Evaluation of Road Traffic Accident Risk Based on Fuzzy Set Theory

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Abstract—In this study, the risk for road traffic accidents on Ubungo – Chalinze route (Tanzania) is comprehensively evaluated and analysed using fuzzy techniques. After identifying the main risk factors for road traffic accidents, the experts’ judgements are used to establish each single factor evaluation fuzzy set. Eventually, the single factor evaluation matrix is multiplied by the risk factor weight set to get fuzzy comprehensive evaluation. The computational results reveal that the road traffic accident risk along the route from Ubungo to Chalinze is high. Thus, the evaluation model can be a useful tool for making informed decisions for road transport safety regulators and policy makers, road transport users and underwriters of public liability and motor insurance policies when setting insurance premiums and reserves. In addition, the proposed risk evaluation model offer theoretical foundation for risk evaluation along other routes.

Keywords—Comprehensive Evaluation, Fuzzy Set, Risk Factor, Risk Model, Road Traffic Accidents.

I. INTRODUCTION

In recent years there has been a drastic increase of road traffic accidents (RTA) in Tanzania. The incidents result into unexpected economic losses (i.e. about 3.4% of the county’s Gross Domestic Product) [1]. The Tanzania traffic police department devotes considerable efforts to collecting information about transport crashes and the resulting fatalities and injuries. Risk assessment information is of paramount importance in improving road safety. The risk evaluation can be applied to improve safety, assist transport planners, and determine public health priorities. In addition, the risk assessment results can help motor vehicle insurers to predict losses (i.e. insurance claims) before they occur. Consequently, the costs of such losses can be financed and redistributed in advance.

The most common way measure of risk in road traffic accidents is the number of road crashes and/or casualties per road length (i.e. casualty density) [2]. However, in Tanzania statistics for the number of road crashes and/or casualties per distance travelled is still lacking. Fuzzy set based methods have proven to perform well when statistical data is relatively small [3].

This study uses fuzzy comprehensive technique to evaluate road traffic accident risk in Tanzania. This paper is structured as follows: Section 2 gives a succinct review of relevant literature; Section 3 presents an overview of comprehensive risk evaluation based on fuzzy sets and Section 4 develops fuzzy sets based risk evaluation for road traffic accidents in Tanzania. Lastly, conclusions are given in Section 5.

II. SURVEY OF PREVIOUS WORK

Recently, the number of studies that deal with the assessment of road traffic accident risk has increased. Methods to evaluate road traffic accident risk are broadly divided into two categories depending on whether real accident data are available or not [4]. The vast majority of these studies employ statistical and probabilistic models to evaluate the risk in road traffic accidents. For instance, Meng et al. [5] use a probabilistic quantitative risk assessment model for the long-term work zone crashes. Malyshtkina et al. [6] apply markov switching negative binomial models to determine vehicle accident frequencies. Lord [7] employs statistical models to compute accident risk on transportation networks. Shankar et al. [8] use statistical methods to analyse accident severity on rural freeways. Kim and Sul [9] develop a risk assessment model for traffic accidents at highway intersections. Turner et al. [10] use Generalised Linear Models (GLMs) to predict the number of roadside hazards in New Zealand.

Abdel-Aty and Radwan [11] use the Negative binomial model to investigate the frequency of accident occurrence and involvement in Central Florida. Cenek and Davies [12] employ Poisson regression modelling to identify critical variables and the form of their relationship with crash risk. Garber and Ehrhart [13] use variables of mean speed, standard deviations of speed, flow per lane, lane width and shoulder width to predict crash rates by multiple linear regression, robust regression and multivariate ratio of polynomials (i.e. deterministic models). Farah et al. [14] use statistical method to model risk relating to overtaking manoeuvre based on road geometry and driver characteristics (i.e. ages and gender).
Pirotti et al. [15] use historic accident to describe a Web Global Information System (GIS) approach that enable multi-user access to an online portal for road risk analysis on a certain road segment. Chen et al. [16] develop a statistical based risk assessment model, which concentrates on accident risk on road curves. The proposed approach uses records (i.e. historic accident data) from insurance companies to determine significant contributory factors for accidents. Cafiso et al. [17] develop a generalized risk model for safety performance for rural roads based on exposure, geometry, various consistency and context variables. They used Global Positioning System (GPS) based surveys and road inspection to record other road characteristics.

