Hazard Level of Vehicle Smoke by Fuzzy Multiple Attribute Decision Making with Simple Additive Weighting Method

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Abstract

Clean air is a necessity for human. Human needs clean and healthy air without being contaminated by vehicle smoke that can endanger human health. vehicle smoke contains harmful substances for human including carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NOx) and lead metal (Pb). This can make air quality worse and can cause human be suffered of diseases including ARI (Acute Respiratory Infection), shortness of breath, sore eyes, coughing, brain damage and mental disability in children. Decision Support System (DSS) is a system to support Managerial decision makers in semi-structured decision situations and in this research author made a study of the DSS model to determine the level of danger of vehicle smoke, this study uses the Fuzzy Multiple Attribute Decision Making method (FMADM) where this method is a way to find optimal alternative from a number of alternatives with certain criteria, from very low things that was from 0-0.25, medium from 0.3-0.50, to the most dangerous thing that was from 0.8-1. Hopefully with the existence of this research later it can be useful for the community, especially for public health.

Key words : Decision Support System, FMADM, Vehicle Smoke

1. INTRODUCTION

1.1. Background

Today, technology development is very rapid, especially in motorized vehicles, now motor vehicles the number of motor vehicle users is increasing, especially in big cities, the selling of motor vehicle is increasing by day, when the price of two-wheeled and four-wheeled vehicles is getting cheaper, vehicle provider is increasingly making profits from community demand. The large number of motorized vehicles will also cause a lot of air pollution that is often not be realized by motor vehicle users. The impact is very dangerous for health and environment. According to the website reported by Satuharapan.com, motor vehicle pollution is the biggest contributor of air pollution in Jakarta. About 70 percent of motor vehicle causes bad air quality in Jakarta with comparative correlations of population growth and the number of motor vehicles.

Jakarta is the worst city with the highest pollution level in Indonesia and the third worst in the world after Mexico and Thailand. Vehicle smoke contains harmful substances for human namely, carbon dioxide (CO_2), it causes increasing of surface temperature of the earth, carbon monoxide (CO), it causes pain in the eyes and lungs, nitrogen oxide (NOx) , it causes irritation to the eye and reduces visibility and lead metal (Pb), it causes brain damage and mental disability of children. According to Law No. 14 1992 about Road Traffic and Transportation, it has imposed the obligation to test motor vehicle emission. Article 50 section (1) and paragraph (2) of the Act states, "To prevent air pollution and noise from motor vehicles that can interfere with environmental sustainability, every motor vehicle must meet the requirements for exhaust smokeand noise level. Decision Support System (DSS) to know the hazard level of vehicle smoke using the Fuzzy Multiple Attribute Decision Making (FMADM) method where this method is a way to find optimal alternatives from a number of alternatives with certain criteria. Hopefully with the existence of this research later it can be useful for the community, especially towards public health.

1.2 Problem Formulation

1. Vehicle smoke contains harazrdous matter for human, among others carbon dioxide (CO2) that causes increasing of surface temperature, carbon monozide (CO) causes pain in the eyes and lungs, nitrogen oxide (NOx), it causes irritation to the eye and reduces visibility and lead metal (Pb), it causes brain damage and mental disability of children
2. How to know harardous level of vehicle smoke?

1.3 Problem Limitation

1. This research used model Decision Support System (DSS) to know hazard level of vehicle smoke using Fuzzy Multiple Attribute Decision Making (FMADM).
2. The danger of vehicle emission

1.4 Research purpose

1. To make community know the danger of vehicle smoketo health level.
2. The air inhaled is fresh, clean and good for health.

1.5 Research benefit.

The benefit of this research for the community is to be able to differentiate vehicles that are suitable for use and those that are not, the vehicles used must carry out maintenance every month

2.   LITERATURE REVIEW
2.1 Main Concept of DSS
2.1.1 Decision Support System (DSS)

Decision Support System (DSS) is a system to support managerial decision makers in semi-structured decision situations. The DSS is intended to be a tool for decision makers to expand their capabilities, but not to replace their judgment (Alit, P. 2012).

