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INCIDENCES AND FATALITIES OF ROAD TRAFFIC ACCIDENTS IN ZAMBIA FOR THE PERIOD 2008 – 2013: A PRELUDE TO SUSTAINABLE ROAD TRANSPORT SECTOR DEVELOPMENT FOR SOCIO-ECONOMIC DEVELOPMENT

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ABSTRACT

Good road transport with appropriate road safety measures promotes efficient movement of goods and services within and between countries. Good road infrastructure and high safety levels are inevitable and a major driving force in sustainable development in Africa. This study was carried out to determine the numbers of road traffic accidents and fatalities for the period 2008 – 2013. This is important because sustainable development in Africa depends on trade and commerce which also heavily relies on efficient road transportation systems. Results obtained showed a total of 139, 002 Road Traffic Accidents; 9,363 people killed; 26, 533 seriously injured and 39, 636 had slight injuries. Such high incidents of accidents hamper trade and commerce and sustainable development of the country and the African continent at large. Future studies should determine black spots and suggest a monitoring strategy to minimize accidents and improve road safety records.

Keywords: Number, Province, Registered vehicles, People killed, People injured, Increase

INTRODUCTION

Road traffic accidents are one of the most critical health and economic challenges of developing countries, particularly in Africa (World Health Organization, 2009). Records show that in 2002 for instance, an estimated 1.2 million people were killed in road traffic accidents (Peden, et al., 2004) many of these being low and middle income countries of which Africa had faced the highest fatality rate (28.3 per 100,000 population), putting Africa on the limelight of fatalities. Such high road carnage incidences have a severe effect on the economies of poor countries where they are estimated to constitute above 1% of gross national product as reported by WHO (2004). As technology used in vehicle manufacture improves availability and affordability will inevitably lead to increased car ownership globally and subsequently congestion and rising levels of road traffic accidents on the already overburdened road systems.

Daie (2013) after a study of accident black spots in Addis Ababa, Ethiopia showed that the increase in road traffic accidents may be strongly linked to the gradual shift of transportation from on-foot to animals and then to vehicle; and even from slower vehicle of the first generation to the fastest vehicles of the 21st generation. The latter coupled with increased car ownership and rapid urbanization have heightened traffic congestion and in consequence accidents. With this background, road safety may, therefore, perhaps remain unresolved and continue to claim unsuspecting lives of millions of people and destruction of property leading to conditions analogous with or perhaps characterizing a social and economic crisis (Peden et al., 2004).

In many third world countries, efforts to reduce road traffic accident incidents through appropriate road designing methods and legal enactment are to some degree more often than not overtaken by rapid urbanization and exponential expansion of unplanned settlements exuberantly surpassing the local authorities' capacity to provide adequate road infrastructure. In amelioration, a sustainable transport development planning would inevitably require the effort of all concerned bodies including transport authority and the community itself as postulated by Kennedy et al. (2005). Daie (2013) arguably reasoned that since the social, economic and political impacts of road accidents are widespread all over the world and involves the loss of lives, damage to property and the associated sorrow being profound, it inexorably has a direct impact on the country's economy and should be given similar attention accorded to HIV/AIDS and TB (Peden et al, 2004). Data provided by WHO (2004) and Guy (2011) further emphasize this fact because vehicle growth is usually accompanied by high urban congestion and increases in the occurrence of road traffic crashes. Accordingly, by 2000 nearly half a million people were killed and up to 15 million people injured in urban road accidents in developing countries each year and figures are getting higher. This means that national road traffic accidents have attained a higher profile perhaps next to malaria, TB and HIV (Downing et al., 2000).

As Getu (2007) cited different sources of road traffic accidents he also emphasized the need to identify *accident black spots*. However, though important in understanding the patterns of accidents, their identification varies from country to country. For example, black-spots in Norway are defined as any place with a maximum length of 100 meters where at least four injury accidents are reported during a four year period (Rune and Vaa, 2005). In the UK, it has only five injury accidents in three years, while in Bangladesh it is having more than 10 injury accidents in a year (Geurts and Wets, 2003). In most developed countries, black-spots are defined as the locations where there are 12 accidents in three (3) years per 0.3 kilometers (Guo and

Kong, 2003), thus four (4) accidents per year. In Czech Republic, junctions or 250 m-long road sections, where at least three (3) road accidents with injuries occurred within one (1) year or at least three road accidents with injuries of the same type occurred within three years or at least five (5) road accidents of the same type occurred within one year, are considered as black-spots (Jitka, 2000). In Ethiopia, Getu (2007) selected and used a three years accident data (2003 – 2006) and determined nine (9) black-spots in roads between Addis Ababa and Shashemene. This implies that despite such variations and even mathematical models available for determining road traffic accidents, (Geurts and Wets, 2003), the intensity of road traffic accidents in terms of severity and frequency can be used in determining severity. Mustakim and Fujita (2011) also provided methods of determining black-spots using Accident Point Weightage (APW). However, in this study, only the frequencies of occurrences of road traffic accidents were considered across the ten provinces of the country. Thus, it could have been most desirable to use intensity of accidents and weighted in terms of the frequency accident data, which has been employed by many authors including Daie (2013), Jitka (2000), Guo and Kong (2003), Geurts and Wets (2003).

Background

Zambia is land locked country surrounded by eight neighbouring countries *viz*; Angola, Botswana, Congo Democratic Republic, Mozambique, Namibia, Tanzania and Zimbabwe. Major access routes to the sea are through Zimbabwe to South Africa (mainly Durban) and to Mozambique (mainly Nacala), Namibia (Walvis Bay), through Botswana to South Africa (mainly Durban), through Malawi to Mozambique (Beira and Nacala) and Tanzania (Dar es Salaam). There are currently plans to improve connectivity with Angola. This shows the important role roads play in the sustainable development of the country and the region. Efficiency of the road transport sector therefore plays a critical role in promoting and sustaining economic growth of the country and Africa at large. Additionally, Zambia is one of the most urbanized countries in sub-Saharan Africa with about 40 % of the population concentrated in the urban areas, along the major transport corridors while rural areas are sparsely populated (CSO, 2010). The movement of people, goods and services therefore, is mainly concentrated in urban centers and this is where there is a build up of car ownership which accentuates traffic congestion and contributes to escalating levels of Road Traffic Accidents (RTAs). According to the Census of Population and Housing Report (2010), Zambia had by then a population of 13,046,508 persons, indicating an increase of 32% from the 2000 population of 9,885,591 persons. This population had reached 15, 246, 086 by 2013 (CIA World Facts, 2016). As the population size increases the number of vehicles had also steadily risen while the road network has relatively remained static in the last decades. The extent to which the rising number of vehicles and RTAs as well as the projected increase in the population and car ownership would affect road safety has not been investigated.

It is assumed however that, as the number of vehicles increase without correspondingly expanding the road network and improving quality, there has been a surge in congestion which is also directly or indirectly linked to the rising incidences of road traffic accidents. Anecdotal reports show that in 2012 when the number of accidents was 16,000 with a loss of 1, 150 lives, there was an estimated loss of K1.3 trillion (USD 1 equivalent to K10, 000) in accident related expenses over the same period." This indeed was a huge cost to the country's economy as it could have been directed towards the nation's productive sectors for sustainable socio-economic development. Such loss of funds impedes the philosophy of sustainable development which Sub-Saharan African countries including Zambia aspire to achieve.

In Zambia a traffic accident is generally referred to as a traffic collision, motor vehicle accident, or automobile accident and occurs when a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree or utility pole. Such collisions more often than not may result in injury, death, vehicle damage or property damage. Akinola (2005) postulated probable risk factors as being; vehicle design, speed of operation, road design, road environment, driver skill and/or impairment, drug and alcohol abuse, driver behaviour and many others. Such risk factors seem to augment each other increasing chances of occurrence reducing it from a mere gamble to an actual possibility.

In 1990, for instance, accidents were rated by World Health Organization as one of the major causes of deaths to individuals in the age group of 10 - 24 years worldwide. They were responsible for approximately 10% of deaths in developing countries, (WHO, 2004). As such it takes away productive labour force necessary for social economic development and huge payments in terms of insurance cover takes away resources which could have been used in sustainable development projects.

Kafula (1997); Odero, Garner and Zwi (1997) also noted that accidents were common among adolescent drivers who were usually under the influence of alcohol which consequently inhibited their good sense of judgment. WHO (1984) established a positive relationship between road accident fatality rates, vehicle density and population size. This latter assertion may be generalized to the Zambian context in that the vehicle density is increasing as the human population size grows.

Singh and Suman (2012) also showed that heavy vehicles such as trucks had a higher incidence and more fatal road accidents on national highways. The prediction model by Singh and Suman (2012) indicated that the number of accidents per km may decrease with improvement in road/shoulder conditions.

In emphasizing the importance of road conditions in understanding causes of road accidents, Williams, Lloyd and Dunbar (1991) reported that in Scotland a road's gradient, curvature, width, lighting, road markings and the presence or absence of hard shoulders or crash barriers contributed to the possibility of accidents.

They further analyzed traffic accident records data in an attempt to model the relationship between the road environmental conditions and the severity of traffic accidents. It was observed that the most influential factor on the accident severity was road shape. Right hand sided curved roads and straight downward roads were associated with body injury related accidents while property damage related accidents occurred on the left hand sided downward, upward or straight upward roads. Miyatake et al. (2013) investigated the relationship between road traffic accidents and drinking habits and observed that road traffic accidents were positively correlated to driving whilst drunk. Asumadu (2012) carried out a study to establish the relationship of age groups to accidents. He observed that youthful age group 16-25 years were mostly killed in road traffic accidents.
With regard to the type and size of vehicle, buses killed the most people while heavy duty vehicles such as bulldozer and trucks killed fewer people, though the latter may in most instances may directly or indirectly create opportunities for an accident to occur. Among the days Saturday was recorded to have the highest incidences.

With respect to the distribution of accidents across the twelve months calendar, Goswami and Sonowal (2010) sought to establish whether road traffic accidents were uniformly distributed over the year or not, or whether they were influenced by

seasons or day and night. They observed that human behavioural characteristics (rush and negligence) had the highest contribution (95.38%) to the road traffic accidents in India. The highest number of accidents (32.3%) was observed in the peak rainy season and the maximum number of victims were also highest compared to other seasons of the year. Sixty percent (60%) of the road accidents were recorded during day time (06:00 to 18:00hrs) as these were also the times when people were more active and mobile.