Models that employ real accident data (i.e. statistical and/or probabilistic models) judge variables related to real accidents and predict future number of accidents. However, they have serious problems as real accident data need to be accumulated for at least three years. In addition, accidents are caused by road environment related factors, driver-related factors, vehicle-related factors or combinations of these factors. As such road traffic accident risk is characterized by uncertainty, subjectivity, imprecision and ambiguity [4]. Fuzzy set theory is a useful mathematical tool for modelling uncertain (i.e. imprecise) and vague data in real situations. Nonetheless, limited researches employ fuzzy models to evaluate the risk of road traffic accidents.

Ma et al. [18] apply fuzzy Delphi method and grey Delphi method to construct road safety performance indicators. Du et al. [19] apply fuzzy comprehensive model to evaluate highway traffic safety level in typical cold region of Heilongjiang Province - China. In their study five factors related to highway safety level are established: dimly-lit in morning and evening in winter, environmental factor in winter, influence of low temperature on performance of automobile, low attachment coefficient on snowy road, and driver personal factors. Lazim Abdullah and Nurnadiah Zamri [20] use correlation analysis and Fuzzy Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) to rank the factors of road accidents in Malaysia.

It is evident that practitioners and researchers in the road transport sector rarely apply Fuzzy Set Theory (FST) to assess the road traffic accident risk. This study therefore presents a fuzzy based comprehensive model for evaluating the risk of road traffic accidents in Tanzania. Unlike the previous studies on fuzzy comprehensive evaluation modelling, the proposed study employs fuzzy comparison method to determine the weights of the risk factors.

In this study three risk factors for road traffic accidents are proposed: human element, vehicle element and road environment element. The study is based on Morogoro road from Ubungo Bus Terminal to Chalinze Bus Terminal. This is a trunk road and the main gateway for most hinterlands and cross borderer countries.

III. OVERVIEW OF FUZZY COMPREHENSIVE RISK EVALUATION

When risk of road traffic accidents is evaluated by the road transport stakeholders such as safety regulators and the underwriters of motor insurance, there is usually more than one factor that initiates the risk. When multiple risk factors are considered to make a comprehensive decision, a process is called comprehensive evaluation. When referred to fuzzy factors, it is called fuzzy comprehensive evaluation whose steps follow [21].

A. Factor Set Formulation

An ordinary set F comprising various factors that influence evaluation results is known as a factor set. We let $F = \{f_1, f_2, \ldots, f_m\}$ where $f_i (i = 1, 2, \ldots, m)$ is a factor, which can be fuzzy or not. Thus, $f_i \in F$ or $f_i \notin F$ but not both.

B. Weight Set Formulation

In general, each factor has got a unique impact. As such we set a weight $w_i (i = 1, 2, \ldots, m)$ for each $f_i$ to reflect its importance. The set $W = \{w_1, w_2, \ldots, w_m\}$ is termed as a weight set.

It is usual for $w_i (i = 1, 2, \ldots, m)$ to have the following properties:

$$\sum_{i=1}^{m} w_i = 1, \quad w_i \geq 0, \quad i = 1, 2, \ldots, m \quad (1)$$

Since $w_i$ is the membership grade of importance, the weight set is a fuzzy subset on the factor set and can be expressed as $W = \frac{w_1}{f_1} + \frac{w_2}{f_2} + \cdots + \frac{w_m}{f_m}$

C. Evaluation Set Formulation

The possible results of final evaluation for an object of study makes an evaluation set $E = \{e_1, e_2, \ldots, e_n\}$ where $e_i (i = 1, 2, \ldots, n)$ is a possible final evaluation result. In essence, fuzzy comprehensive evaluation is used to find out the best evaluation result based on all influence factors.
D. Single-factor Based Fuzzy Evaluation

When the membership grade for an object of study is evaluated based on one factor, the procedure is called single-factor fuzzy evaluation. If the evaluation is based on the i-th factor $f_i$, the membership grade to the j-th element $e_j$ of the evaluation set is $v_{ij}$. The evaluation result for the i-th factor $f_i$ is the fuzzy set:

$$V_i = \frac{v_{i1}}{e_1} + \frac{v_{i2}}{e_2} + \cdots + \frac{v_{in}}{e_n}$$

(2)
called fuzzy evaluation set for single factor. In addition, $V_i$ is a fuzzy subset of evaluation set $E$, denoted by $V_i = (v_{i1}, v_{i2}, \ldots, v_{in})$.