The next attempt in defining the DSS concept was done by Steven L. Alter.Alter conducted a study of 56 decision support systems used at the time, the study provided knowledge in identifying six types of DSS, namely:

a. Retrive information element
b. Analyze entries files
c. Prepare reports form multiple files (standart report from some files).
d. Estimate decisions consquences
e. Propose decision.
f. Making decisions.

In DSS there are three purposes that mus be achieved, namely :
a. Help manager in making decision in solving semi structured problem
b. Support manager decision and not changing the decision
c. Improve manager effectivity in decision making and not efficiency enhancment

This purpose relates to three basic principles of DSS concept, namely the structure of the problem, decision support, and decision effectiveness. Decision Support System (DSS) as a system that provides support to a manager, or to a relatively small group of managers who work as a problem-solving team, in solving semi-structured problems by providing information or suggestions regarding to certain decisions. This information is provided by periodic reports, special reports, as well as output from mathematical models. The model also has the ability to provide advice at various levels

2.1.2   Fuzzy Multiple Attribute Decision Making (FMADM)

FMADM is a method used to find optimal alternatives from a number of alternatives with certain criteria. The essence of FMADM is to determine the weight value for each attribute, then proceed with the ranking process that will select alternatives that have been given. Basically, there are 3 approaches to find attribute weight score, namely subjective approach, objective approach and integration approach between subjective and objective. Each approach has advantages and disadvantages. In the subjective approach, the weight value is determined based on the subjectivity of the decision makers, so several factors in the alternative ranking process can be determined freely. Whereas in the objective approach, the weight score is calculated mathematically so that it ignores the subjectivity of the decision maker.

2.1.3 FMADM Algorithm
FMADM Algorithm is:
1. Give score for each alternative (Ai) in each determined criterion (Cj) where the score is based on crisp i=1,2,....m dan j=1,2,....n.
2. Give weight score (W) that is obtained from crisp score.

3. Perform matrix normalization by calculating normalized performance rating score from Ai alternative in Cj attribute based on equation adjusted with attribute (benefit attribute = Maximum or cost = Minimum. If the attribute is benefit then crisp score (Xij) from each attribute column is divided by MAX Xij crips score from each column, wherease for attribute cost, Min crisp score (MIN Xij) from each column is divided by Xij crisp score each column.
4. Perform ranking process by multiplying normalized matrix (R) with weight score (W).
5. Determine preference score for each alternative (Vi) by adding the multiplication result between R normalized matrix with weight score (W). The greater Vi score indicates Ai alternative is more selected.

2.1.4 Finishing Step

This research used SAW method FMADM.
The steps are :
1. Determine criteria that can be reference in decision making namely Ci
2. Determine compatibility rating for each alternative in each attribute.
3. Make decision matrix based on Ci criterion then perform matrix normalization adjusted with attribute type (benefit attribute or cost attribute) so it is obtained R normalized matrix.
4. Final result obtained from ranking process is addition from R normalized matrix multiplication with weight vector so it is obtained greatest score selected as best alternative (Ai) as solution.

2.1.5 Simple Additive Weighting (SAW)

SAW (Simple Additive Weighting) known, also known as weighted addition method. Main concept of SAW method is looking for weighted addition from performance rating of each alternative in all attribute. SAW method needs decision normalized matrix (X) to a comparable scale with all existing alternatives.

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{\underset{i}{Max}\, x_{ij}} \\[2ex] \dfrac{\underset{i}{Min}\, x_{ij}}{x_{ij}} \end{cases}$$

Description :
r_{ij} = Performance rating score
Max x_{ij} = Maximum score from each row and column
Min x_{ij} = Minimum score from each row and column
X_{ij} = row and column from matrix
With r_{ij} is normalized performance rating from Ai alternative at Cj; i =1,2...m and j = 1,2...n.