Despite the overwhelming evidence and data on the on the major causes for the rising incidences of road traffic accidents at local and international levels, many people in Zambia still believe that it is an act of God and occurs only when one is unlucky even in incidences where there was proven negligence on the part of the drivers involved (Desai, 2011). This belief has led to a common practice where evangelical pastors often give prayers in every bus before it starts off on a long journey. While this practice is commendable, it is critical for the law enforcement agencies to monitor the critical risk factors. On the other hand, these road safety records signal under investment in the road transport sector. If Zambia, being land locked country has to achieve high levels of sustainable development, investments in the road sector are inevitable.

In view of the overwhelming evidence which shows the importance of road safety in making road transport safe for the movement of goods and services for sustainable development we decided to commission this study in order to; i)determine the number of road traffic accidents and accompanying fatalities, ii) compare such data between provinces, and iii) establish the number of vehicles registered with the Road Transport and Safety Agency as a potential factor in the rising incidents of road traffic accidents. This study considers those gaps by dealing with RTAs. The ultimate goal is to achieve optimum road safety which will contribute to sustainable socio-economic development of the country and the sub-region.

METHODS AND MATERIALS

Data collection

This study used secondary data collected from the Road Transport and Safety Agency (RTSA) and the Zambia Police, Traffic Department at Force Headquarters in Lusaka. The two agencies of the state are the custodians of all information on reported road transport accident incidents. The data covered all the nine provinces of the country. The data for the newly created and tenth Muchinga province was merged with either Northern or Eastern provinces based on the district where the accident occurred. Data for the period 2008 – 2013 were collected as it was fairly well documented than before.

Accident fatalities were classified as killed when the victim died on the spot or in transit to hospital. Serious or severe injuries when victims sustained severe physical injuries to the body, bled profusely, unconscious and unable to talk, were in severe pain having broken some body parts, sustained permanent disability and would need hospitalization to survive or showing signs of restlessness, anxiety, convulsions, or unconsciousness. Slight injuries were minor and victims were able to explain what happened, did not feel any serious pain and some may not even be admitted in hospital or if admitted may be discharged sooner than the serious injuries.

Data analysis

Data collected were analyzed using Ordinary Least Squares (OLS) method to build a simple linear regression model. The Analysis of Variance (ANOVA) and Completely Randomized Block Design (CRBD) tests were used to check mean difference of Road Traffic Accidents' occurrence among provinces.

To determine the rate at which RTAs were increasing in the country depending on the number of vehicles, the numbers of accidents were regressed (at 0.05 level of significance) on the number of vehicles and the coefficient of the independent variable (number of vehicles) was taken to be the rate as it indicates how much the dependent variable will change when there is a unit change in the independent variable.

Annual growth rate of registered vehicles was determined by the formula;

$$PR = [\frac{Vpresent - Vpast}{Vpast}] \times 100$$

Where, PR is percent rate

V-present is the present value

V-past is the past value

Then the annual growth rates were subjected to weights, which were obtained by multiplying annual growth rates by the weights. The weighted average annual growth rate of registered vehicles was estimated by dividing the sum of the weights into the sum of the weighted annual growth rates.

Determining RTAs parameters was essential for directing appropriate investments in the road transport sector for sustainable development.

FINDINGS

Number of road traffic accidents and accompanying fatalities

During the period 2008 – 2013, a total number of 139, 022 Road Traffic Accidents were reported. Of this number of accidents 9,363 people were killed, 26, 533 were seriously injured and 39, 636 had slight injuries (Figure 1). A comparison between years showed that 2009 and 2012 had the highest reported Road Traffic Accident incidents (Figure 1). The loss of 9,363 people predominantly below the age 60 which is also the most productive part of the population has a negative effect on socio – economic development for the country. The loss of skill through accidents some of it trained at high cost has a direct and indirect effect on the maintenance of socio – economic development of the country.

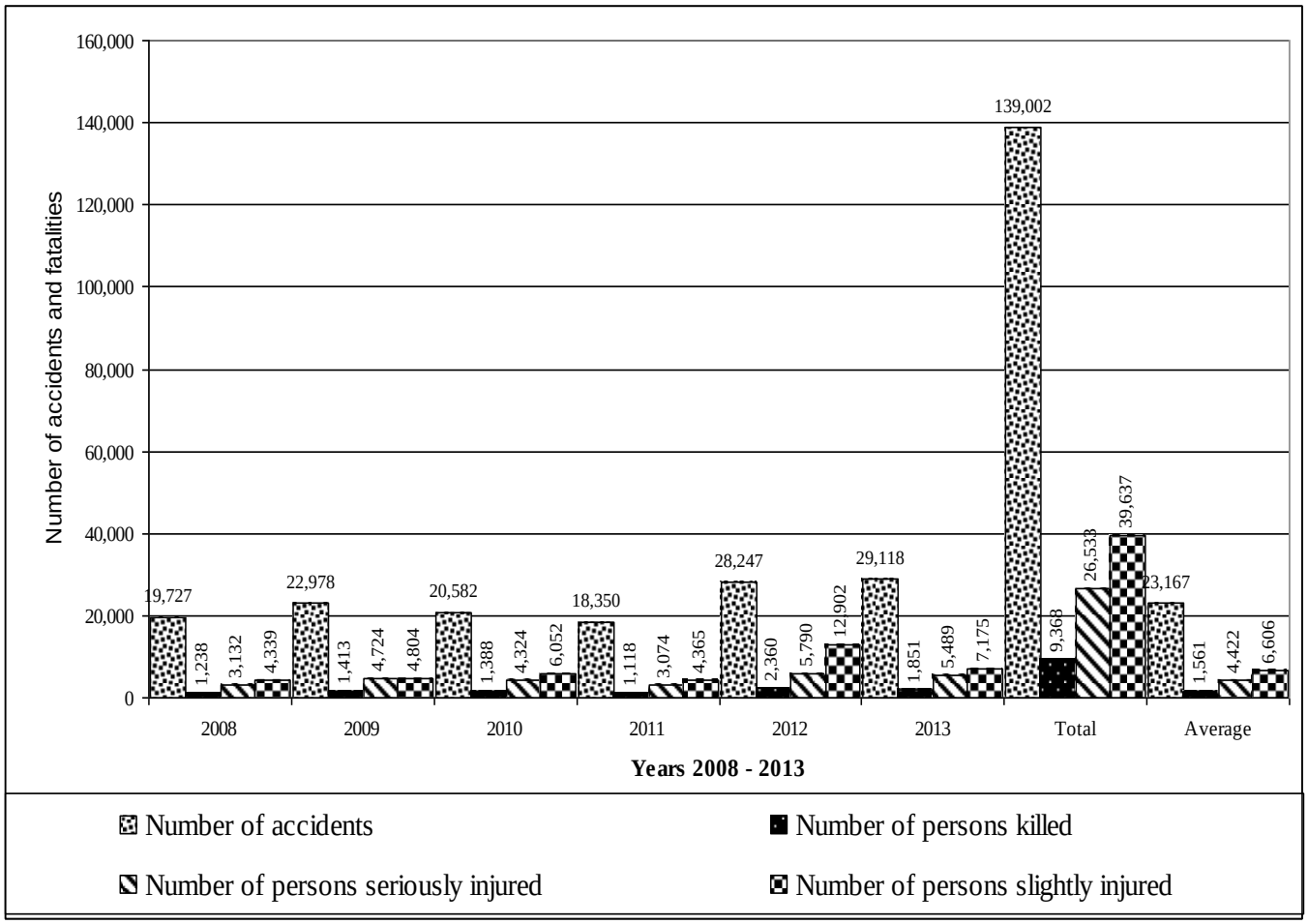


Fig. 1 Total number of accidents, people killed, seriously injured, and slight injuries for the period 2008 – 2013, Zambia.

The mean values were 23,167/ yr^{-1}, or 64 accidents per day, 1561 people killed yr^{-1} or 4 people killed each day, 4,422 seriously injured or 12 people per day, and 6,006 slightly injured or 18 people per day (Figure 2).

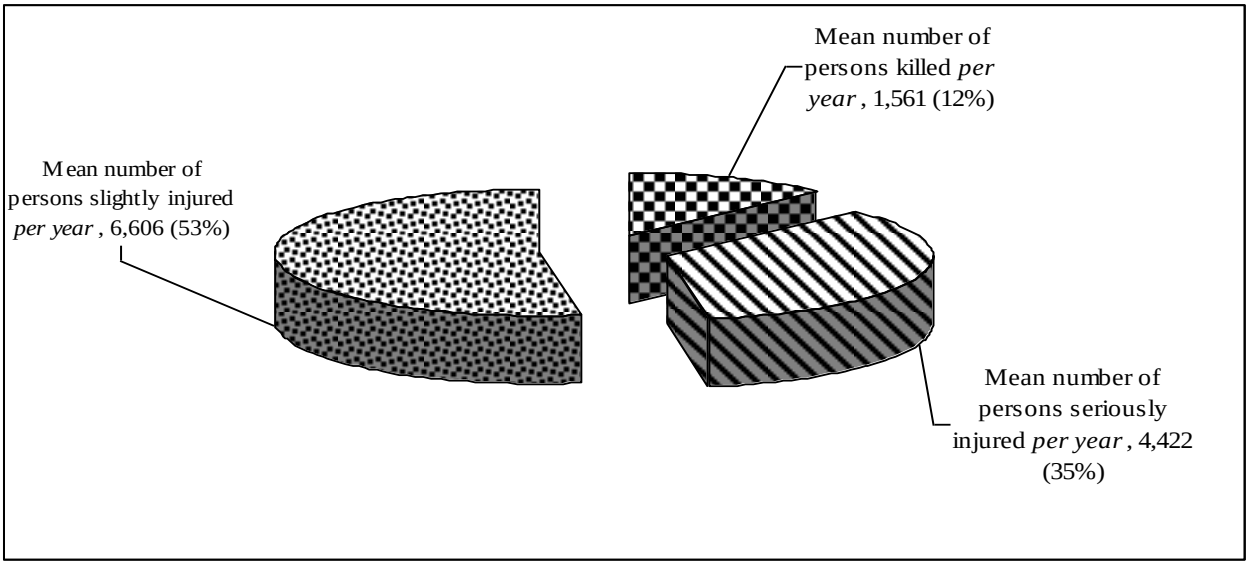


Fig. 2 Mean values for reported number of accidents, number of people killed, seriously and slightly injured respectively and proportional percentage contribution. (Notes: For each day during the period 2008 - 2013, there were 64 reported accident incidents, four (4) people killed, 12 people seriously injured and 18 people sustaining slight injuries).