Thus, a series of single-factor evaluation set is deduced as follows:

$$V_1 = (v_{11}, v_{12}, \ldots, v_{1n}),$$
$$V_2 = (v_{21}, v_{22}, \ldots, v_{2n}),$$
$$V_m = (v_{m1}, v_{m2}, \ldots, v_{mn}).$$

(3)

Let $V$ be single-factor evaluation matrix and $V_i$ be the row of $V$, then

$$V = \begin{bmatrix}
v_{11} & v_{12} & \cdots & v_{1n} \\
v_{21} & v_{22} & \cdots & v_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
v_{m1} & v_{m2} & \cdots & v_{mn}
\end{bmatrix}$$

(4)

E. Multi-factor Based Fuzzy Evaluation

Now the fuzzy comprehensive evaluation is considered based on all factors. From single-factor evaluation matrix $V$, the i-th row reflects the influence of the i-th factor to each element of evaluation set and the j-th column reflects the influence of each factor to the j-th element of evaluation set. Consequently, $V_{ij} = \sum_{k=1}^{n} v_{ij}$ ($j = 1, 2, \ldots, n$) may be taken as the total influence of all factors to the j-th element. Nevertheless, $V_{ij}$ doesn’t take the importance of various factors into account. This shortcoming is resolved by multiplying $v_{ij}$ with the weight $w_i$ ($i = 1, 2, \ldots, m$). Hence, the fuzzy comprehensive evaluation is obtained as follows:

$$C = \begin{bmatrix}
w_1 & w_2 & \cdots & w_m
\end{bmatrix} \otimes \begin{bmatrix}
v_{11} & v_{12} & \cdots & v_{1n} \\
v_{21} & v_{22} & \cdots & v_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
v_{m1} & v_{m2} & \cdots & v_{mn}
\end{bmatrix}$$

$$= \begin{bmatrix}
c_1 & c_2 & \cdots & c_n
\end{bmatrix}$$

(5)

Where $\otimes$ is a fuzzy operator which stands for multiplication and $C$ is fuzzy comprehensive evaluation set.

IV. RISK EVALUATION OF ROAD TRAFFIC ACCIDENTS IN TANZANIA

The prevalence rates of road traffic accidents have recently gone up in Tanzania. Thus, it is useful to collect information on the prevalence rates of road traffic accidents and to find out the relationship between prevalence rates and risk factors of these road traffic accidents for auto-insurance and road safety policy formulation. The risk factors (i.e. causes) of RTA in Tanzania Mainland are established by the Ministry of Home affairs-Traffic Police Department. According to the official statistics over the past two decades the major causes of road traffic accidents are: Reckless driving (i.e. Inappropriate speed), Defective Motor Vehicles, Careless Pedestrians, Excessive speed, Careless Motor Cyclists, Careless Pedal Cyclists, Intoxication, Others (i.e. Bad road, Slippery) [1]. Since the boundaries of these influential factors cannot be precisely determined, it is better to treat them as fuzzy factors.

A. Determination of Main Risk Factors

There are many risk factors for road traffic accidents established by the Tanzania Traffic Police Department. However, these factors can be classified into three major categories which are: human error (i.e. reckless driving, careless pedestrians, excessive speed, careless motor cyclist, careless pedal cyclists, and intoxication), vehicle failure (i.e. loss of brakes, tyre blowouts, and tread separation, steering or suspension failure), the road environment including the operating rules and Traffic Control Devices (TCD) [1]. Consequently, the risk factor set for the proposed study is $F = \{f_1, f_2, f_3\} = \{\text{Human error, Vehicle failure, Non-conducive road environment}\}$.

B. Weight Determination of Influential Factors

Generally, influential factors have relative contribution to the risk evaluation level. Academicians and practitioners engaging in Fuzzy Set Theory (FST) have suggested a number of approaches to determine the weights $w_i$ of the risk factors. These techniques include Analytical Hierarchy Process (AHP), researcher’s experience, judgement of road safety experts, comparison method, over standard weighting method, F-statistics weighting method, probability based weight determination, entropy method and so on. Of all these approaches, the AHP is the most popular method for solving Multi-criteria Analysis (MA) problems involving qualitative data [22]. This study, however, adopts the ranking procedure for weights applied by Massami [23]. In the developed evaluation approach the weights of risk factors are determined by fuzzy pairwise comparison method.
The proposed fuzzy approach offers the following strengths over the AHP technique: (1) it reduces the unbalanced scale of judgements inherent in the AHP approach, and (2) It ranks the factors in a relatively simple and straightforward manner. The fuzzy pairwise comparison method compares each two influential factors at a time, in which the considered relatively important index is assigned a value 1 and another index is assigned a value 0 and assigns a value 0.5 whenever there is no distinction between the two indices.

