

Identifying and Fixing High Traffic Crash Locations in the Road Network in Uganda

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ABSTRACT

This paper presents findings of the first part of a research to develop a procedure to identify and fix high crash locations in Uganda using crash data. The paper comprises of a review of literature on best practices and methods in traffic crash analysis, evaluation of existing data collection and storage systems, vehicle and crash statistics, procedure to identify high crash locations, and improvements to crash data collection process in Uganda. Preliminary findings show that existing crash data records are inadequate in both quantity and quality making it impossible to carryout meaningful engineering safety studies. Consequently, an improved data collection instrument has been designed for awaiting stakeholders' input and approval. The study recommended major investments in robust data handling, storage and retrieval systems for the country.

Key Words: Crash data collection, Traffic crashes, Road Traffic Safety

1.0 INTRODUCTION

The issue of road safety has become apparent in Uganda due to increased fatal crashes on major highways. Traffic crash fatalities have become a significant health and economic challenge to the country with hospitals having to cope with ever increasing traffic crash victims. The World Health Organization [WHO] (2004) referred injuries resulting from road crashes as "*neglected public health challenge*" to the world as a whole that needs immediate attention if the trend is to reverse. In the case of Uganda the period between 1993 and 2006, close to 24,000 persons lost their lives and 126,000 persons sustained various body injuries with only close to 316,000 vehicles on the country's roads by 2006 (Statistical Abstracts 1999, 2000, 2004, 2005, 2006 & 2007). The fact is that the vehicle population is expected to increase rapidly the coming years with sustained economic growth. It is therefore important that a road safety culture is nurtured early to reverse the trend and prepare for the enormous challenge ahead.

The major challenge has been lack of a clear road safety framework to devise consistent intervention measures and evaluation of the impacts. The responsibility of identifying road safety schemes is left to the discretion and judgment of respective engineering entities without logical and statistical procedures to identify problem areas for improvement in the planning process. This has complicated monitoring and evaluation of the impact of policies, engineering and enforcement measures. The purpose of this research was to develop procedures to identify high crash locations and counter-measures using crash data in the road network based on statistical techniques and procedures used in developed countries.

2.0 RESEARCH OBJECTIVE

The main objective was to develop a procedure to identify and fix high crash locations in the road network based on traffic crash data. Specific objectives included; review of literature on best practices and procedures for identifying high crash locations, analysis of crash data collection procedures in Uganda, evaluation of suitability of crash data collection, storage and retrieval for safety analysis, and development a statistical based procedure for identifying high crash location based on crash data records for Uganda.

3.0 LITERATURE REVIEW

Road safety improvement interventions involve integrated approaches requiring cross cutting measures encompassing not only engineering but also user education, enforcement and emergency management (4E's). It involves an assessment of roadways for safety in terms of interactions between the driver, vehicle and roadway; Roess, Prassas, & McShane (2004) and Assum (1998). A guide to Road Safety Engineering cited in *Roess et al* presented five strategies in road safety management namely; exposure control, crash prevention, behaviour modification, injury control and post-injury management. Exposure control strategies stem from overall operational planning aimed at reducing roadway traffic volume. Crash prevention strategies are aimed at removing perceived safety bottlenecks and reduce crash risk. Injury control, behavioural modification and post-injury management strategies relate to the quality both the drivers and vehicles. In this study, we concentrate on crash prevention through systematic identification and fixing of roadway defects based on traffic crash data.

3.1 Crash Data Collection

Road safety analyses using crash data require extensive data related to the user, vehicle and roadway conditions for complete comparison amongst spatially distributed locations. Southeast Michigan Council of Governments Information Services [SEMCOG] (1997) identified and categorized the data types necessary for a complete safety analysis of crash locations to include; traffic volume and composition, traffic control devices, roadway and roadside design features, perceived operational and safety problems, maintenance record of objects struck in crashes, traffic citation pattern, and adverse litigation history. Whereas traffic volume and composition, control devices and roadway features can be determined with accuracy through field inspections; crash data is transient and complex due to the random and unpredictable nature of crashes. Therefore data collection process must gather all the necessary details at the crash scene for meaningful evaluation through uniform but practical data collection procedures. Practice and research by authors SEMCOG (1997); Assum (1998); Lacroix, Silcock and Koehler (2002); Roess *et al*; and Minnesota Department of Transportation [MDOT], (2000) have indicated that traffic crash data collection is the responsibility of enforcement agency which is usually the police using pre-designed forms to fill in data at crash scene. However, the details vary among countries depending on additional legal, social and political requirements. The major components of the form include; crash date, time, type, weather, light, location, road conditions, severity, crash diagram and details of vehicle(s) involved and persons. The variability in data collection creates significant challenges in handling, storage, retrieval and analysis; with a need for more dynamic and data storage systems.

