

## Analysis of Road Traffic Accidents and Ranking of Sites Severity: A Case Study of EL Minia / Beni-suef Eastern Desert and Agricultural Roads, Egypt

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**Abstract:** Road traffic accident is a massive health hazard in Egypt and all over the world. Also, Road traffic injuries (RTIs) are a major cause of global mortality and morbidity. Available funds are insufficient to solve problems in all accident locations at the same time. Consequently, accident locations need to be ranked according to its severity for best allocation of available funds to repair the most severe locations. El Minia-Beni suif east and Agriculture roads are of the roads that have a highly repetition of accidents. This study compares between accident characteristics on both roads. In addition, areas of high accident occurrence are ranked according to its severity. Accident data on both roads is abstained from General Authority of Roads, Bridges and Land transport (GARBLT) for the period from 2010-2014. Analysis proved that Agriculture road has the major part of accidents, death and injuries. The maximum number of accidents on both roads occurs at kilometers between 20 and 30. The road section length of highly accident location on both roads is divided into subsections with length 2 km. These subsections are ranked according to its severity using the accident weight methodology. Accident weight is estimated using the economic cost of death, injury and property damage. Black spots are determined using Critical Crash Rate approach. Analysis proved that two locations on the study area can be considered as black spots. One on each road at the same km (24-26) is considered as a black spot. The present study recommends starting modifications with these two black spots sites then other locations according to its rank of severity. Also, the research recommends that the methodology introduced in should be used on all Egyptian roads.

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### 1- Introduction:

Road traffic accidents (RTAs) become a huge global health and development problem. The statistical profile reflects that About 1.25 million people die each year as a result of road traffic accidents. Road traffic injuries are the leading cause of death among young people, aged between 15-29 years. About 90% of the world's fatalities on the roads occur in devolving countries, although these countries have approximately half of the world's vehicles. Without solutions, road traffic accidents are expected to be the 7<sup>th</sup> leading cause of death by 2030. Research carried out in 2010 suggests that road traffic accidents cost countries approximately 3% of their gross national product. This figure rises to 5% in some low- and middle-income countries (WHO, 2015).

In Egypt, The number of registered traffic accidents in 2013 was 15578. These accidents have killed 6700 persons and injured 22397 persons in addition to damaging 22039 vehicles (CAPMS, 2015).

In this study, an effort was made to know the location of highest rate of injuries resulting from accidents for both Eastern desert and agricultural

roads and analysis the causes of accidents in these regions.

### 2- Literature Review:

About 12 000 person lost in Egypt due to road traffic crashes every year. Egypt has a road traffic fatality rate of 42 deaths per 100 000 population. Furthermore, 48% of those killed are passengers of four-wheelers though pedestrians also constitute a significant proportion (20%) of these fatalities (WHO, 2012).

Accident study work may be described as the task of improving road safety. Enhancement includes the geometrical and environmental characteristics of the problematic sites in the existing road network. Ranking sites according to severity is essential to set priorities for dangerous locations. In accident study, site ranking become an important task to best utilize the limited funds as effectively as possible.

Mahalel (1978) proposed that black spots should be defined as those sites whose number of accidents is significantly higher than expected at some prescribed level of significance. According to Hauer (1996) some researchers rank locations by accident rate

(accidents per vehicle-kilometres or per entering vehicles), some use accident frequency (accidents per km-year or accidents per year) and some use a mixture of the two.

The most common assumption for a black spot determination is the repetition of accidents. The criteria for identify black spots vary from country to another, international preliminary comparison is provided in Table, 1 (Mungnimit Sujin, *et al.*, 2009).

**Table (1): country Section Length.**

Country	Section length	Frequency
Australia	Fairly Short	At least 3 casualty crashes in 5 years
England	300 meters	12 crashes in 3 years
Germany	300 meters	8 crashes in 3 years
Norway	100 meters	4 crashes in 3 years
Portugal	200 meters	5 crashes in 3 years
Thailand	(DOH) Vary	At least 3 crashes in 1 years

Liyamol Isen, *et al.* (2013) used Weighted Severity Index Method (WSI) by assigning scores based on the number and severity of accidents in that particular location during the last 3 years.

$$\text{Weighted Severity Index, (WSI)} = (41 \times K) + (4 \times GI) + (1 \times MI) \dots\dots\dots (1)$$

Where, K is the number of persons killed; GI is the number of serious injuries; and MI is the number of minor injuries.

