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AHP-based Prioritization on Road Accidents Factors: A Case Study of Thailand

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ABSTRACT

As Analytic Hierarchy Process (AHP) being to handle multi-criteria analysis for complex decision making, AHP has been used as a study tool to learn and prioritize information that could prevent and reduce accidents. Information is obtained from questionnaire with one hundred respondents. Criteria and sub-criteria are adapted from White Paper for Safe Roads in 2050 of UN (2010). Four criteria include factors pertinent to 1) engineering (sub-criteria: road geometries, traffic signs, traffic signals, and rainwater drainage), 2) economics (sub-criteria: cost-effective road safety investments, cost-effective auto maintenance investments, and cost-effective road maintenance investments), 3) environmental and social (sub-criteria: medical service, quality of life, public transportation, and bicycle commuting), and 4) safety management (sub-criteria: law enforcement, quality of accident data, and road users' knowledge of road rules). Respondents are selected groups of policemen, health care staffs (physicians and nurses), highway department personnel, academic and engineering staffs, and people in general. The questionnaire survey applies pairwise comparison, to study attitudes/preferences of respondents regarding accident factors of these criteria and sub-criteria. From AHP analysis, safety management factor is ordered first in the prioritization of this study. This agrees with AHP sub-criterion analysis that the most prioritized factors are law enforcement and knowledge of road rules, respectively.

1. Introduction

In Thailand, there are more than, up to end of December 2014, 34,682 registered vehicles of

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all types (TTP, 2015). Road accidents appear at a very high rate, with an estimated road traffic death rate 38.1 per 10000 populations (WHO, 2013). Only Bangkok alone, there are 2433 reported accidents in 2014 (ThaiRSC, 2015), *see* Figure 1. Thailand will need to give importance to accidents in order to prevent and reduce risk of accidents from happenings in the future. Accidents partly come from violations of traffic law especially where no cops present (Leelavijarn *et al*., 2014). Accidents also happen from many other factors. This study surveys and collects perceptions factors related to causes of accidents. Questionnaire is used to collect the information from respondents of selected professions. Questionnaire focuses on pairwise comparisons of criteria and sub-criteria of accident factors. The results are then prioritized using AHP as an analytical tool.

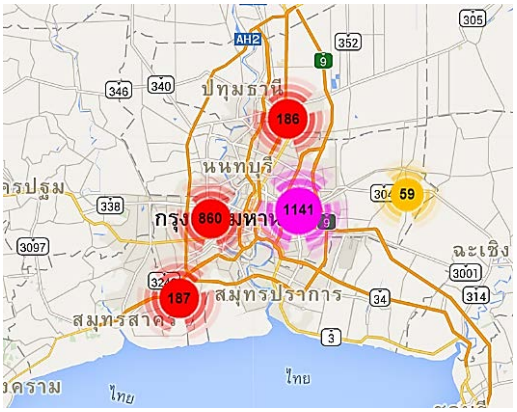

Figure 1: Reported accidents in Bangkok for 2014 (ThaiRSC, 2015).

2. Literature Review

Baker and Ross (1960) studied concepts and classification of traffic accident causes. Accidents causes are a combination of simultaneous and sequential variables. Contributing factors are in terms of operations and conditions of road-driver-car system.

Agent (1974) studied relationships between roadway geometrics and accidents (an analysis of Kentucky records). The study was to identify hazardous sites and hazardous highways using three-year accident Kentucky statewide records through types, frequencies, traffic control, safety belt usage, and severity index. The study found that accidents on curves had the highest severity index. Also, wearing safety belts could reduce severity.

Pengfei (2004) developed a rescue system that could find the shortest routes to accident sites. The study applied AHP and GIS, so the involved staffs could quickest arrive the accident scene for first aid.

Kang and Lee (2007) applied AHP to priorities of median barrier installation to maximize the effectiveness of median barriers in be installing in four-lane or wider national highways. AHP can deal with qualitative variables allowed making decisions by personal judgment in a logical way. With a systematic framework, the conditions are road sections and the overall

priorities of evaluation factors. This framework shows multiple criteria (economic efficiency, safety, possibility of installation, and regional equity) synthetically, and it gives the greatest weight to safety.

In 2010, more than 1.2 million people were killed on world roads' accidents (WHO, 2013). Engineering tools like bumps and humps (Namee and Witchayangkoon, 2011) cannot be applied on main streets and highways, for self-control driving. Ponboon *et al.* (2010) studied contributing factors of road crashes in Thailand using evidences from the accident for in-depth study. The findings found different characteristics of crashes encapsulating most of the accident cases in Thailand, relating to motorcycle accidents, behavior of young drivers, road side hazard crashes, and rollover crashes. However, there has never been a study about opinions on road accidents factors from selected group in Thailand using AHP. This study then prioritizes accident factors using AHP as analyzing tool.