Preference score for each alternative (Vi) given as ::

$$V_i = \sum_{j=1}^{n} w_j r_{ij}$$

V_i = Preference score
W_j = ranking weight
r_{ij} = normalized performance rating
Greater V_i score indicates Ai alternative is more selected.
Some steps in finishing Simple Additive Weighting (SAW) :
1. Determine reference criteria in decision making namely Ci.
2. Determine compatibility rating for each alternative in each criteria.
3. Create decision matrix based on (Ci) criterion then perform matrix normalization based on adjusted equation with attribute type (benefit attribute or cost attribute) so it is needed R normalized matrix.
4. Final result is obtained from ranking process namely addition from matrix multiplication with R normalized with vector weight so it is obtained greatest score which is selected as Ai best alternative as solution [2].

2.1.6 Smoke

Smoke is a suspension of small particles in the air (aerosols) that comes from incomplete combustion of a fuel. Smoke is generally an unwanted byproduct of fire (including stoves and lamps) and heating, but can also be used for pest eradication (fumigation), communication (smoke signals), defense (smoke screen) or tobacco or dope. Smoke is sometimes used as a flavoring agent and preservative for various food ingredients.

2.1.7 Vehicle

Vehicle is a means of transportation, both driven by machines and by living things. These vehicles are usually man-made (cars, motorcycles, trains, boats, planes), but some are not man-made and can still be called vehicles, such as icebergs, and floating tree trunks. Non-motorized vehicles can also be driven by humans or pulled by animals, such as carts.

3. RESEARCH METHOD

3.1 Data Collection

Data collection methods used were as follows :
1. Observation
   Perform observation to know how danger the vehicle emission.
2. Interview
   - Why vehicle smoke is dangerous ?
   - What kind of disease caused by vehicle smoke?
   - How to overcome it?
3. Literature study by looking for references :
   - Related books
   - Internet
   - Library

3.2 Design Model

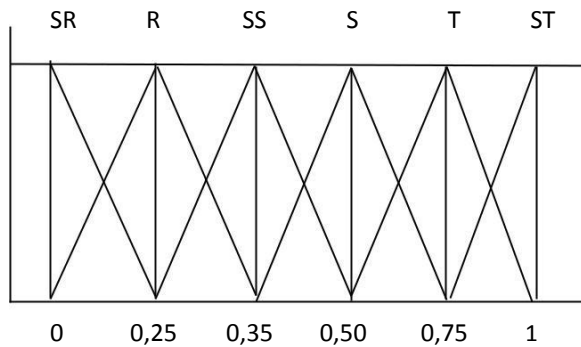Design model used in this research was Fuzzy Multiple Attribute Decision Making (FMADM).

Figure 1. Hazard variable level of vehicle smoke

3.3 System need analysis

3.3.1 Input need analysis

Input need data or hardware in this study was all objects needed by built system namely decision support system. Collected data will be processed become output.

3.3.2 Output need analysis

Output need data is output from input data processed become information to be a real decision support system.

4. DESIGN AND IMPLEMENTATION

In this research, selection of vehicle smoke hazard level used *Fuzzy Multiple Attribute Decision making (FMADM)* with some criteria among others :

C1= vehicle fuel
C2 = vehicle smoke color
C3 = pollutan material of vehicle smoke
C4 = substance component of vehicle smoke
C5 = disease caused by vehicle smoke
C6= impact to environment

The result was the ranking of alternative from lowest rank to highest rank. Final result obtained from each criteria had different weight score, from each criterion was determined its weight. At weight contained four numbers namely: very low (SR), low (R), very medium (SS), medium (S), high (T), very high (ST), the following are table criteria :

Table 1. (C1) Criteria of vehicle fuel

Vehicle Fuel	Weight	Crisp Number
Premium	Very low (SR)	0
Pertamax	Low (R)	0.25
Diesel Fuel	Very medium (SS)	0.35

4.1 Color of vehicle smoke

These criteria   are the data needed in making decisions based on the color of the vehicle's smoke, namely thin white, thick white, bluish and black. The following is the interval description of the number of persons who live and have been converted to fuzzy number.

Table 2. (C2) Criteria of color

Smoke color of vehicle	Weight	Crisp Number
Thin white	Very low (SR)	0
Thick white	Low (R)	0.25
Bluish	Very medium (SS)	0.35
Black	Medium (S)	0.50

4.2 Pollutant resulted by vehicle smoke

These criteria are the data needed in making decisions based on air pollutant including particle, energy, gas and chemical substance. The following is the interval description of the number of persons who live and have been converted to fuzzy numbers.