The procedure for weight determination is as follows [24]:

Assuming the assessment indexes values form the following vector

\[ F = (f_1, f_2, \ldots, f_m) \]

Where \( f_i \) is the value of assessment index, \( i \in \{1, 2, \ldots, m\} \) and \( m \) is the total number of assessment indexes.

Now we want to obtain the weight vector of index set, \( W \). First, setting a qualitative sorting matrix of pairwise comparison on importance for all factors in the index set, and assuming that

1. If \( f_i \) is more important than \( f_j \), then given a scale \( s_{ij} = 1, s_{ji} = 0 \);
2. If \( f_i \) and \( f_j \) make no distinction, then given a scale \( s_{ij} = 0.5, s_{ji} = 0.5 \);
3. If \( f_j \) is more important than \( f_i \), then given a scale \( s_{ij} = 0, s_{ji} = 1 \);

Where \( i = 1, 2, \ldots, m; j = 1, 2, \ldots, m \).

After the experts have judged the relative influence on the traffic accident risk for each pair of factors, we get a qualitative sorting matrix of pairwise comparison of risk factors. Table I depicts the sorting matrix constructed based on the surveyed data from expert 1.

Table I
Pairwise Comparison Matrix Formed Based On The Data From Expert 1

<table>
<thead>
<tr>
<th>Risk Factor ((f_i))</th>
<th>HE ((f_1))</th>
<th>VF ((f_2))</th>
<th>RE ((f_3))</th>
<th>Sum ((s_i))</th>
<th>(w_i = \frac{s_i}{\sum_{i=1}^{3} s_i})</th>
</tr>
</thead>
<tbody>
<tr>
<td>HE ((f_1))</td>
<td>N/A</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0.67</td>
</tr>
<tr>
<td>VF ((f_2))</td>
<td>0</td>
<td>N/A</td>
<td>1</td>
<td>2</td>
<td>0.33</td>
</tr>
<tr>
<td>RE ((f_3))</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>(\sum_{i=1}^{3} f_i)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table I, gives the weight set formed from expert 1’s data. That is,

\[ W_0 = \{w_{01}, w_{02}, w_{03}\} = \{0.67, 0.33, 0.00\} \]

Using the same procedure we get the weight sets using the data from the other 9 experts as follows:

Weight set formed based on expert 2’s data,

\[ W_1 = \{w_{11}, w_{12}, w_{13}\} = \{0.66, 0.17, 0.17\} \]

Weight set formed based on expert 3’s data,

\[ W_2 = \{w_{21}, w_{22}, w_{23}\} = \{0.67, 0.33, 0.00\} \]

Weight set formed based on expert 4’s data,

\[ W_3 = \{w_{31}, w_{32}, w_{33}\} = \{0.67, 0.33, 0.00\} \]

Weight set formed based on expert 5’s data,

\[ W_4 = \{w_{41}, w_{42}, w_{43}\} = \{0.50, 0.50, 0.00\} \]

Weight set formed based on expert 6’s data,

\[ W_5 = \{w_{51}, w_{52}, w_{53}\} = \{0.67, 0.33, 0.00\} \]

Weight set formed based on expert 7’s data,

\[ W_6 = \{w_{61}, w_{62}, w_{63}\} = \{0.66, 0.17, 0.17\} \]

Weight set formed based on expert 8’s data,

\[ W_7 = \{w_{71}, w_{72}, w_{73}\} = \{0.67, 0.33, 0.00\} \]

Weight set formed based on expert 9’s data,

\[ W_8 = \{w_{81}, w_{82}, w_{83}\} = \{0.50, 0.00, 0.50\} \]

Weight set formed based on expert 10’s data,

\[ W_9 = \{w_{91}, w_{92}, w_{93}\} = \{0.66, 0.17, 0.17\} \]

Since \( w_{ij} \geq 0; i \in \{0, 1, 2, 3\} \) and \( \sum_{i=0}^{3} w_{ij} = 1, j \in \{1, 2, 3\} \), both the non-negativity condition and the normalized condition are satisfied.

