant. This is an obvious result as the movement of vehicles is more important in those days because of different activities.

We can represent the different causes of accidents as depicted in Fig. 5, during a time interval between 2000 and 2013, classifying the causes between excess speeds, failure to respect signs, mechanical defects or other reasons.

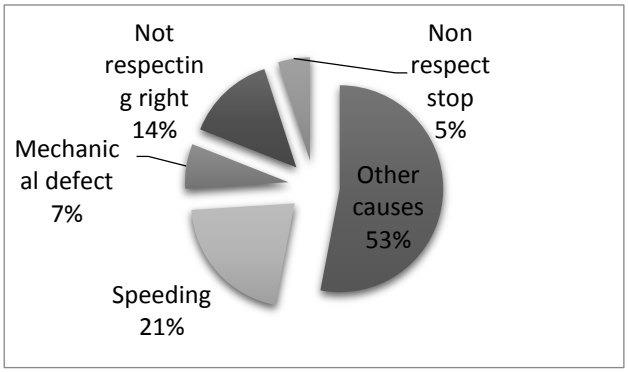

Figure 5. Causes of accidents

According to statistical book of Tangier city, the causes of accidents have been summarized as follows in Fig. 5:

21% speeding, 14% not respecting right and 53% other causes, they may be stress, talking on phone, weather, poor infrastructure…

In almost all cases, the human factor follows the predominant, distraction, speeding, fatigue ...etc.

It will also be an important fact to see the type of transport with which more accidents are done, this will give an idea of the mode of transport most used and therefore the actions that we must take to control or better manage this use, because it is the one that causes most accidents, as shown in Fig. 6.

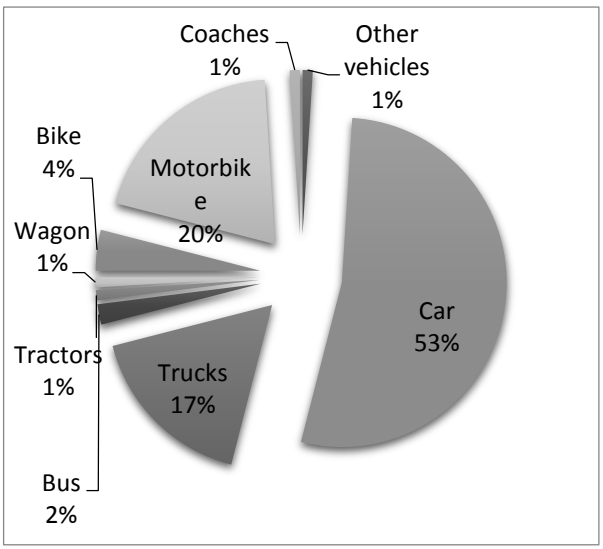

Figure 6. Causes of accidents according to means of transport

Cars (Fig. 6) carry more than half of the accidents out and with 20%, 17% of accidents is due to motorcycles and trucks respectively.

It will be also an important indicator, representing the different victims of accidents as we can see in the following Fig. 7:

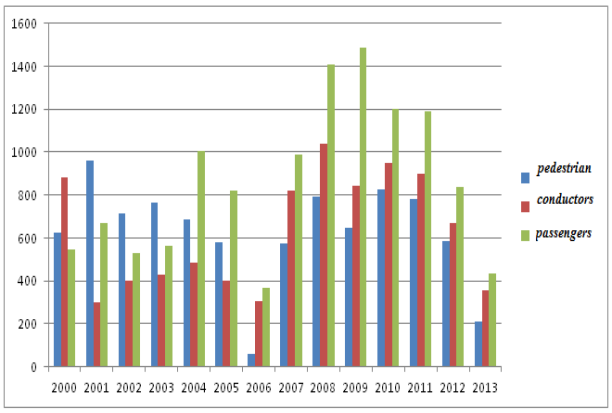

Figure 7. Distribution of victims during the period 2000-2013

The victims of accidents are distributed among the period 2000 to 2013, between passengers, pedestrians and drivers, according to the Fig. 7 passengers are the most

affected by accidents, in some articles have studied the severity of passenger injuries of vehicles [16].

Researchers in Europe have developed many models of accident prediction, and have reached a unified model through the PRACT project, and in each country the model is adjusted according to calibration factors [17].

In our case, we use statistical regression to determine the strength of the relationship between dependent variable (in this case is the frequency of accident) and a series of other changing variables (independent variables). Also to explain or predict the outcome of the dependent variable Y.

$$Y = \frac{Number\ of\ victims}{Number\ of\ vehicles} \quad (5)$$

We can model the frequency of accidents in each year, as a chronological series and analyze accidents trend as shown in Figs. 8, 9, 10. Finally, we chose the best model, based on statistical parameters.

Model performances were evaluated using MAPE, MAD, and MSD statistics, to compare the fits of different forecasting and smoothing methods. For all three measures, smaller values usually indicate a better fitting model:

Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Deviation (MSD) [18].