Table 3. (C3) criteria of air pollutant

Air pollutant	Weight	Crisp number
Particle	Very low (SR)	0
Energy	Low (R)	0.25
Gas	Very medium (SS)	0.35
Chemical substance	Medium (S)	0.50

4.3 The contain of vehicle smoke

These criteria are the data needed in making decisions based on the substance content of smoke from vehicles where the content can interfere with human health. The following is the interval description of the number of persons who live and have been converted to fuzzy numbers.

Table 4.(C4) criteria of vehicle smoke contain

Vehicle smoke contain	Weight	Crisp number
Carbon dioxide (Co2)	Very low (SR)	0
Carbon monoxide (Co)	Low (R)	0.25
Nitrogen dioxide (Nox)	Very medium (SS)	0.35
Sulfur dioxide	Medium (S)	0.50
Lead metal (Pb)	High (T)	0.75

4.4 Disease caused by vehicle smoke

These criteria are the data needed in making decisions based on vehicle smoke-induced diseases, namely eye irritation, ARI, Lung and brain damage which can interfere with human health. The following is the interval description of the number of persons who live and have been converted to fuzzy numbers.

Table 5. (C5) criteria of disease caused by vehicle smoke

Disease caused by vehicle smoke	Weight	Crisp Number
Eye irritation	Very low (SR)	0
Nasal irritation	Low (R)	0.25
Throat irritation	Very medium (SS)	0.35
ISPA	Medium (S)	0.50
Lung disease	Very low (SR)	0.75
Brain damage	low (R)	1

4.5 Impact to environment

These criterion are the data needed in making decisions based on the impact to environment of the vehicle, namely, acid rain, damaging the ozone layer and inhibiting plant growth. The following is the interval description of the number of persons who have been converted to fuzzy numbers.

Table 6. (C6) criteria of impact to environment

Air pollutants	Weight	Crisp number
Acid rain	Medium (S)	0.50
Damaging ozon layer	High (T)	0.75
Inhibit plant growth	Very high (ST)	1

4.6 Weight calculation

The following is manual calculation formed by X converted decison matrix with Simple Additive Weighting, as follows :

Alternative	Criteria					
	C1	C2	C3	C4	C5	C6
A1	0.25	0.35	0.75	0.50	1	0.25
A2	0.35	0.50	0.35	0.25	0.50	0.35
A3	0.75	1	0.25	0.35	0.50	0.25
A4	0.50	0.25	0.35	1	0.45	0.35
A5	1	0.50	0.25	0.75	0.35	0.45
A6	0.25	0.35	0.50	1	0.35	0.25
A7	0.45	0.25	0.35	0.50	0.25	1
A8	0.35	0.50	0.75	0.25	0.25	0.35
A9	1	0.75	0.35	0.25	0.50	0.25
A10	1	1	0.25	0.35	0.50	0.25

From C1 column maximal score was 0.75, then every row from C1 column was divided with maximum score of C1 column.

$R_{1,1} = 0.25/0.75 = 0.33$
$R_{2,1} = 0.35/0.75 = 0.47$
$R_{3,1} = 0.25/0.75 = 0.33$
$R_{4,1} = 0.50/0.75 = 0.7$
$R_{5,1} = 0.35/0.75 = 0.47$
$R_{6,1} = 0.25/0.75 = 0.33$
$R_{7,1} = 0.35/0.75 = 0.47$
$R_{8,1} = 0.35/0.75 = 0.47$
$R_{9,1} = 0.75/0.75 = 1$
$R_{10,1} = 0.25/0.75 = 0.33$

From C2 column maximal score was 1, then every row from C1 column was divided with maximum score of C2 column.

$R_{1,1} = 0.35/1 = 0.35$
$R_{2,1} = 0.50/1 = 0.50$
$R_{3,1} = 1/1 = 1$
$R_{4,1} = 0.25/1 = 0.25$
$R_{5,1} = 0.50/1 = 0.50$
$R_{6,1} = 0.35/1 = 0.35$
$R_{7,1} = 0.25/1 = 0.25$
$R_{8,1} = 0.50/1 = 0.50$
$R_{9,1} = 0.35/1 = 0.75$
$R_{10,1} = 1/1 = 1$

From C3 column maximal score was 0.75, then every row from C3 column was divided with maximum score of C3 column.