3.2 Crash Data Storage Systems

Future use of crash data for engineering analyses requires proper storage of daily traffic crash reports not only for over a long period of time, but also in a unique manner that is easy to aggregate and retrieve. The storage mechanisms depend on technology and methods of data management employed. Roess *et al* and SEMCOG (1997) discussed two basic storage systems; manual filing which is the cheapest and commonly used, and computer based record systems. The drawback to manual filing system is the enormous space requirements for storage and associated

retrieval difficulties. Computer based storage systems allow data from different sources to be stored uniquely in a single database. However, computer databases require proper programming and investments in terms of computer hardware and software.

3.3 Crash Data Statistics

Several statistical parameters exist in the literature; Roess *et al* and Otero (2004). The statistics are broadly classified as; population, number of registered vehicle and exposure-based rates. However, population and vehicle population based rates are only useful for social, political and economic assessments and bear little significance in engineering assessment. The exposure based rates are the most useful to the traffic engineer and include; spot map, crash frequency, crash rate, frequency rate, crash severity and crash probability index as in SEMCOG (2007) and severity index as in Roess *et al*. The spot map method uses clusters and symbols plotted on plain paper or digitally in geographical information system (GIS) to identifying high crash locations. The frequency method ranks locations by number of reported crashes. The crash rate compares the number of crashes at a location or segment to the average daily traffic volume, and is the most widely used exposure based statistical measure in identifying severe crash locations. Equations 1 & 2 represent crash rate (CR) estimation for segments and intersections expressed in crashes per million vehicle mile (MVM) and crashes per million vehicles (MV) respectively.

$$CR_{Section} = \frac{1,000,000 * Crash}{ADT * Length * Days} \quad (1)$$

$$CR_{Intersection} = \frac{1,000,000 * Crash}{ADT * Days} \quad (2)$$

Where; $CR_{Section}$ = Crash rate for the section, crashes/MVM, $CR_{Intersection}$ = Crash rate for the intersection, crashes/MV, Crash = Number of crashes for the section, Days = Number of days for the study, ADT = Average daily traffic, and Length refers to length of section. Other methods include; severity index and crash probability index.

3.4 High Crash Location Identification

The crash statistics create different rates for a location for comparison amongst locations. Segments and intersections are treated independently. The challenge comes at determining the threshold rates for locations to be categorized as high crash or critical. Roess *et al* defined the criteria for determining the thresholds by assuming a normal distribution of rates and 95-percent confidence level. The highest 5-percent (one tailed test) locations are categorized as high crash locations. The procedure assumes symmetric distribution of crashes for all locations under study based on large sample theory. Similar equation for critical crash rate is discussed in Green, Agent and Pigman (2006).

3.5 Before and After Analysis

Before and after analyses involve evaluation of the effect of improvements on crash reduction or complete elimination. The number of crashes at the location before and after improvements is compared. The critical issue is for the time period of both sets of data to be equal and preferably at least a year. Six months periods could be used if limited sufficient data is available.

4.0 METHODOLOGY

The methodology adopted involved; review of literature on traffic safety analyses with emphasis on practices in both developed and developing countries, collection of crash data together with sample collection instruments, evaluation of suitability of crash data and develop new crash data collection instruments. The study was founded on the premise that suitable traffic crash records exist and therefore statistical methods were applicable.

5.0 FINDINGS

5.1 Identifying High Crash Locations

The process of identifying high crash locations is statistical. A two stage process was developed from the literature to identify ‘*candidate high crash locations*’ and ‘*final high crash locations*’ summarized in Figure 1. Development of candidate high crash locations data set is based on crash frequency, and the process is less rigorous. Several statistical rates are used identify final high crash locations such as crash rates, and severity rates that incorporate the average daily traffic (ADT) and vehicle miles travelled.

5.2 Estimated Vehicle Population

According to data obtained from Uganda Bureau of Statistics in Statistical Abstracts mentioned earlier; the estimated vehicle population in Uganda by 2006 was 315,903; an increase from 60,000 in 1993 as shown in Figure 2a. Registered vehicles per 100,000 persons increased from 333 in 1993 to 1,155 in 2006 as shown in Figure 2b. This rate is still very low due to low vehicle ownership and therefore expected to increase in the near future with sustained economic growth. Vehicle ownership rate depicts Uganda as largely a pedestrian country.

5.3 Traffic Crash Trend

The total annual crashes rose from 5,674 in 1990 to close to 19,783 in 2005 and 17,428 in 2007 as shown in Figure 3. Years 1992 and 1998 indicate significant reductions in the total number crashes. The cause of the reduction in 1992 was not readily determined; but that in 1998 was attributed to a policy directive on loading limits (14 passengers) of Omni-buses. The directive had positive impact on reduction of overall total crashes although it led to more deaths per crash.