Apparao (2013), introduced a methodology to identify hazardous locations called Critical Crash Rate Factor Method. This method unites the traffic volume to determine if the crash rate at a particular location is significantly higher than the average for the study area. If the crash rate of a particular location is significantly higher than the average crash rate for other locations in the jurisdiction having similar characteristics, the location is classified as an Accident Black Spot. The steps involved in this method are as follows.

**1. Determination of the location’s crash rate on the basis of affecting data:** These factors include traffic volume and the length of road section being considered in the analysis. Rate per 100 million vehicle kilometers (RMV) is the number of accidents per 100 million vehicle kilometers of travel. It may be estimated as follows:

$$\text{RMV} = (A \times 100,000,000) / \text{VT} \dots\dots\dots (2)$$

A = Total number of accidents in the study section during a given Period, VT = Vehicle, kilometers of travel during the given period = ADT x (No: of days in study period) x (No: of Years) x (length of road Segment).

**2. Determination of the critical crash rate:** The Critical Crash Rate Factor method involves the following expression:

$$\text{CR} = \text{AVR} + (0.5/\text{TB}) + \text{TF} \sqrt{\frac{\text{AVR}}{\text{TB}}} \dots\dots (3)$$

Where,

CR= Critical Crash Rate, per 100 million vehicle-Km, AVR= Average Crash Rate for the Facility type, TF= Test factor, standard deviation at a given confidence level (TF= 1.96 for 95% confidence level), TB = traffic base, 100 million VMT or million entering vehicles.

**3. Comparison of the location’s crash rate to the critical crash rate:** If the crash rate exceeds the critical crash rate, the location may be considered a Black Spot. Accident Black spots are identified by using the —Critical Crash rate factor method.

Jian Lu, *et al.* (2007) argued that the indices “Significance” and “Severity” are used in ranking the potential safety problems. With the consideration of significance and severity, a safety index is introduced to rank a particular safety problem, such as non-sufficient sight distance for a given intersection. The safety index can be calculated by the following equation:

$$R_i = W1C_i + W2S_i \quad (i = 1, 2, \dots, n)$$

where:

R<sub>i</sub> – safety index for the ith particular safety problem, W1 – weight for significance index, C<sub>i</sub> – significance index for the ith particular safety problem, W2 – weight for severity index, S<sub>i</sub> – severity index for ith particular safety problem, and n – Number of the potential safety problems.

Road section length used in black spot analysis is an important question. In most studies, considered length is not justified and not controlled. No clear rule exists regarding the best length of a dangerous road segment should be, nor or whether an optimal length can be defined (Thomas, 1996).

Sujin Mungnimit, *et al.* (2009) stated that black spots should be determined based on variable section length instead of fixed length. The criteria used for section length determination is that all nearby accidents within 100-meter of distance will be grouped together as a black spot location, where any accident located

farther than 100-meter away from the current location will be assigned another black spot location ID. However, the severity of the black spot has been determined based on the accident frequency only.

**Ibrahim (2008)** has estimated the social cost of killed person on a road accident as LE 256165. This value contains loss of productivity, pain and suffering, administration cost, and delay cost. The cost of injured person in a road accident was estimated by Ibrahim Ramadan as LE 60643. The cost of property damage was given by him as LE 25523. Although these figures need to be updated, it reflects the relative weight of each accident type.

### 3- Data Collection And Analyses Methods

The study attempts to analyze the data of the Road Vehicular Accidents (RVAs) from 2010 to 2014 and data was collected from General Authority of Roads, Bridges and Land transport of Egypt (GARBLT), followed by numerical analysis with SPSS software and figures was designed on excel 2007 software. Site survey and observation has been done for location of high percentage of accidents. The results revealed the location of highest rate of injuries resulting from accidents for both roads and calculate the equation of the accident site weight for Egyptian roads.

#### 3-1 Black point's determination methodology.

Hereafter, the methodology used to determine and rank black points is introduced in steps:

**Step (1):** Estimation of the site weight

Accordingly, the relative weight between killing, injuries, and property damage is 10: 2.4: 1. Consequently, the accident site weight for Egyptian roads can be calculated from the following equation:

Site weight (SW) = 10\*Killed persons + 2.4\*injured persons + total number of accidents

**Step (2):** Transforming weight into weight per 100 million vehicle kilometers using the following equation.

Weight per 100 million vehicle km =  $SW * 100000000 / (\text{traffic volume}) * \text{section length}$