3. Methodology

3.1 AHP

In this study, analytic hierarchy process (AHP) is used to understand the understanding of respondents pertinent to the importance of the accident factors, in a prioritizational way, that could prevent and reduce accident rate. This study uses free JavaScript web-based AHP analytical tool from BPMSG AHP Online System (BPMSG, 2014). AHP method supports multi-criteria decision making, by deriving ratio scales from paired comparisons of criteria. This study inputs are subjective opinions obtained from questionnaire. AHP calculates *priorities* (weightings) and a *consistency ratio* (BPMSG, 2014). Having study goal on prioritized accident factor, with multi-criteria and multi-sub-criteria, AHP help to derive *priorities*, as shown in Figure 2.

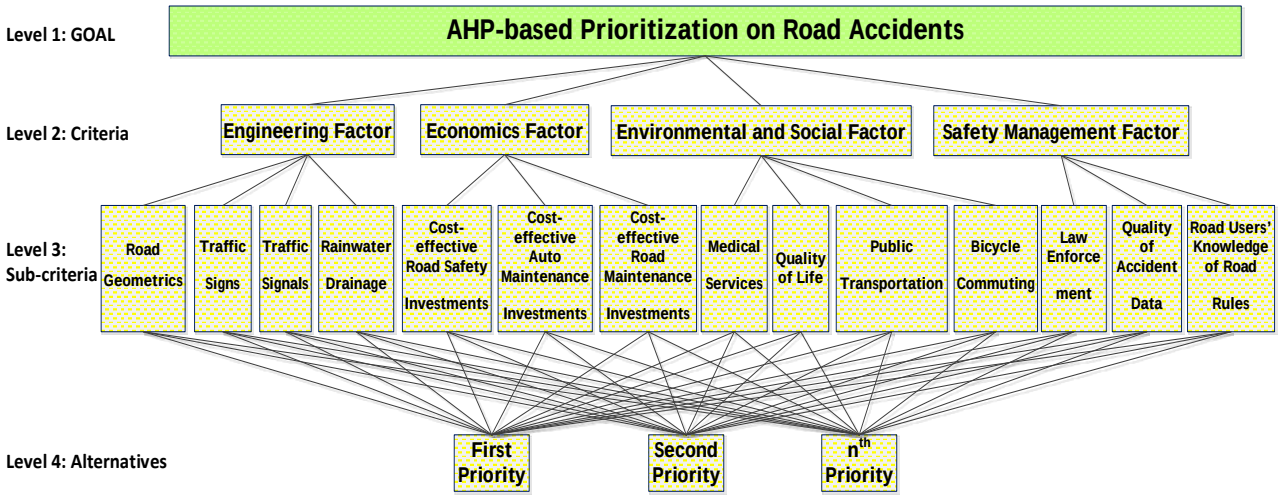

Figure 2: AHP-based periodization on road accidents factors with criteria and sub-criteria.

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3.2 Questionnaire Survey

A questionnaire consists of a series of questions (checklist close-ends). Total four criteria are asked including factors pertinent to engineering, economics, environmental and social, and safety management. Each criterion has sub-criteria. For criterion on engineering factor, sub-criteria are road geometry, traffic signs, traffic signals, and rainwater drainage. For criterion on economics factor, sub-criteria are cost-effective road safety investments, cost-effective auto maintenance investments, and cost-effective road maintenance investments. For criterion on environmental and social factor, sub-criteria are medical service, quality of life, public transportation, and bicycle commuting. For criterion on safety management factor, sub-criteria are law enforcement, quality of accident data, and road users' knowledge of road rules. All these criteria and sub-criteria are adapted from White Paper for Safe Roads in 2050 of UN (2010).

A privacy statement is stated that no interviewer's identity is collected. The pilot test questionnaire is conducted for ten respondents to obtain feedbacks for improvements, such that each questionnaire question can be more clearly understood.

There are 100 respondents taken parts in the questionnaire survey, during August 2014. Respondents are selected group of policemen, health care staffs (physicians and nurses), highway department personnel, staffs from academic and engineering, and people in general. This study has 20 respondents from each selected group.

3.3 Pairwise Comparison

This questionnaire survey applies pairwise comparison. Pairwise comparison is used to study attitudes/preferences of respondents. With pairwise comparisons, criterion entities in pairs are judged for relative importance of one criterion over another. Respondents are asked to compare criterion/ sub-criterion as pairwise comparison with details intensity of importance, definition, and explanation as exhibited in Table 1. Sub-criteria are explained in Table 2. These information are given in the questionnaire for respondents to read and get better understanding about the asked questions.

Table 1: Intensity of importance for criterion/ sub-criterion pairwise comparison (adapted from Saaty (2008))

Scale	Definition	Explanation
1	Equal importance	Two criteria pay equally to the accident factor.
2	Moderate importance	Experience and judgment slightly favor one criterion over another
3	Strong importance	Experience and judgment strongly favor one criterion over another
4	Very strong or demonstrated importance	A criterion is favored very strongly over another.
5	Extreme importance	The evidence favoring one criterion over another is of the highest possible order of affirmation.