The weight sets are used to determine the average weight set \((\bar{W})\) to be used in the fuzzy comprehensive evaluation. The average weight set \((\bar{W})\) is given by the following formula:

\[ \bar{W} = \frac{\sum_{i=1}^{n-1} W_i}{n}, \quad n = 10 \]  

(6)

All the weight sets formed based on the data collected from the 10 experts and the average weight calculated using equation (6) are showed in Table II.
The average weight set:
\[
\bar{W} = \{0.633, 0.266, 0.101\}.
\]  
(7)

The weight set satisfies both the normality condition and the non-negativity condition i.e.
\[
\bar{W}_i \geq 0, \forall i \in \{1, 2, 3\} \quad \text{and} \quad \sum_{i=1}^{3} \bar{W}_i = 1
\]

According to experts' opinions; human element is the major risk factor (63.3%) for road traffic accidents along Ubungo – Chalinze route in Tanzania. On the other hand, the road environment including poor Traffic Control Devices (TCDs) and enforcement of traffic regulations is the least risk factor (10.1%) for road traffic accidents.

In order to validate the fuzzy pairwise comparison method, its results are compared with the ones calculated using the data from the traffic police department (i.e. non-fuzzy method – relative frequency approach). Generally, if the total number of accidents reported as a result of any one risk factor is big enough, the statistical frequency in every circumstance during the survey approximately replaces the membership grade directly [25]. In this regard, the raw data of risk factors associated with road traffic accidents in Mainland Tanzania are deduced from the literature [1]. The procedure for weight determination when the statistical frequency method applies is as follows:

\[
w_i = \frac{n_i}{\sum_{i=1}^{m} n_i}, \quad i \in \{1, 2, ..., m\}
\]  
(8)

Table III shows the weight set obtained by the non-fuzzy approach, \(W = \{w_1, w_2, w_3\} = \{0.77, 0.16, 0.07\}\)

Since \(w_1 \geq 0, i \in \{1, 2, 3\}\) and \(\sum_{i=1}^{3} w_i = w_1 + w_2 + w_3 = 1\), both the non-negativity condition and the normalized condition are satisfied.

In Table IV the comparison of weight determination by fuzzy evaluation method and non-fuzzy (i.e. relative frequency) evaluation method are presented. Since the contribution of each risk factor is more or less the same by both approaches, the fuzzy pairwise comparison method is validated.
### Table IV

Comparison Of Weight By Fuzzy Approach And Non-Fuzzy Approach

<table>
<thead>
<tr>
<th>Risk factor (f_i)</th>
<th>Weight by fuzzy approach</th>
<th>Weight by non-fuzzy method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human element (f_1)</td>
<td>0.633</td>
<td>0.77</td>
</tr>
<tr>
<td>Vehicle element (f_2)</td>
<td>0.266</td>
<td>0.16</td>
</tr>
<tr>
<td>Road element (f_3)</td>
<td>0.101</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.000</strong></td>
<td><strong>1.00</strong></td>
</tr>
</tbody>
</table>

C. Evaluation Set Formulation for Road Traffic Accident Risk

The experts’ judgements are used to scale the severity of risk emanating from a road traffic accident into four levels: risk-free, low risk, moderate risk and high risk. As there are no clear boundaries among the three scales, it is more useful to illustrate them with fuzzy sets. Thus, the evaluation set is \( E = \{e_1, e_2, e_3, e_4\} = \{\text{risk-free, low risk, moderate risk, high risk}\} \).

D. Single Risk Factor Evaluation Matrix for Road Traffic Accidents

A group of 10 experts composed of road safety professionals, experienced drivers and traffic police officers, was chosen to form a risk evaluation team for road traffic accidents on a road segment, from Ubungo Bus Terminal to Chalinze Bus Terminal (i.e. Morogoro road) - Tanzania. Each expert was given enough time to think critically about the influence of the three risk factors on the road traffic accidents. The expert was asked to indicate how a given factor influences the level of road traffic accident. Four different levels (i.e. risk-free, low risk, moderate risk, and high risk) were stated in the questionnaire to be chosen from.