The years 2012 and 2013 had the highest number of reported accidents, 28, 242 and 29, 118. The number of serious injuries 5,790 and 5,489 respectively was also the highest. The rest had correspondingly less than 27,000 incidents each (Figure 2).

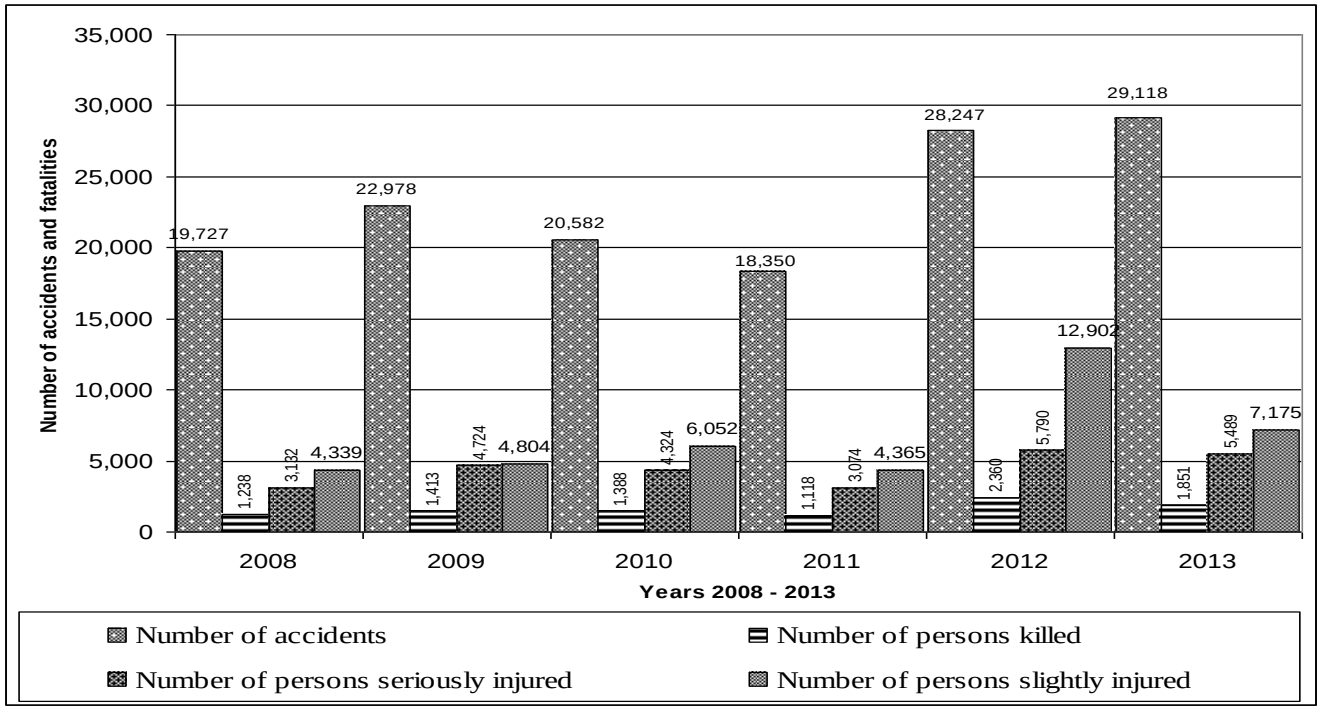


Fig. 3 Number of reported road traffic accident incidents and fatalities between years 2008 – 2013.

Annual variations in reported road traffic accident incidents

The variation in Reported Road Traffic Accident incidents showed an increase over the years. A weighted average annual growth rate using the formula,

$$PR = [\frac{Vpresent - Vpast}{Vpast}] \times 100$$

Where, PR is percent rate

V-present is the present value

V-past is the past value; resulted into a 13 percent increase (Table 1; Figure 4).

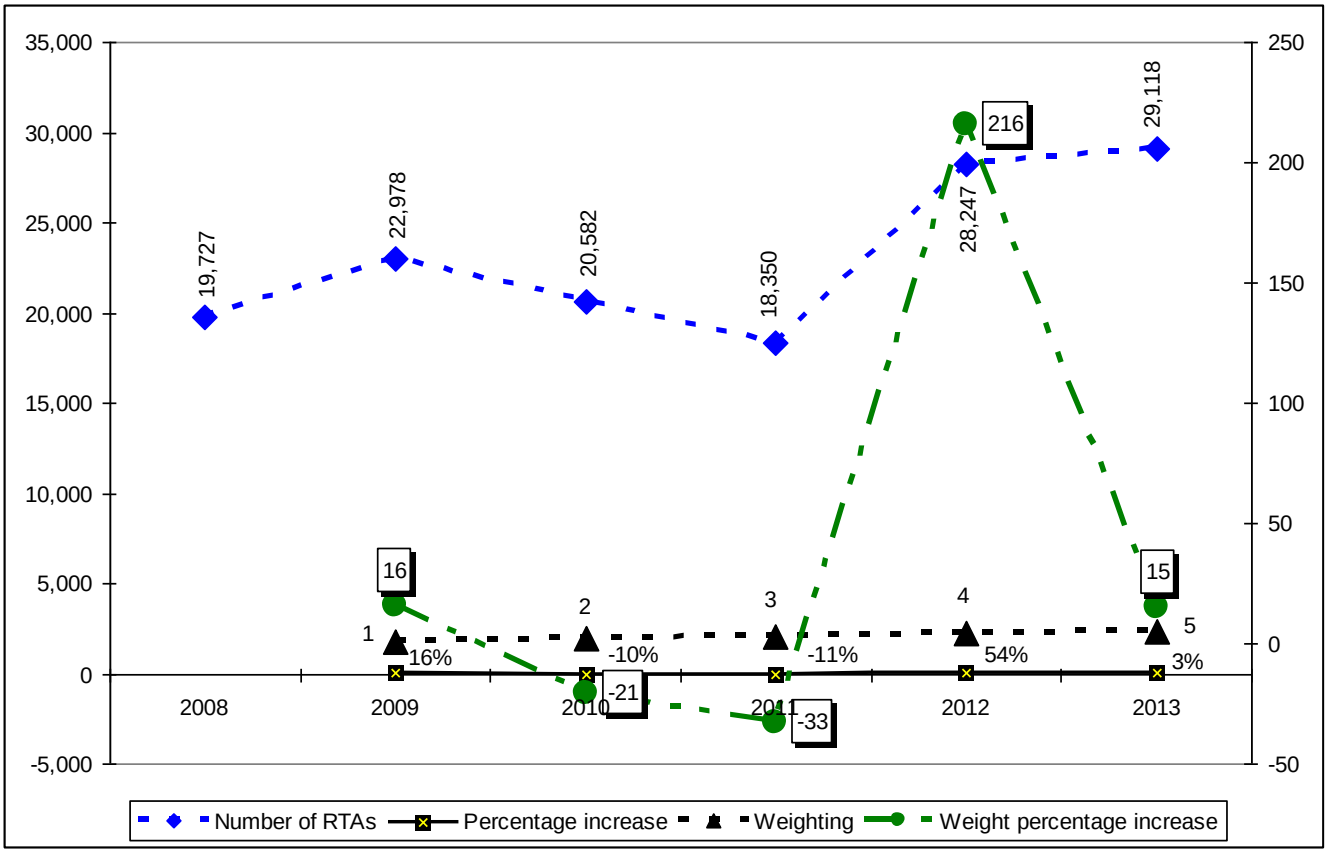


Fig. 4 Weighted growth rate of Road Traffic Accident incidents between years

Table 1: Road Transport Accident Incidents Growth Rate

Number of RTAs	Percentage increase	Weighting	Weight percentage increase
19,727			
22,978	16%	1	16
20,582	-10%	2	-21
18,350	-11%	3	-33
28,247	54%	4	216
29,118	3%	5	15

Comparison of road traffic accidents between provinces

Lusaka and Copperbelt provinces which are the most urbanized had the overall highest number of reported road traffic accident incidents and fatalities, while Luapula and Western had the lowest.

ANOVA, F value = 139.1997 for the Provinces was greater than the F - critical value = 2.18017 at 5% level of significance, implying that the accident means for provinces were significantly different, while F value = 3.543303 for the years was greater than the F-critical value = 2.449466 at 5% level of significance, suggesting that the annual accident means were also significantly different (Table 2).

The most industrialized and most developed provinces are the most prone to RTAs. These are also the provinces where the movement of goods and services is highest and road safety lowest, which if not addressed would impede suitable socio-economic development.

Table 2: Two way ANOVA analysis output

Summary	Count	Sum	Average	Variance
Row 1	6	74207	12367.83	3225844
Row 2	6	26690	4448.333	3545197
Row 3	6	8058	1343	264718
Row 4	6	8377	1396.167	150975.4
Row 5	6	4419	736.5	56235.1
Row 6	6	1517	252.8333	1045.367
Row 7	6	6931	1155.167	92444.17
Row 8	6	5160	860	87209.2
Row 9	6	3633	605.5	35028.3
Column 1	9	19727	2191.889	12295525
Column 2	9	22978	2553.111	14347620
Column 3	9	20572	2285.778	12153659
Column 4	9	18350	2038.889	12714740
Column 5	9	28247	3138.556	18596016
Column 6	9	29118	3235.333	23066971

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	7.2E+08	8	89943785	139.1997	1.01E-26	2.18017
Columns	11447513	5	2289503	3.543303	0.009573	2.449466
Error	25845968	40	646149.2			
Total	7.57E+08	53				

Lusaka and Copperbelt provinces had 74,207 and 26, 690 reported road traffic accident incidents respectively, while all the other provinces had less than 10,000 incidents each. Lusaka province had a 53 percent proportion of all accidents followed by Copperbelt with 19% and the least was Luapula province with 1% (Figure 5).