**Step (3):** Sites Ranking: According to site weight, sites may be ranked

**Step (4):** Calculation of the average weight for all sights

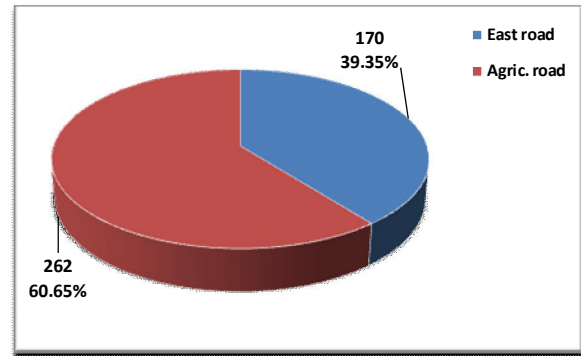
**Step (5):** Estimation of the critical Crash Rate, per 100 million vehicle-Km using equation 3

**Step (6):** All sites with weight greater than the critical crash rate will be considered as a black spot.

### 4- Results And Data Analysis.

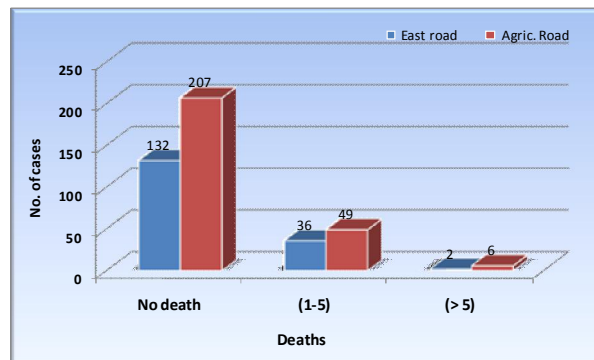
Figure (1) shows the distribution of the total number of accidents between El Minia-Beni Suf east road (East road) and El Minia- Beni Suf agriculture road (Agriculture road). It is clear that accidents on

Agriculture road represent 60.65% of the total accidents.



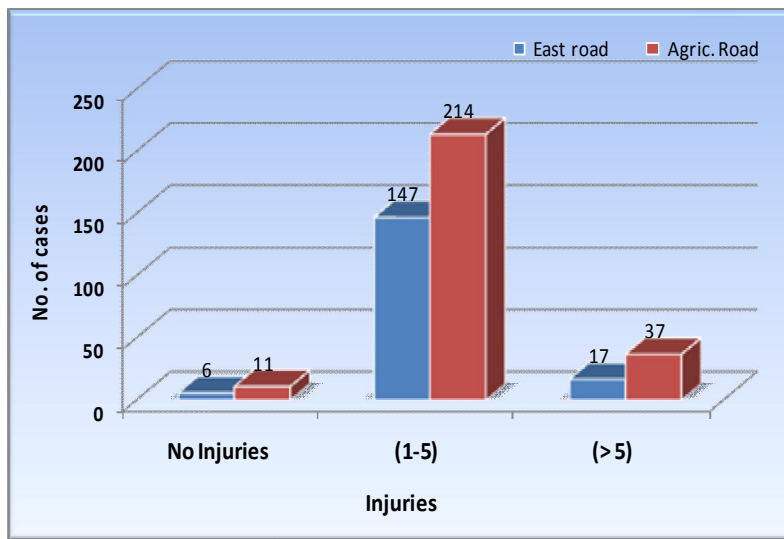
**Figure (1):** Number of accidents of the two roads.

The number of deaths accidents on the two roads is shown in figure (2). It is clear that Agriculture road had the major part of death accidents. It had 49 accidents with number of deaths between 1-5 (persons) and 6 accidents with more than 5 deaths. These numbers of accidents represents 18.7% and 2.3%, respectively of the total accidents on this road. However, the east road had 36 accidents with death between 1-5 persons and 2 accidents with number of killed persons more than 5. These numbers of accidents represent 21.2% and 1.2% respectively of the total number of accidents on this road.