$R_{1,1} = 0.75/0.75 = 1$
$R_{2,1} = 0.35/0.75 = 0.47$
$R_{3,1} = 0.25/0.75 = 0.33$
$R_{4,1} = 0.35/0.75 = 0.47$
$R_{5,1} = 0.25/0.75 = 0.33$
$R_{6,1} = 0.50/0.75 = 0.7$
$R_{7,1} = 0.35/0.75 = 0.47$
$R_{8,1} = 0.75/0.75 = 1$
$R_{9,1} = 0.25/0.75 = 0.33$
$R_{10,1} = 0.75/0.75 = 1$

From C4 column maximal score was 2 then every row from C4 column was divided with maximum score of C4 column.

$R_{1,1} = 0.50/1 = 0.50$
$R_{2,1} = 0.25/1 = 0.25$
$R_{3,1} = 0.35/1 = 0.35$
$R_{4,1} = 1/1 = 1$
$R_{5,1} = 0.75/1 = 0.75$
$R_{6,1} = 1/1 = 1$
$R_{7,1} = 0.50/1 = 0.50$
$R_{8,1} = 0.25/1 = 0.25$
$R_{9,1} = 0.25/1 = 0.25$
$R_{10,1} = 0.35/1 = 0.35$

From C5 column maximal score was 0.50 then every row from C5 column was divided with maximum score of C5 column.

$R_{1,1} = 0.25/0.50 = 0.5$
$R_{2,1} = 0.50/0.50 = 1$
$R_{3,1} = 0.35/0.50 = 0.7$
$R_{4,1} = 0.50/0.50 = 1$
$R_{5,1} = 0.35/0.50 = 0.7$
$R_{6,1} = 0.35/0.50 = 0.7$
$R_{7,1} = 0.25/0.50 = 0.5$
$R_{8,1} = 0.25/0.50 = 0.5$
$R_{9,1} = 0.35/0.50 = 0.7$
$R_{10,1} = 0.25/0.50 = 0.5$

From C6 column maximal score was 1 then every row from C6 column was divided with maximum score of C6 column.

$R_{1,1} = 0.25/1 = 0.25$
$R_{2,1} = 0.35/1 = 0.35$
$R_{3,1} = 0.25/1 = 0.25$
$R_{4,1} = 0.35/1 = 0.35$
$R_{5,1} = 0.50/1 = 0.50$
$R_{6,1} = 0.25/1 = 0.25$
$R_{7,1} = 1/1 = 1$
$R_{8,1} = 0.35/1 = 0.35$
$R_{9,1} = 0.25/1 = 0.25$
$R_{10,1} = 0.25/1 = 0.25$

Then from rij normalization result made R normalized matrix

Then determining the weight that will be used for ranking process.

Next step was ranking searching or best score by inputting every criteria obatined then it will be created matric multiplication W*R and addition from multiplication result to obtain best alternative by performing ranking and it was obtained greatest preference as follows :

$V1 = (0.33 \times 0.3) + (0.35 \times 0.3) + (1 \times 0.01) + (0.50 \times 0.01) + (0.5 \times 0.5) + (0.25 \times 0.5)$
$= 0.009 + 0.105 + 0.01 + 0.0050 + 0.25 + 0.125$
$= 0.594$

$V2 = (0.47 \times 0.3) + (0.50 \times 0.3) + (0.47 \times 0.01) + (0.35 \times 0.01) + (1 \times 0.5) + (0.35 \times 0.5)$
$= 0.141 + 0.15 + 0.0047 + 0.0035 + 0.5 + 0.175$

$= 0.9742$
$V3 = (0.33 \times 0.3) + (1 \times 0.3) + (0.33 \times 0.01) + (0.25 \times 0.01) + (0.7 \times 0.5) + (0.25 \times 0.5)$
$= 0.3 + 0.3 + 0.0033 + 0.0025 + 0.35 + 0.125$
$= 0.8798$