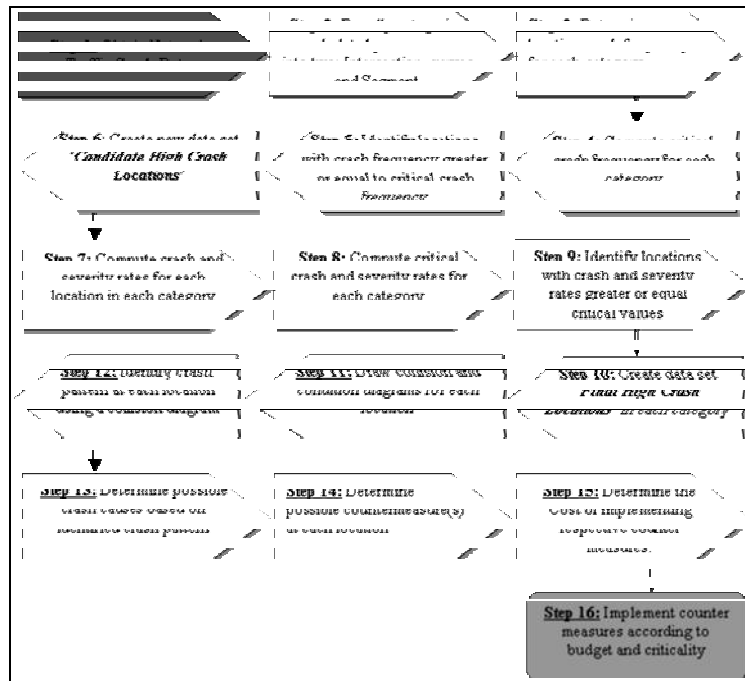


Figure 1: Procedure to Identify and Fix High Traffic Crash Locations in a Network

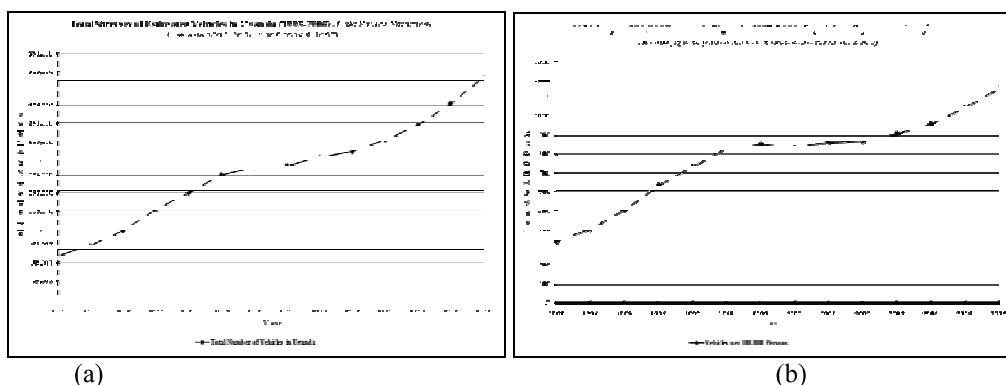


Figure 2: (a) Estimated Registered Vehicles in Uganda and (b) Vehicles per 100,000 Persons (1993-2006)

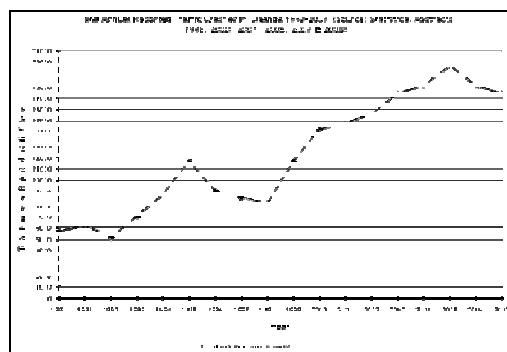


Figure 3: Trend of Traffic Crashes in Uganda (1990-2007)

5.4 Existing Crash Data Collection and Storage Issues

The Uganda Police Force is mandated by law to collect, store and disseminate traffic crash data and use a simplistic data collection instrument. Main features on the form are time, date of occurrence of the crash, place and nature, crash cause and the details of vehicles. The form lacks provisions for crash type, collision diagram, and precise crash location among others. Crash severity is recorded as minor and serious injury and fatal crashes as appropriate although no precise distinction is made between minor and serious crashes. To overcome the above shortfalls, there is need to improve the existing data collection instrument. On the other hand, data handling and storage; manual filing of daily crash reports on a monthly basis is done with appropriate summaries. However, the summaries are made for crash types, dates and severities. The readily accessible summaries cannot be relied upon for traffic engineering studies.