**Figure (2):** Comparison between roads regarding deaths.

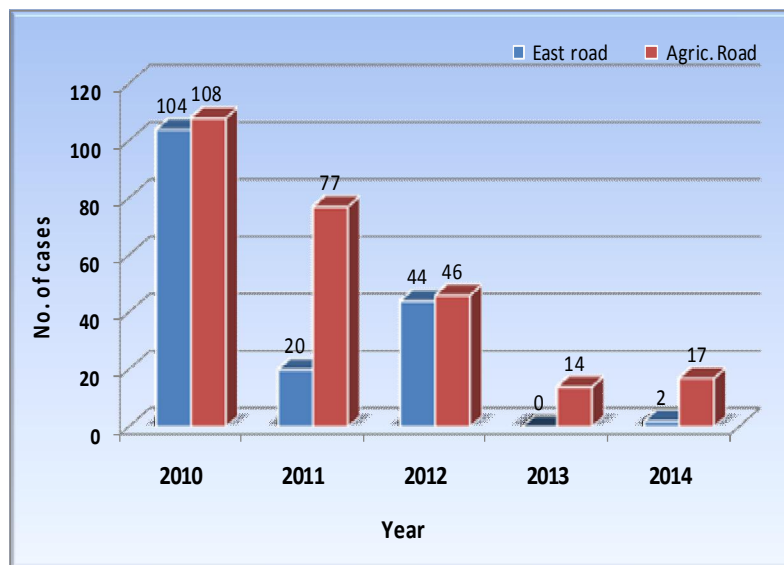
Figure (3) compares between the two roads regarding the number of injuries. It is clear that the agriculture road had the higher prevalence of accidents with injuries than the east road. The agriculture road has 214 (81.7%) accidents with number of injuries between 1-5 and 37 (14.1%) accidents with number of injuries more than 5 persons. On the other hand, east road has number of accidents 147 (86.5%) with injures between 1-5 and 17 (1.0%) with injuries more than 5 persons.



**Figure (3): Comparison between roads regarding injuries.**

Figure (4) explains accidents prevalence over years between the two roads. It is obvious that the agriculture road always had higher prevalence of

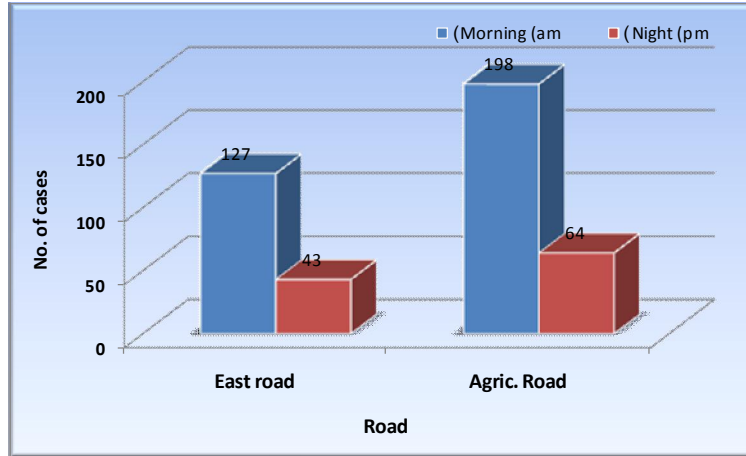
accidents than the east road in different studied years (2010-2014). Additionally, the trend of accidents declined gradually every year on both roads.



**Figure (4): Accident prevalence over years on the two roads.**

The effect of day time on accident occurrence on both roads is presented in figure (5) shows. It is shown that about 75% of accidents occur in the morning on both roads and the rest of 25.0% occurred

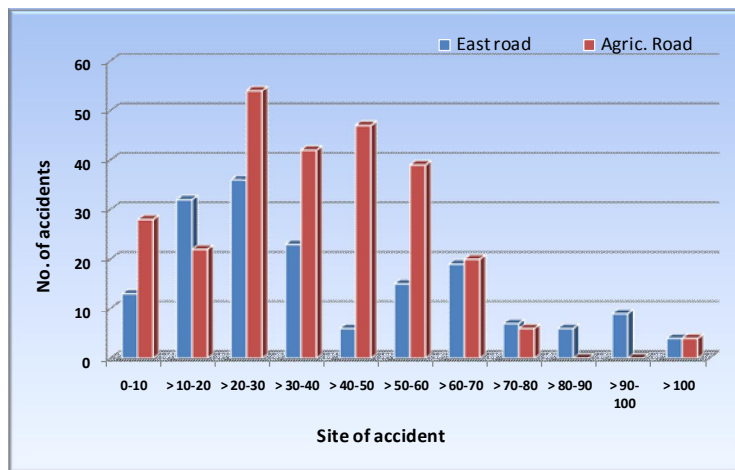
at night. It is worth mentioning that this high percentage of accidents in the morning may be due to the majority of traffic occur in the morning.



**Figure (5): Effect of day time on the accident occurrence.**

Figure (6) explains comparison between accidents of the two roads along their whole length. It is clear that agriculture road has number of accidents greater than east road accidents on all locations. In

addition, the maximum number of accidents on both roads occurs at kilometers between 20 and 30. Consequently, in the following sections, analysis will focus on this specific section of both roads.



**Figure (6): Comparison between road regarding number of accidents in specific kilometers.**

Figure (7) shows a comparison between numbers of accidents on the highest section divided into distances 2 kilometers each. It is clear that distance between kilometer 24 and 26 has the highest level of accident occurrence on both roads. In addition, agriculture road has more accident occurrence than east road on all locations in the highest sections.