The number of respondents choosing a particular risk level helps to determine the membership degree for that level. As such, the membership grade corresponding to the j-th element of the evaluation set, \( v_{ij} \) is given by equation (9).

\[
v_{ij} = \frac{f_{ij}}{\sum_{k=1}^{4} f_{ik}} ; i, j \in \{1, 2, 3, 4\}
\]  

(9)

Where \( f_{ij} \) stands for the number of respondents whose opinions about the influence of factor \( i \) on the road traffic accident correspond to the \( j \) risk level. Hence, the single-factor risk evaluation fuzzy set attributable by factor \( V_i \) is given by equation (10).

\[
V_i = (v_{ij}) ; i, j \in \{1, 2, 3, 4\}
\]  

(10)

After the experts’ evaluation, the result is as follows: As far as the human element is concerned, none expert thinks it is risk-free, none expert thinks it has low risk, none expert thinks it has moderate risk, ten experts think it has high risk. Thus, the single risk evaluation fuzzy set attributable by human factor is,

\[
V_1 = (v_{11}, v_{12}, v_{13}, v_{14}) = (0.0, 0.0, 0.0, 1.0)
\]

Similarly, the results of experts’ evaluation on the other two risk factors are as follows: The single-risk evaluation fuzzy set attributable by vehicle defectiveness is,

\[
V_2 = (v_{21}, v_{22}, v_{23}, v_{24}) = (0.0, 0.1, 0.7, 0.2)
\]

The single-risk evaluation fuzzy set attributable by road factor is

\[
V_3 = (v_{31}, v_{32}, v_{33}, v_{34}) = (0.0, 0.5, 0.3, 0.2)
\]

Each single-risk evaluation fuzzy set (i.e. \( V_1, V_2, V_3 \)) meets the normalized condition as the sum of the weight of the vector is 1.

Using the fuzzy set notation,

\[
V_i = \sum_{j=1}^{4} \frac{v_{ij}}{e_j} , i \in \{1, 2, 3\}
\]

The single-factor evaluation fuzzy sets can be given by equation (11) below.

\[
\begin{align*}
V_1 &= \left[ \frac{0.0}{e_1} + \frac{0.0}{e_2} + \frac{0.0}{e_3} + \frac{1.0}{e_4} \right] \\
V_2 &= \left[ \frac{0.0}{e_1} + \frac{0.1}{e_2} + \frac{0.7}{e_3} + \frac{0.2}{e_4} \right] \\
V_3 &= \left[ \frac{0.0}{e_1} + \frac{0.5}{e_2} + \frac{0.3}{e_3} + \frac{0.2}{e_4} \right]
\end{align*}
\]  

(11)

Based on the above three single-risk evaluation fuzzy sets, the single-factor evaluation matrix for road traffic accident risk on the route from Ubungo Bus Terminal to Chalinze Bus Terminal - Tanzania is as follows:

\[
V = \begin{bmatrix}
V_1 \\
V_2 \\
V_3
\end{bmatrix} = \begin{bmatrix}
0.0 & 0.0 & 0.0 & 1.0 \\
0.0 & 0.1 & 0.7 & 0.2 \\
0.0 & 0.5 & 0.3 & 0.2
\end{bmatrix}
\]

E. Fuzzy Comprehensive Risk Evaluation for Road Traffic Accidents

The comprehensive evaluation of experts on the risk assessment of road traffic accidents for the chosen road segment in Tanzania is given as follows:
The comprehensive evaluation shows that 0% of the experts believe that road traffic is risk-free from accidents, 7.71% of the experts believe that the road traffic accident risk is low, 21.65% of the experts believe that the road traffic accident risk is moderate and 70.64% of the experts believe that the road traffic risk along Ubungo – Chalinze route in Tanzania is high. As the sum of the weight in the comprehensive evaluation fuzzy set is 1 and evaluation level "high risk" corresponds to the maximum membership grade, the principle of maximum membership grade suggests that the road traffic accident risk along the proposed route in Tanzania is high.

V. CONCLUSIONS

This paper presents a fuzzy based comprehensive model for assessing the road traffic accident risk on the route from Ubungo to Chalinze -Tanzania. The main risk factors for road traffic accidents are given by the Tanzania traffic police department. The severity scale of each risk factor is determined by appropriate experts in the transport industry. The weight of each risk factor to be used in the fuzzy comprehensive model is calculated by fuzzy pairwise comparison method. The evaluation results show that the road traffic accident risk on Ubungo – Chalinze route is high and the major contributory risk factor is human element. Thus, decision makers (i.e. road transport safety regulators) are called to take measures that will substantially reduce the impact and frequency of road traffic accidents. In addition, the fuzzy comprehensive evaluation model developed in this study can be a useful tool for insurers for setting adequate reserves and pricing of public liability and motor-insurance products. It is our view that the model also can be a right tool for risk assessment in various industrial enterprises. Furthermore, the proposed risk evaluation model can offer theoretical foundation for assessment of road traffic accident risk in other countries.

REFERENCES