5.5 Crash Data Collection Improvements

To overcome the shortfalls on the existing data collection instrument, a new instrument was designed. The design objectives were to; increase the quality and quantity of data collected at the crash scene, reduce the time spent at the crash scene by minimizing writing by the investigating officer, create uniformity amongst data collected by different investigating officers and reduce individual investigator decision making process, ease interpretation, understanding and use of collected data, and enhance authenticity of the collection instrument. A copy of the proposed crash data collection instrument is shown in Figure 4, and is subject to fine tuning and contributions from stakeholders.

5.6 Crash Data Storage Improvements

Existing data storage and retrieval methods (manual filing) are too bulky in terms of both handling and interpretation. The study proposed use of more advanced computer database systems. The software, hardware and programming requirements are well within the competence of locally available programmers. The important feature of the database design that it should reflect all the attributes of the data collection instrument. A proper database system should; allow entry of data directly from daily crash reports and aggregation by a primary key, robust enough to store data for several years and ease the retrieval process, have the capability to generate crash reports as required by the end user, and allow access irrespective of location for easy data entry; preferably web-based.

6.0 CONCLUSION

The study established that existing crash data records lack attributes pertinent to engineering safety analyses. For instance, it is impossible to determine precise location of the crash in the records. Existing data collection instrument is insufficient in both quantity and quality of data collected at the crash scene. An improved data collection instrument was designed awaiting stake holder's input and approval. Existing crash data storage systems render data retrieval difficult. It was therefore proposed that computer and/or web-based crash databases be designed for proper data storage and retrieval.

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 THE REPUBLIC OF UGANDA UGANDA POLICE FORCE TRAFFIC ENFORCEMENT DEPARTMENT TRAFFIC CRASH SCENE REPORT		Case #: Case Disposition <input type="radio"/> Open <input type="radio"/> Closed Reviewer: Name, Rank/Reg. No																										
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General Remarks by Investigating Officer (Human activity, road side environment, landscape, etc)																												

Figure 4: Proposed Traffic Crash Data Collection Form

CHAPTER 7: RENEWABLE AND SUSTAINABLE ENERGY

A Cost Effective Solar PV Power Solution for Rural Household in Tanzania: The case of Kondo District

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ABSTRACT

A study on the cost effectiveness of solar photovoltaic as power solution has been conducted. This work was aimed at evaluating the economic viability of this technology for rural electrification in Tanzania. The study was conducted in Kondo District rural area where 7 villages out of 177 villages were considered with a total sample of 61 households. The research involved field visits, System inspection, Interviewing end users and Questionnaires. On the other hand, economic viability of solar PV systems was evaluated using replacement cost of kerosene, small petrol generators and disposable dry batteries. In order to determine the most cost effective solutions, the life cycle cost (LCC) analysis of the components was employed as well as the inflation rate. The research findings show that kerosene is the most dominant source of energy for lighting in Kondo District rural area while electric energy use pattern is characterized by low consumption. Nevertheless, comparison between a solar PV system sizing 40 W with other alternatives was found to be more cost effective than others. This observation suggests that a small stand-alone system can be more economical for rural electrification.

Keywords: Cost-effective, Renewable energy, Rural electrification, Solar PV

1.0 INTRODUCTION

Electricity improves the quality of basic services for the well being of people, such as clean water, education, medical care, entertainment and communication. While this energy is important for economic growth, only 2 % of Tanzania's rural population has access to grid electricity (HBS, 2007), which is generated mainly from hydropower, gas turbines and diesel generation plants (URT, 2003). Such a situation displays poor electricity-based services and commodities in rural areas.

Grid-based power is the least-cost option for large concentrations of household or productive loads. It offers substantial economies of scale, owing to the large fixed-cost investment in distribution lines and generation facilities. However, grid solutions require a minimum threshold level of electricity demand and certain load densities to achieve these economies of scale (Sørensen, 2004; Luque & Hegedus, 2003). Deciding whether the grid or off-grid power solution like solar PV is the least-cost option for supplying electricity to rural areas requires a consideration of many factors. These factors include distance from grid, resource availability, equipment availability, community organization, income level, household service level, total number of households to be served, load density, productive loads and load growth (Kalogirou, 2009; Patel, 2006).

2.0 BACKGROUND AND CASE STUDY AREA

Kondo District has a population of nearly 428,090 individuals who live in 91,500 households according to National Bureau of Statistics, census of August 2002 (<http://www.nbs.go.tz>). About 87,500 (95 %) of these households are located in rural areas and the remaining are found in areas