Having applied the previous stated methodology, Table (2) summarizes accident rate on both road on the critical section in addition to the estimated site weight.

It is clear from table (2) that ranking sites based on the total number of accident sometimes become misleading. This is clear is the distance of kilometer (20-22) on both roads had the same number of accidents while the severity of site (20-22) on agriculture road is more than that of the east road. Table (3) shows site weight per 100 million kilometer. It is clear from this table that accident ranking based on site weight per 100 million vehicle km is different from that is based on the number of accident. This means that the severity of a site does not depend on the number of accident only but it depends also on the number of fatalities and injuries.

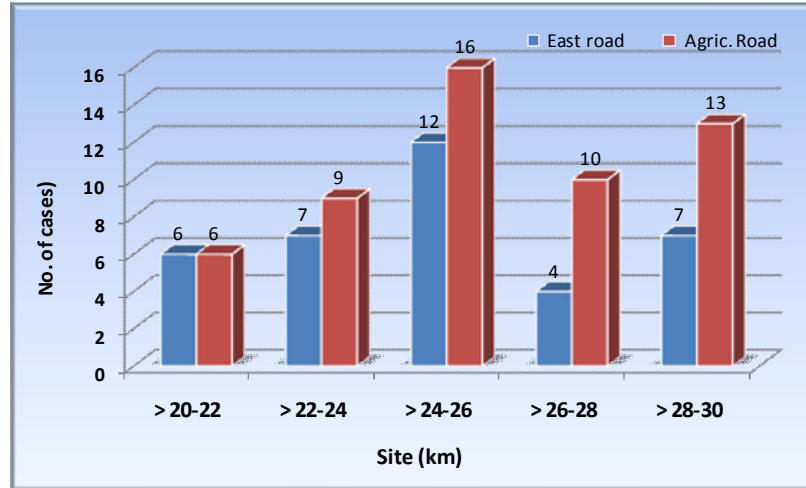


Figure (7): Comparison between roads regarding the distance of the higher prevalence of accidents.

Table (2): Estimated accident sites weight.

Km	East road						Agriculture road					
	total	killed		injured		Site weight	total	killed		injured		site weight
		1-5	>5	1-5	>5			1-5	>5			
20-22	6	0	0	4	2	54	6	1	0	5	0	61
22-24	7	2	0	3	2	99	9	1	0	8	0	82
24-26	12	4	0	8	0	160	16	3	0	11	2	181
26-28	4	1	0	3	0	47	10	0	0	10	0	70
28-30	7	0	0	7	0	49	13	1	0	10	2	122

Table (3): Sites weight per 100 million km.

km	East		agriculture	
	weight	weight per 100 million km	weight	weight per 100 million km
20-22	54	781	61	992
22-24	99	1432	82	1334
24-26	160	2314	181	2943
26-28	47	680	70	1138
28-30	49	709	122	1984

Table (4) shows site ranking based on accident weight per 100 million vehicle km. It is obvious that the most severe site is that at km 24-26 on agriculture road then that on the same site on the east road.

Table (4): Sites ranking based on the suggested methodology.

km	East road rank	Agriculture road rank
20-22	8	7
22-24	4	5
24-26	2	1
26-28	10	6
28-30	9	3

Having applied equation 3, the critical crash rate is estimated to be 1445.5 accidents per 100 million vehicle km in the survey period. Having compared the

critical crash rate by the accident weight per 100 million vehicle km for each site, it may be concluded that one site on each road can be classified as a black spot. These black spot sites are at km 24-26 on both roads.

**5- Conclusion and Recommendation:**

Reference to the previous analysis and results, it can be concluded that:

- Accidents on agriculture road represent 60.7% of the total accidents on both roads and agriculture road has the major part of death accidents.
- Accidents with number of injuries between 1-5 represent the major part of accidents on both roads.
- From 2010 to 2014, trend of accidents rate declining on both roads.

- About 75% of accidents occur in the morning and 25% occur at night on both roads.
- The maximum number of accidents on both roads occurs at kilometers between kilometer 20 and 30.
- The most critical location is that at km 24-26 on the agriculture road follow by the same km on the east road. Thus, this area can be considered as a black spot on both roads.

**From the previous conclusion, authors recommend the following:**

- Sites ranking should be based on the accident weight per 100 million accidents using the previous equation.
- Enhancement studies should start with location at km 24-26 on agriculture road then km 24-26 on the east road.
- The suggested ranking methodology should be extended to include all roads in Egypt.

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