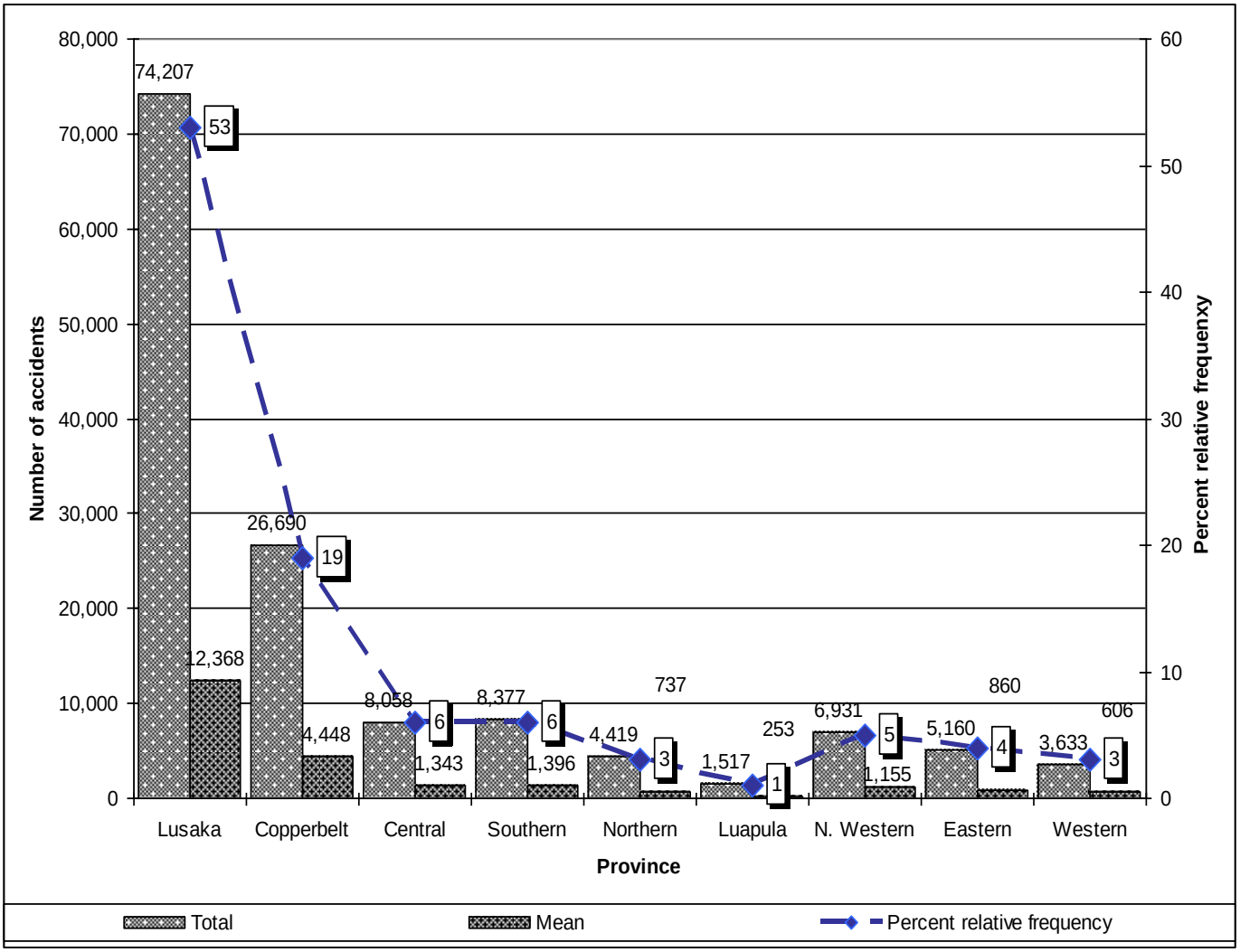
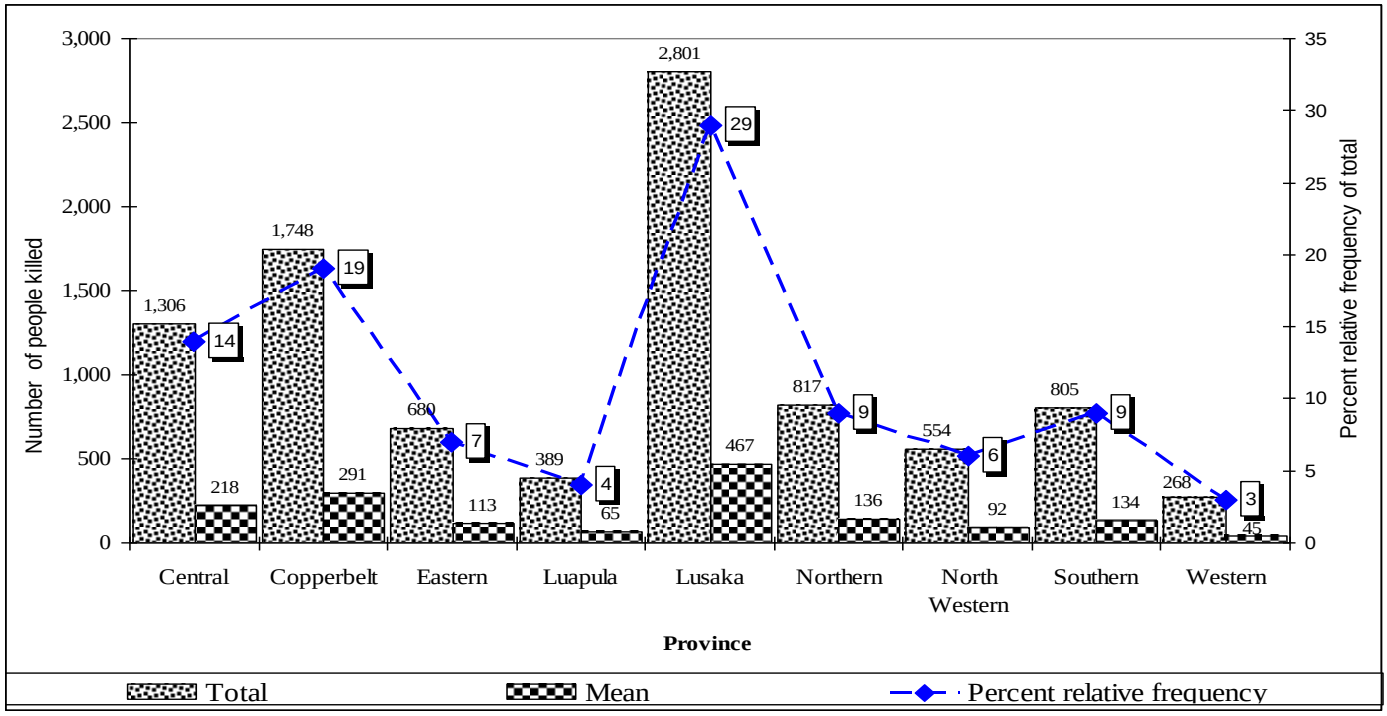


Fig. 5 A comparison of the total reported Road Traffic Accident incidents per province for the period 2008 – 2013.

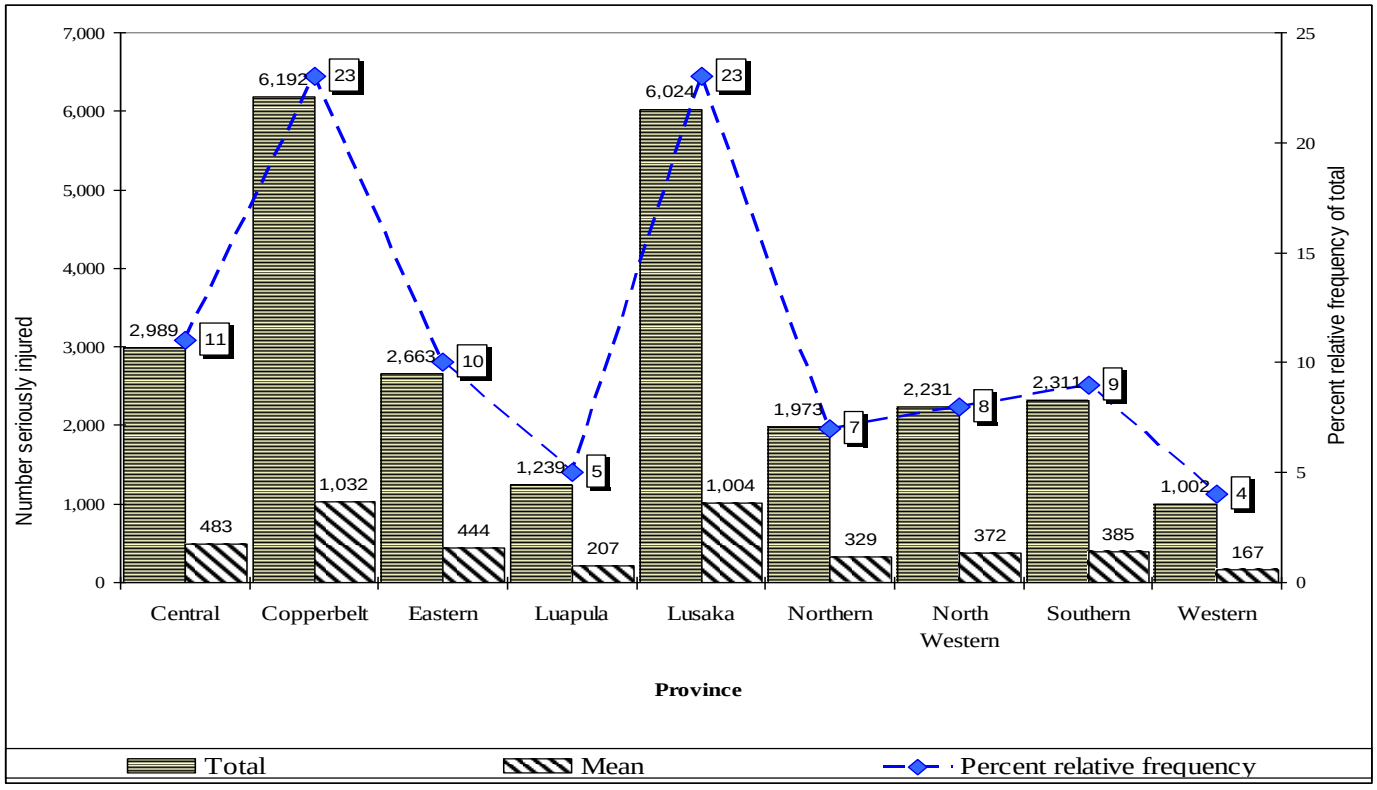
Lusaka and Copperbelt provinces, did not only lead in the number of reported road traffic accident incidents, they also had the largest number of fatalities. Lusaka had (2,801 people killed) 29 percent of all people killed followed by Copperbelt (1,748 people killed) 19 percent and the least was Western (268 people killed) three percent (Figure 6a).