IV. Modeling Accident Frequencies

A. Linear Model

We will study the linear evolution of the frequency of accidents (Eq. 6) over time in the interval between 2000 and 2013 as illustrated in Fig. 8.

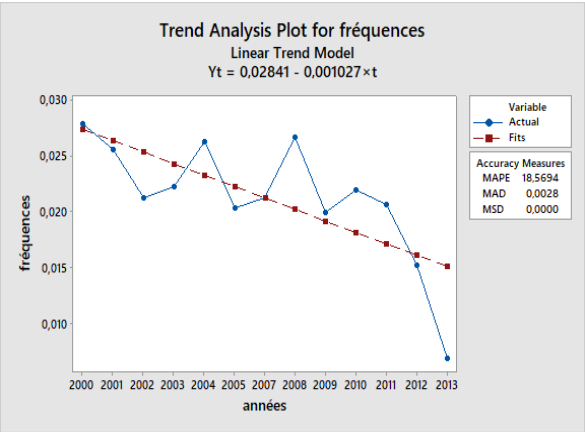

Figure 8. Trend equation

Fitted Trend Equation:

$$Yt = 0,\ 02841 - 0,\ 001027.t \quad (6)$$

B. Quadratic Model

We can also define the relation between variables as a quadratic relation (Eq. 7) and evaluate the statistic parameter as shown in figure 9.

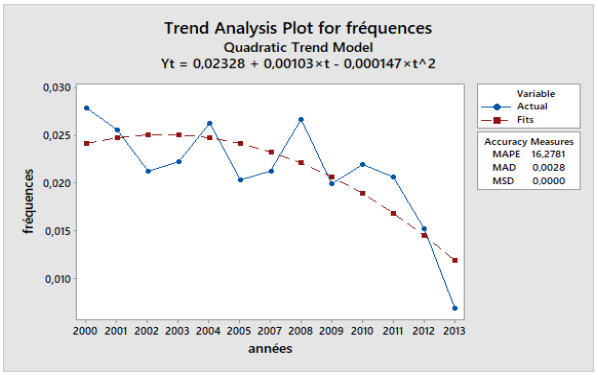

Figure 9. Trend equation

Fitted Trend Equation:

$$Y_t = 0,\ 02328 + 0,\ 00103.t - 0,\ 000147.t^2 \quad (7)$$

C. Exponential Model

We can evaluate the relation between variables as exponential relation (Eq. 8) as illustrated in Fig. 10.

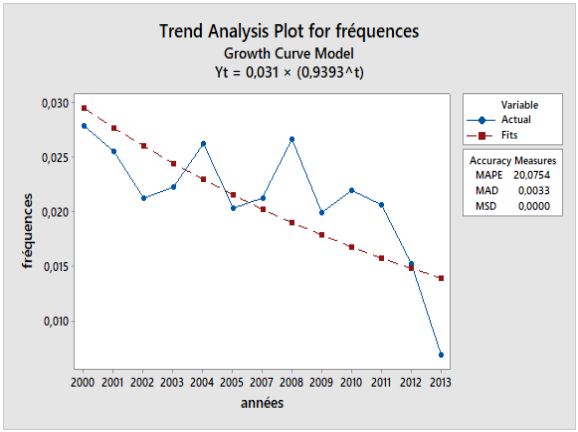

Figure 10. Trend equation

Fitted Trend Equation:

$$Yt = 0,031.\ (0,9393^{t}) \quad (8)$$

Among the three models, we have to choose the one that best fits our study and we rely on our choice in:
Smaller values of MAPE, MAD and MSD indicate a better fitting model [17]:

The second model (quadratic model) show the best representation, with MAPE=16,2781 MAD=0, 0028 and MSD=0, 0000.

From our point of view, the most direct solutions to reduce the accident rate in the city of Tangier is:

- Technical conditions

The construction of tunnels in the roundabouts with high-flow cars, such that the city of Tangier contains around seven roundabouts that produce a high congestion. Also, have to decrease the streets with a unique sense, because they cause confusion to the drivers when carrying out maneuvers of circulation. Equip the police with the new methods and control technologies (video surveillance cameras, radar in the different streets of the city ...).

- Conditions concerning the driving license

- Review the conditions of insurance companies.
- Reasonable intervention of insurance companies.
- Determine the scope of civil and criminal liability.
- Deliver the driving license with conscience and rigor.

V. Conclusion

In the last 10 years, the region of Tangier has experienced a great urban expansion, which has caused the increase of the mobility degree; this immediately translates in the increase of accidents.

While many efforts were deployed to fix road infrastructure and develop more secure vehicles, one of the main reasons of traffic accidents is still the driver's responsibility. The human factor is present in more than 90% of recorded accidents.

To counter this issue, the National Committee of Traffic Accidents Prevention runs continual field studies to measure behavioral indicators. The results of these studies show a serious disrespect of traffic laws, including disregard of stop signs and not wearing seatbelts the mathematical modeling show the quadratic relation between accidents frequencies and years, which demonstrate an augmentation in accident in the future. The ministry is planning to reinforce traffic control with high-tech radar and a more vigilant traffic police.

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