$V4 = (0.47 \times 0.3) + (0.25 \times 0.3) + (0.47 \times 0.01) + (1 \times 0.01) + (1 \times 0.5) + (0.35 \times 0.5)$
$= 0.21 + 0.075 + 0.0047 + 0.01 + 0.5 + 0.175$
$= 0.9747$

$V5 = (0.47 \times 0.3) + (0.50 \times 0.3) + (0.33 \times 0.01) + (0.75 \times 0.01) + (0.7 \times 0.5) + (0.50 \times 0.5)$
$= 0.141 + 0.15 + 0.0033 + 0.0075 + 0.35 + 0.25$
$= 0.9018$

$V6 = (0.33 \times 0.3) + (0.35 \times 0.3) + (0.7 \times 0.01) + (1 \times 0.01) + (0.7 \times 0.5) + (0.25 \times 0.5)$
$= 0.099 + 0.105 + 0.07 + 0.01 + 0.35 + 0.125$
$= 0.759$

$V7 = (0.47 \times 0.3) + (0.25 \times 0.3) + (0.47 \times 0.01) + (0.50 \times 0.01) + (0.5 \times 0.5) + (1 \times 0.5)$
$= 0.141 + 0.075 + 0.0047 + 0.005 + 0.25 + 0.5$
$= 0.9757$

$V8 = (0.47 \times 0.3) + (0.50 \times 0.3) + (1 \times 0.01) + (0.25 \times 0.01) + (0.5 \times 0.5) + (0.35 \times 0.5)$
$= 0.141 + 0.15 + 0.01 + 0.0025 + 0.25 + 0.175$
$= 0.7285$

$V9 = (1 \times 0.3) + (0.35 \times 0.3) + (0.33 \times 0.01) + (0.25 \times 0.01) + (0.7 \times 0.5) + (0.25 \times 0.5)$
$= 0.3 + 0.105 + 0.0033 + 0.0025 + 0.35 + 0.125$
$= 0.8858$

$V10 = (0.33 \times 0.3) + (1 \times 0.3) + (1 \times 0.01) + (0.35 \times 0.01) + (0.5 \times 0.5) + (0.25 \times 0.5)$
$= 0.099 + 0.3 + 0.01 + 0.0025 + 0.25 + 0.125$
$= 0.7865$

From score calculation above obtained score as follows :

no	Score	Hazard Level
1	V1=0.594	Medium
2	V2=0.9742	High/dangerous
3	V3=0.8798	High/dangerous
4	V4=0.9747	High/dangerous
5	V5=0.9018	High/dangerous
6	V6=0.759	High/dangerous
7	V7=0.9757	High/dangerous
8	V8=0.7285	High/dangerous
9	V9=0.8858	High/dangerous
10	V10=0.7865	High/dangerous

From selection obtained, in determing hazard level of vehicle smoke then obtained alternative V7 = 0.9757 that was highest variable.

5. CONCLUSION AND SUGGESTION

5.1 Conclusion

The concept of decision support system design to determine the level of vehicle smokehazard using Fuzzy Multiple Attribute Decision Making (FMADM) and it is expected to be a reference for further system development. In this study the authors can conclude that in determining the level of vehicle smokehazard there were some alternatives: V1 = 0.594 was medium variable, V2 = 0.9742 and V3 = 0.8798 were high / dangerous variable, V4 = 0.9747 was high / dangerous variable, V5 = 0.9018 was high / dangerous variable, V6 = 0.759 was variable high / dangerous, V7 = 0.9757 was high / dangerous variable, V8 = 0.7285 was high / dangerous variable, V9 = 0.8858 was high / dangerous variable, V10 = 0.7865 was high / dangerous variable.

5.2 Suggestion

Author expects in this journal creation can be developed different methods like :

1. DSS method to know hazard level of vehicle smoke using fuzzy multiple attribute decision making (FMADM) with vb net application.
2. DSS model to determine the level of vehicle smokehazard using analytical hierarcy process (AHP) methods etc.

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