With regard to the number of seriously injured victims, Copperbelt had slightly higher number of (6,192 people) 23 percent followed by Lusaka (6,024 people) 23 percent, Central (2,898 people) 11 percent and the least was Western (1,002 people) four percent (Figure 6b). Under the slightly injured category, Lusaka had the largest number (16,958 people) 44 percent, Copperbelt (10,448 people) 26 percent and the least was Luapula (379 people) one percent (Figure 6c); (Figure 7a b).

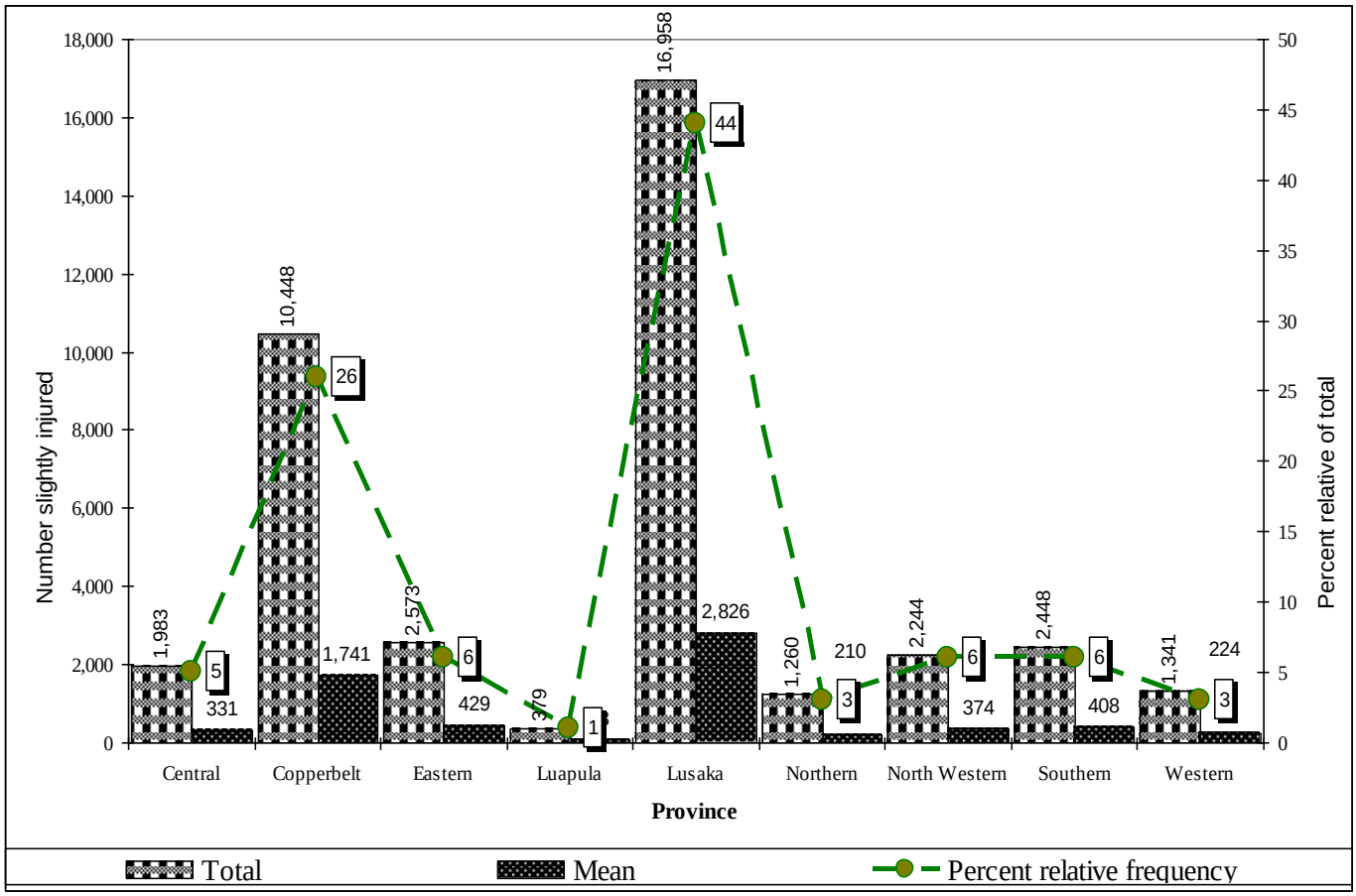
The high levels of serious injuries are a strain on limited health facilities which takes away resources required for sustainable development.


Number of people killed
Percent relative frequency of total
Province
Central
Copperbelt
Eastern
Luapula
Lusaka
Northern
North Western
Southern
Western
1,306
218
14
1,748
291
19
680
113
7
389
65
4
2,801
467
29
817
136
9
554
92
6
805
134
9
268
45
3
Total
Mean
Percent relative frequency

(a)

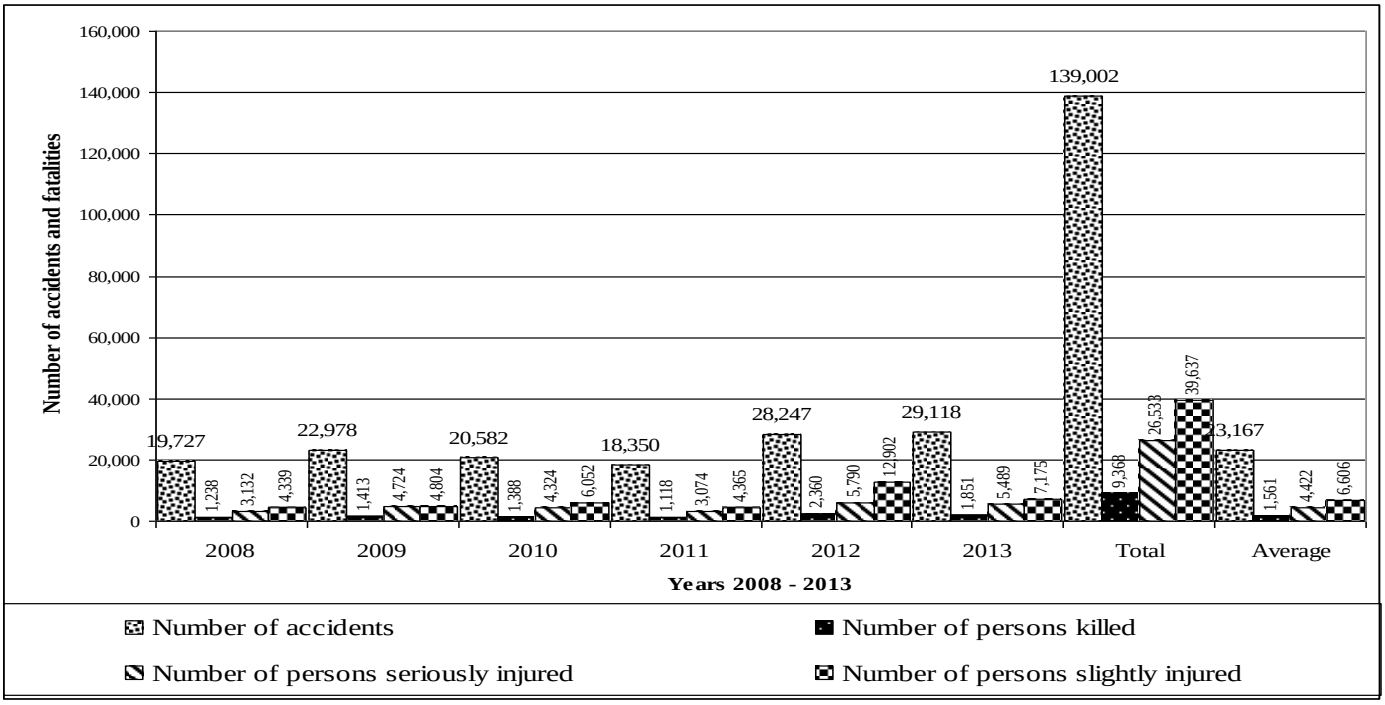

Number seriously injured
Percent relative frequency of total
Province
Central
Copperbelt
Eastern
Luapula
Lusaka
Northern
North Western
Southern
Western
2,989
483
11
6,192
1,032
23
2,663
444
10
1,239
207
5
6,024
1,004
23
1,973
329
7
2,231
372
8
2,311
385
9
1,002
167
4
Total
Mean
Percent relative frequency

(b)

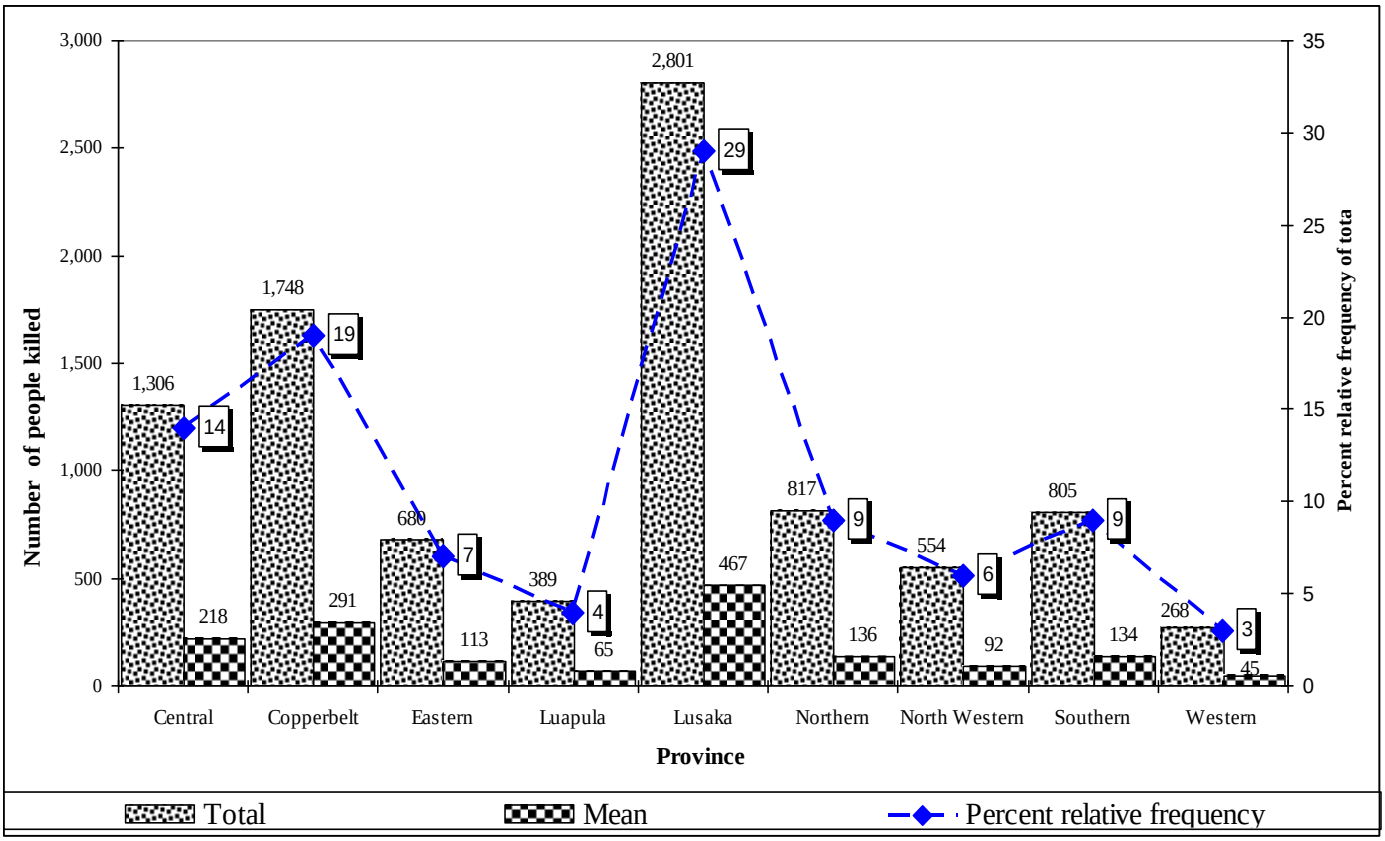


(c)

Fig. 6 Total number and proportional contribution of fatalities; a) people killed, b) seriously injured, and c) slightly injured in each province, Zambia.



(a)



(b)

Fig. 7a) Number of accidents and fatalities, b) percentage relative frequency of total

Number of vehicles registered with road transport and safety agency and road traffic accidents

The number of vehicles registered with the Road Transport and Safety Agency (RTSA) increased steadily over the period 2008 – 2013, though accidents increased at a much lower rate. Vehicles ($y = 8228.8\ x^2 – 1815\ 6x + 295432$; $R^2 = 0.9783$), accidents ($y = 665.57\ x^2 – 2929.5x + 23326$; $R^2 = 0.6689$) (Figure 8).

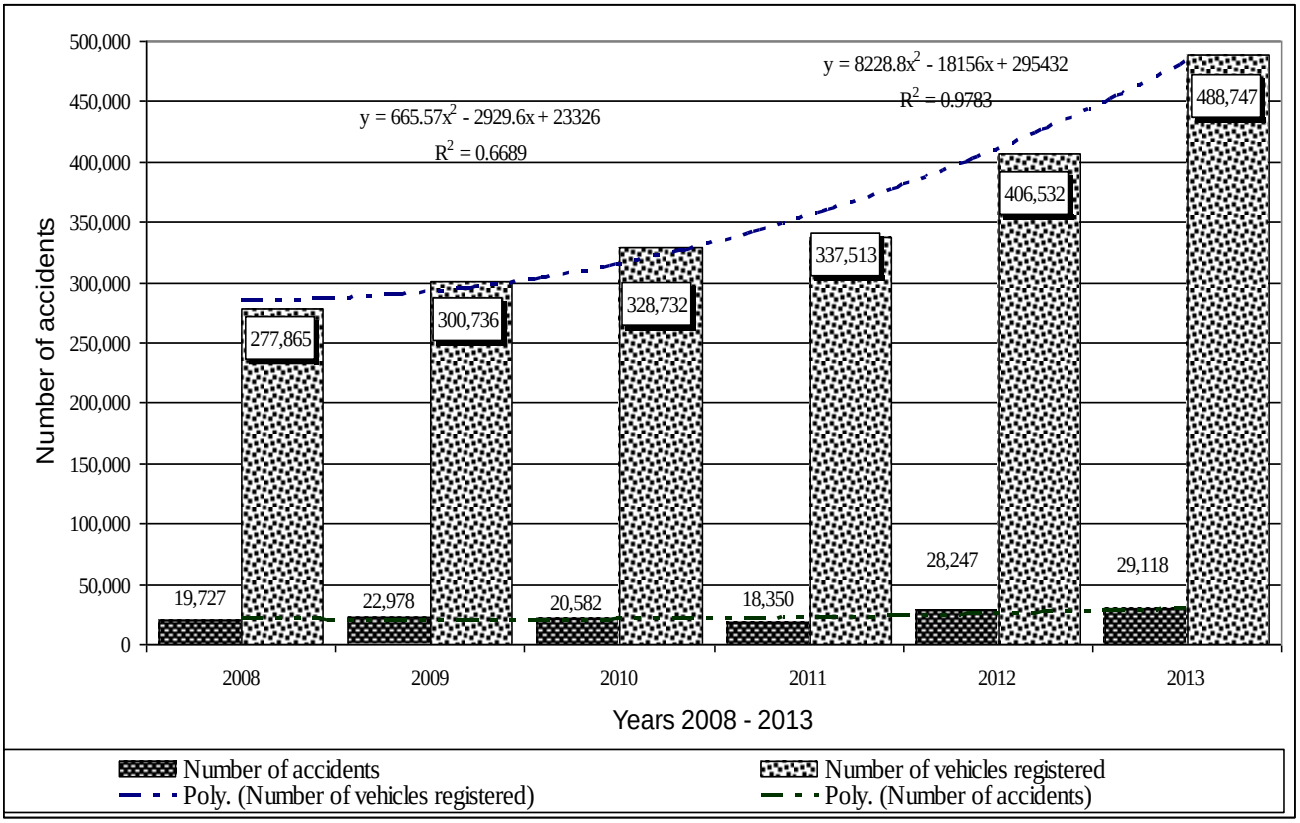


Fig. 8 Increase in the number of vehicles registered with the Road Transport and Safety Agency, compared with the increase in the number of Road Traffic Accident Incidents for the period 2008 – 2013.

The regression analysis output in Table 2 gives a good fit, R squared being 0.70447 which means that the data fits the model by 70 percent (or 70 percent of the variations in RTAs are explained by the number of vehicles in the country). In 2013 for instance, there were 600 RTAs per 10,000 vehicles, or six accidents per 100 vehicles.

The coefficient of number of vehicles which is 0.0488363 indicated that a 100 increase in the number of vehicles in the country would result in an increase of five (5) RTAs and vice-versa. In general, it indicates a positive relationship between the occurrence of RTAs and the number of vehicles in the country. The t-statistic was used to test the hypothesis that the coefficient is equal to zero (or insignificant) and the P-value gives the probability that the t-statistic is significant (or probability that the coefficient is equal to zero). In this model, the P-value for the coefficient of number of vehicles was 0.0036649 indicating that it was significant at 0.05 level of significance, thus the number of vehicles influenced the occurrence of RTAs.

As the number of car ownership increases, marching developments in the road transport sector, such as improved public transport and road infrastructure are inevitable for sustainable development. The regression analysis is shown in Table 3 below.

Table 3 Regression analysis output

Regression Statistics	
Multiple R	0.8393295
R Square	0.704474
Adjusted R Square	0.6305925
Standard Error	2758.262
Observations	6

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	5747.7096	5752.41771	0.999181539	0.374252
X Variable 1	0.0488363	0.015815319	3.087909922	0.036649

The output simple linear regression model was;

Number of accidents = 5747.7096 + 0.0488363(Number of vehicles)

The model was checked for absence of heteroscedasticity, absence of autocorrelation and linearity of the variables. If these assumptions are not met, it leads to the estimated parameter not being efficient.

The Glejser Test allowed for checking if heteroscedasticity was present in the model (Table 4, and 5)

Table 4 Glejser Test values

Residuals $(\hat{\varepsilon})$	**Residuals** $(\lvert\hat{\varepsilon}\rvert)$	**Number of Vehicles registered**
409.3976355	409.3976355	277,865
2543.463089	2543.463089	300,736
1219.75739	1219.75739	328,732
-3880.58876	3880.58876	337,513
2645.78007	2645.78007	406,532
-498.2946435	498.2946435	488,747

Table 5 Glejser Test regression output

Regression Statistics	
Multiple R	0.158582754
R Square	0.02514849
Adjusted R Square	-0.21856439
Standard Error	1524.443734
Observations	6

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	2867.730842	3179.261803	0.902011542	0.418054983
X Variable 1	-0.00280783	0.008740853	-0.321230458	0.764119928

The P value (0.764119928) is greater than the level of significance (0.05), hence the coefficient was not significant. It was concluded that the variances of the error term $(\hat{\varepsilon})$ were homogeneous.

Regarding autocorrelation, the Durbin-Watson test (Table 2) was used to check for presence of autocorrelation. If the Watson d statistic is less than two (2), it means there is presence of autocorrelation but if greater than 2 then autocorrelation is absent. The Watson d statistic lies between 0 and 4.

$$d = \sum_{i=2}^{n} (\hat{\varepsilon}_i - \hat{\varepsilon}_{i-1})^2 \Big/ \sum_{i=1}^{n} \hat{\varepsilon}_i{}^2$$

Table 6 Durbin-Watson test values

Residuals$(\hat{\varepsilon}_i)^2$	RESIDUALS$(\hat{\varepsilon}_{i>1})$	RESIDUALS$(\hat{\varepsilon}_{i-1})$	$\hat{\varepsilon}_{i>1} - \hat{\varepsilon}_{i-1}$	$(\hat{\varepsilon}_{i>1} - \hat{\varepsilon}_{i-1})^2$
167606.424	2543.463089	409.3976355	2134.065453	4554235.358
6469204.48	-1219.75739	2543.463089	-3763.220479	14161828.37
1487808.09	-3880.58876	-1219.75739	-2660.83137	7080023.578
15058969.1	2645.78007	-3880.58876	6526.36883	42593490.1
7000152.18	-498.2946435	2645.78007	-3144.074713	9885205.804
248297.552				**78274783.22**
30432037.9				

From Table 6, Watson $d = 2.6$. Hence, since $d > 2$, there was no autocorrelation.

As for detection of linearity, residues were analyzed (Table 7; Figure 9) and showed non-linear relationship because the points were far from line zero.

Table 7 Linearity values

Residues $(\hat{\varepsilon})$	***Predicted Y***
409.3976355	19317.60236
2543.463089	20434.53691
1219.75739	21801.75739
-3880.58876	22230.58876
2645.78007	25601.21993
-498.2946435	29616.29464

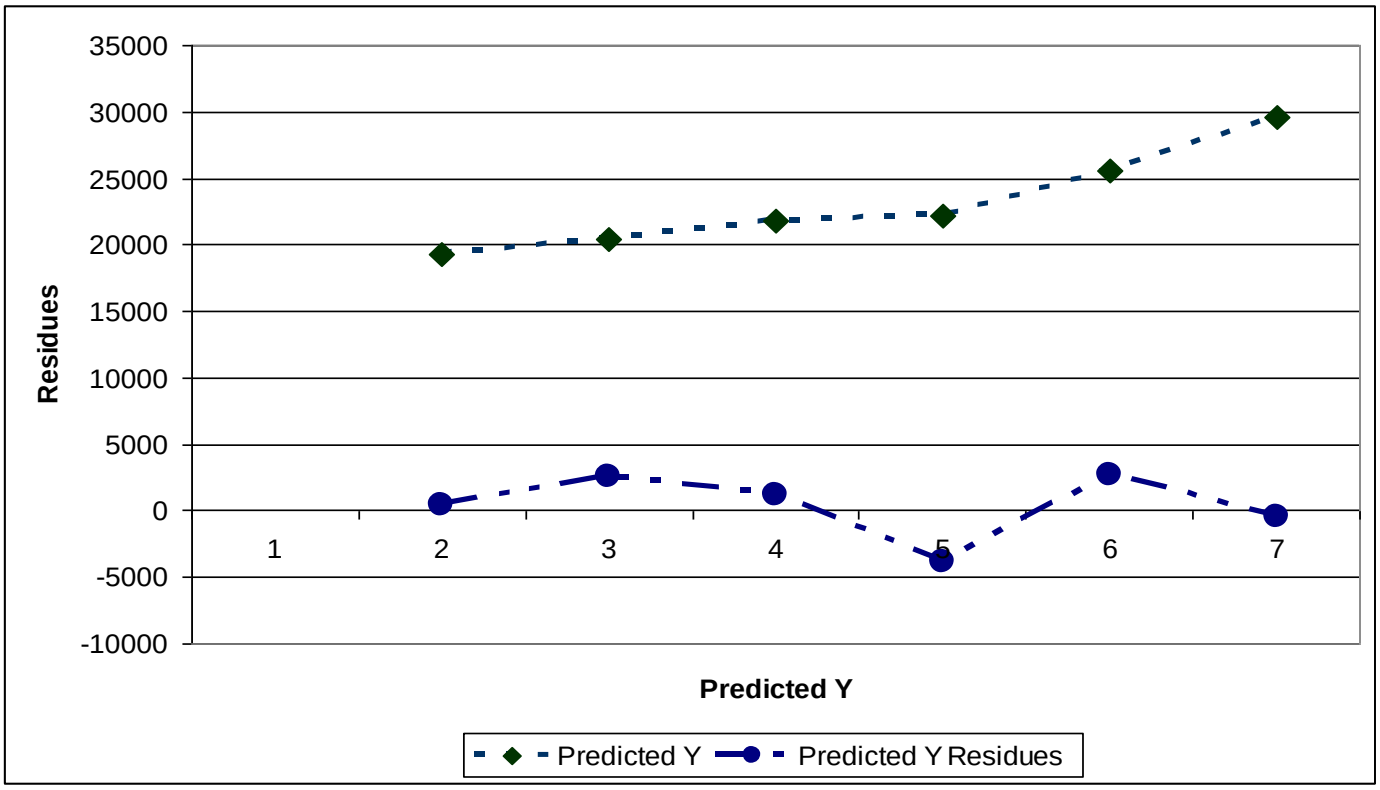


Fig. 9 Linearity output

Weighted average annual growth rate of registered vehicles

Table 11 shows the projected number of vehicles and number of accidents for the next 10 years. The expected number of accidents for the next 10 years was obtained by using the simple linear regression. There were no corresponding figures for the investment in the road sector and improvement of public transport which are critical for sustainable development.

The vehicle growth rate is given in Table 8a and b, below.

Table 8a Number of vehicle growth rate

Number of registered vehicles	**Growth rate**	**Weight**	**Weighted growth rate**
277,865			
300,736	8%	1	8%
328,732	9%	2	19%
337,513	3%	3	8%
406,532	20%	4	82%
488,747	20%	5	101%

Table 8b Projection of number of vehicles and RTAs

Year	Number of registered vehicles	Number of road traffic accidents
2014	562,059	33,197
2015	646,368	37,314
2016	743,323	42,049
2017	854,822	47,494
2018	983,045	53,756
2019	1,130,502	60,957
2020	1,300,077	69,239
2021	1,495,088	78,762
2022	1,719,351	89,714
2023	1,977,254	102,309

DISCUSSION

In the last few years, Zambia has experienced an economic growth averaging 5% which is good for sustainable development and has also achieved GDP per capita of above USD 1,000 at least since 2006. At the same time it has witnessed high rates of population growth, urbanization and car ownership, while the road network has not expanded at the same rate to meet the rising demand for car movements and parking space. Increase in human population and car ownership accounts for the increased number of road traffic accident incidents with accompanying human fatalities. The massive production of cars and the availability of cheap second hand cars sold online have characterized high rates of car ownership typifying an exponential growth of car ownership (see Figure 8).

In Zimbabwe for instance, Muzdengerere and Madiro (2013) in their study of Sustainable urban traffic management in Zimbabwe, reported an increase in the number of people being killed and injured in road accidents owing in part to the increased number of vehicles. In another report by WHO (2004), Ethiopia was reported to have the highest rate of fatalities per vehicle in the world while Uganda was second, both countries had registered an increase in the number of vehicles coupled with inadequate and poor road infrastructure. In Ghana and South Africa, pedestrians were the most vulnerable road users. Thus third world countries are on the lead in terms of traffic accidents. The traffic observations done in Bulawayo, Zimbabwe by Muzdengerere and Madiro (2013) reviewed that the roads with huge volumes of traffic such as main street, Fort Street, Robert

Mugabe Avenue, Fife Street and Leopold Takawira Street experienced the highest numbers of traffic accidents especially at intersections controlled by STOP or GIVE WAY signs as motorists usually did not take precautions when crossing such busy roads. Such pattern of traffic incidents in busy streets and non observance of traffic rules also applies to Zambia, thus explaining the high incidents of RTAs in Lusaka and Copperbelt Provinces which are also the most urbanized provinces in Zambia. Non functional robots/traffic lights at some controlled intersections owing to power cuts could also contribute to the high number of RTAs in Lusaka and Copperbelt provinces which also have the largest number of road intersection with robots/ traffic lights. In Ethiopia, accidents were related to among others, risky behaviours of drivers. In Mekele town, Ethiopia Daie (2013) found that significant numbers of study subjects (66.6%) had risky driving behaviours. Of this, more than 28.6% had less knowledge about basic traffic signs, 51.7% had negative attitude towards risky driving behaviours; 42.3% had a habit of using mobile phone while driving and 9.7% had experience of driving after drinking alcohol (Hassen et al., 2011). These factors also apply to Zambia and may to a greater degree account for the high number of accidents in urban provinces.

With regard to Lusaka having the highest incidents, it is clear that Lusaka holds the highest proportion of the country's population, hence the number of vehicles is higher than any other province and since the province hosts the capital city, it no wonder that most economic activities are carried out which explains the leading role in RTAs. The high rate of accidents in the capital city which is also the commercial nerve centre of the country is a hindrance to sustainable socio- economic progress. Business is delayed, while police officers more often than not may be drawn from other useful duties to strengthen traffic controls particularly at peak times. If Zambia has to improve the efficiency of the road transport sector for sustainable development, improved management of the traffic will be cardinal.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Trade and commerce is one of the most critical tools to achieve sustainable development in Zambia and Africa at large. The movement of goods and services within and between countries in Africa does not only connect African societies previously disconnected during the colonial era when international boundaries were demarcated irrespective of ethnic relations, but also connect their economies and enhance exchange of knowledge and skills. This requires sustainable investments in the road sector to promote efficiency. Reduced road carnage would not only save lives but resources from insurance claims which can be rechanneled into other sectors of the economy.

To the contrary, the results of this study revealed that RTAs claim large human fatalities, particularly in the most urbanized provinces of the country. The research also found that there was an exponential increase in car ownership, while the road network and quality has not expanded and improved at a matching or corresponding rate. Consequently congestion has reduced road safety levels while the police are overwhelmed with the increased numbers of vehicles and are incapable of coping with rising incidents of RTAs. Such incidences are a cost to business, as workers often report late for work, and important meetings are delayed when participants are held up in traffic jams.

The current trends as based on the vehicle projections suggests that the situation will worsen in future, unless alternative means such as improving railway transport and introducing tram services in large towns are considered. It can also be concluded that RTAs claim more lives each year, perhaps next to malaria and HIV/AIDS. This takes away skill as most of the people killed

are within the most productive age groups, which indirectly negatively affects sustainable development. For those who are injured, man hours are lost while expenses incurred and insurance claims take away valuable financial money capital for sustainable socio-development.

It is also clear that most RTAs are concentrated in Lusaka Province which has the largest urban population and is the place where most economic activities take place and people frequently travel in and out of the province. As a capital city, Lusaka is supposed to be the most efficient which also improves and reduces the cost of doing business. Continued and increasing levels of traffic congestion negatively affects suitable development as it takes away valuable time at work as employees spend more time to reach their work places.

This study also confirms that the rate of RTAs in the country is increasing at about 13 percent as shown by the weighted average annual growth rate, while the average annual growth rate in the number of vehicles was estimated at 15 percent. This obviously signals the need for sustained investments in the road transport and railway sectors.

Recommendations

Traffic Problems

Rapid urbanization and an increase in car ownership have influenced the flow of traffic causing congestion, pollution and road accidents. In amelioration, urban authorities may address these challenges by considering the following;

Re-plan the settlements and road systems and networks in a sustainable manner so that they are compatible with the rising traffic demands.

Improve use of urban space so that people can park their cars in suitable places and walk to a place where they can access public transport.

Improve public transport so that most people can leave their cars at home and use public transport.

Identify and continuously monitor and update major accident black spots and take appropriate measures to reduce RTAs.

More commuter omnibuses (Toyota Hiace) are now found in all cities in Zambia and their recklessness driving causes a lot of traffic congestion and more carnage on the as also reported by Detr, (1998). To address this challenge it may be necessary to ban all minibuses in urban areas and replace them with big buses and trams.

Traffic Management

All cities in Zambia like other third world countries were designed during the colonial era based on the western developed concepts. It may be important at this time to learn from the western world and consider adjusting or adapting the use of an existing road system to meet specified objectives without substantial new road construction which would attract huge budgetary support from particularly Breton Woods institutions which aggrandizes the debt burden on third world countries (Newman and Jeffrey, 1999). In the long term however, sustainable investments in the road transport sector will be inevitable to spur sustainable development for the benefit of citizens and the economy in general.

Public Transport

The liquidation of the United Bus Company of Zambia (UBZ) which was a transport company wholly owned by the government of Zambia left a gap that has not been filled by the private sector as earlier envisioned. Privately owned transporters usually do not comply with government regulations and in many incidences particularly when the number of accidents increase, the maximum penalty has been to withdraw the licence to operate. This has not improved things. Private operators often overcharge and increase fares as and when they like particularly when there is an increase in fuel prices while the conditions of carriage mostly customer care is bad. There is need for establishing decent and sustainable public transport systems to address the current challenges where every one is compelled to buy their own car to avoid the inconveniences prevalent on and persistently sustained by privately owned buses.

A few privileged institutions provide transport to their workers to and from work ensuring timely reporting at work. The remaining population usually uses minibuses (Toyota Hiace Panel Vans). They are fast as compared to the big buses and so popular with many passengers. However, the carrying capacity of such vehicles is supposed to be fourteen or less, but often carry eighteen or sometimes twenty passengers, making them uncomfortable and riskier.

Since most of the buses belong to individual operators, their primary motive is to maximize profit while offering the least comfort to passengers. As such, some operate aging fleets of buses affordability and profitability even without providing safety to passengers as also reported by Muzdengerere and Madiro (2013).

Commuter trains are non existent. While commuter trains and trams are perhaps the most sustainable form of public transport, they are non existent in Zambia. Previous attempts were done during the first republic when a rail car operated between Copperbelt and Lusaka, but this operation collapsed and one has given an objective explanation to its closure. The Zambian government has not invested in the railway transport sector. Consequently passengers using small buses in particular are subject to;

a) Delays as there are many stops along the way because of picking and dropping passengers at any point even at dangerous points.

b) Rude and uncompromising conductors who often quarrel and in some instances insult or fight with passengers.

c) Long queues for boarding the public transport particularly after 17:00hrs after knocking off from work.

d) Overloading, recklessness driving and ill-treatment of passengers in general.

e) Sitting on very uncomfortable chairs that are locally fabricated using inappropriate metals which becomes very dangerous to passengers when ever there is an accident accounting for deaths and serious injuries. This is because, as we now know, the minibuses commonly in use in Zambia were not manufactured as passenger's vehicles but as panel vans. They are imported without passenger chairs. Chairs are then fabricated locally by ordinary welding methods without using proper materials that guarantee safety.

f) Difficulties in boarding or dropping especially for the old and disabled as there are no provisions for that and the conductors or the drivers do not seem to care.

In view of the above; it would be necessary to consider reestablishing a tram service, train commuter service and public buses similar to UBZ. If UBZ was to be re-established it would be operated on electronic transactions so that theft is eliminated by preventing use of cash in all transactions.

In the wake of developing green economies that are sensitive to the environment and the concerns of climate change, government must encourage use of sustainable public and shared transport and use of bicycles in urban areas as earlier postulated by the Intergovernmental Panel on Climate Change (Figure 10).

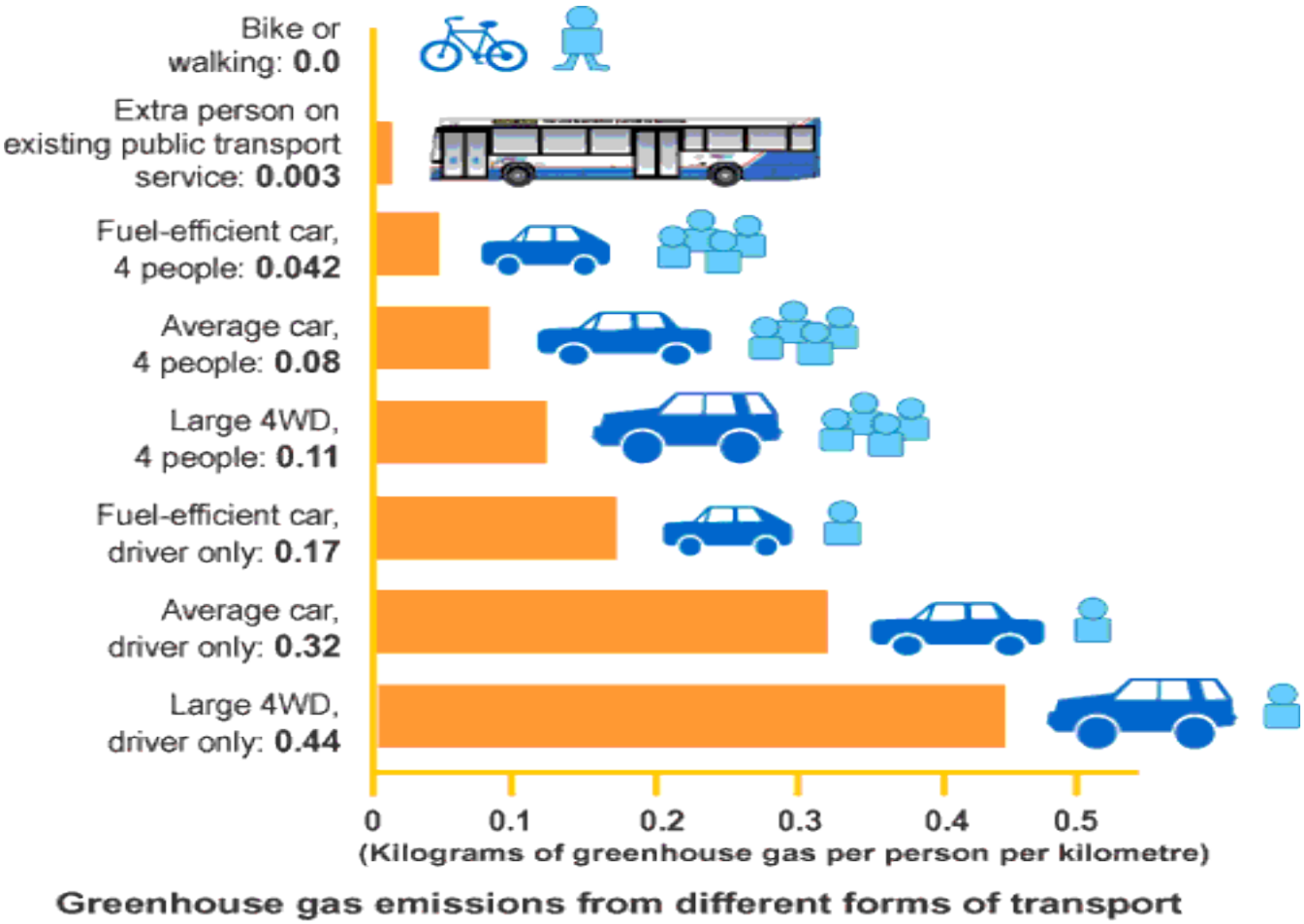


Fig. 10 Use of public and shared transport for reduced green house emissions
(Source: Intergovernmental Panel on Climate Change)

Traffic Control

In Zambia most goods and humans are transported by road which creates a huge challenge to the Road Transport and Safety Agency and the Traffic Section of the Zambia Police Service. Traffic control is by signs such as; stop sign, give way sign, robot/traffic lights or roundabout/traffic circle. In other instances particularly at intersections, motorists give way to the traffic on the right side. In other instances particularly where small roads feed into main road, precedence is given to vehicles on the main road. Such traffic control systems are not effective as they depend on the good will of motorists who more often than not ignore them leading to accidents.

In the long term as technology improves it will be necessary to use more sustainable and effective methods such as electronic monitoring combined with camera surveillance of motorists.

Parking

Mudzengerere and Madiro (2013) noted that land value in the city centers would fall because of the lack of parking facilities. City decay is associated with poor traffic management measures and people have a tendency of running away from such cities as more productive time is lost because of traffic congestion and this also brings negative effects on people's emotional state. Lusaka in particular is faced with inadequate parking space. Along Cha Cha Cha road for instance, when vehicles park on each side of the road only one lane remains. Decency is only when business owners provide parking space for customers and employees. As for the latter, they are normally labeled. In future it will be necessary to develop more sustainable and cost effective methods such as; under ground and/or upper storey parking lots. Bicycle parking lots should also be considered and promoted which would encourage residents to use bicycles, which is more sustainable, healthier and environmentally friendly. Encouraging use of public transport would be necessary as a sustainable way of improving movement of people to and from work. Use of public transport creates more parking spaces, because one vehicle may carry many passengers instead of each passenger driving himself/herself. For instance, the use of a 65 seater bus would be equivalent to removing 65 cars from the road reducing congestion as well as leaving 65 car parking spaces vacant. Sharing vehicles should also be encouraged as a sustainable way of managing parking lots.

For sustainable socio-economic development through trade, the link Zambia 8,000 a projected expected to upgrade and create a total of 8,000 km of road network should be enhanced as it will contribute to the sustainable growth of trade and commerce and expectantly decongest the highways in particular. I will improve efficiency of road transport and reduce the number of accidents. Such investments should be factored into the routine operations of the Road Transport and Safety Agency (RTSA), Road Development Agency (RDA) and National Road Fund Agency (NRFA) and others for sustained road transport development.

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