Table 2: Explanation of each sub-criterion.

criterion	sub-criterion
1.Engineering Factor	1.1 Roadway geometrics Roadway should have good geometrics, following highway manual and standard. Roadway factor includes lane, degree of horizontal curvature, shoulder and median widths, and the section's length.
	1.2 Traffic Signs All traffic signs can be clearly seen at all time, along the route without confusing users. All traffic signs must be free from obstructions such as trees, light poles. All traffic signs must be placed correctly, according to the standard for installation.
	1.3 Traffic Signals Traffic signals must be seen clearly without being distracted. Traffic signals are seen in the specified direction correctly, no conflict with traffic lights from nearby intersections.
	1.4 Rainwater Drainage Road surface, with a slope adequate drainage, can prevention flooding. Rainwater drainage system is maintained in good condition.
2.Economics Factor	2.1 Cost-effective Road Safety Investments Cost-effective road safety investments are via applying engineering tools, such as traffic cones, traffic barriers, speed bumps/humps, and highway crash cushions, etc.
	2.2 Cost-effective Auto Maintenance Investments Cost-effective auto maintenance investments involved the repair and maintenance spending amount to keep vehicles in good condition, in order to reduce accidents, as accidents make other vehicles to waste fuel from traffic jam caused by such accidents.
	2.3 Cost-effective Road Maintenance Investments Cost-effective road maintenance investments embraced continuing maintenance for accidents reduction. Road maintenance investments are in terms of traffic signs, road surface conditions, and road surface markings and comply with involved standards.
3.Environmental and Social Factor	3.1 Medical Services With emergency calling system, emergency ambulance can take care of injuries from road accidents using modern medical equipment. Vehicles should equip with the emergency calling system (E-Call system) for information and a quick trip of the ambulance.
	3.2 Quality of Life Improvement of road way condition and surrounding, including unsafe area, is implemented to enhance quality of life.
	3.3 Public Transportation Public Service involves availability of public transport, convenience of travel, as well as satisfaction of users on public services such as taxi, bus, train, subway, vanpool commuting, etc.
	3.4 Bicycle Commuting Roadways should give adequate channels for travel by bicycle while giving safety. Riders should ride with confident about safe riding.
4.Safety Management Factor	4.1 Law Enforcement Law enforcement should be stringent; a person who has committed or is committing a violation of traffic laws shall have the authority to arrest the person.
	4.2 Quality of Accident Data Data collection and quality of accident data should be improved to be more accurate. It should also improve data processing, data storage and retrieval, data distributions.
	4.3 Road Users' Knowledge of Road Rules Public–private partnership (PPP) should roll out campaigns and activities to urge the road users to realize the traffic rules, and accept ethical and safety driving.

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Respondents are asked to give relative importance rating between two main criteria, as pairwise comparison, *see* Table 3. Similarly, pairs of sub-criteria factors of each criterion are also pairwise compared through relative importance ratings, *see* Tables 4, 5, 6, and 7.

Table 3: Relative importance scoring of pairwise comparison on criterion factor affecting road accidents.

Criterion A	Criterion A is more importance compared to criterion B	=*	Criterion B is more importance compared to criterion A	Criterion B
Engineering factor	5 4 3 2	1	2 3 4 5	Economics factor
Engineering factor	5 4 3 2	1	2 3 4 5	Environmental and social factor
Engineering factor	5 4 3 2	1	2 3 4 5	Safety management factor
Economics factor	5 4 3 2	1	2 3 4 5	Environmental and social factor
Economics factor	5 4 3 2	1	2 3 4 5	Safety management factor
Environmental and social factor	5 4 3 2	1	2 3 4 5	Safety management factor

* = referring to equal importance of criterion A and criterion B.

Table 4: Relative importance scoring of pairwise comparison on sub-criterion factor (under Engineering criterion) affecting road accidents.

Sub-criterion A	Sub-criterion A is more importance compared to sub-criterion B	=*	Sub-criterion B is more importance compared to sub-criterion A	Sub-criterion B
Roadway geometrics	5 4 3 2	1	2 3 4 5	Traffic Signs
Roadway geometrics	5 4 3 2	1	2 3 4 5	Traffic signals
Roadway geometrics	5 4 3 2	1	2 3 4 5	Rainwater Drainage
Traffic Signs	5 4 3 2	1	2 3 4 5	Traffic signals
Traffic Signs	5 4 3 2	1	2 3 4 5	Rainwater Drainage
Traffic signals	5 4 3 2	1	2 3 4 5	Rainwater Drainage

* = referring to equal importance of sub-criterion A and sub-criterion B.

Table 5: Relative importance scoring of pairwise comparison on sub-criterion factor (under Economics criterion) affecting road accidents.

Sub-criterion A	Sub-criterion A is more importance compared to sub-criterion B	=*	Sub-criterion B is more importance compared to sub-criterion A	Sub-criterion B
cost-effective road safety investments	5 4 3 2	1	2 3 4 5	cost-effective auto maintenance investments
cost-effective road safety investments	5 4 3 2	1	2 3 4 5	cost-effective road maintenance investments
cost-effective auto maintenance investments	5 4 3 2	1	2 3 4 5	cost-effective road maintenance investments

* = referring to equal importance of sub-criterion A and sub-criterion B.

Table 6: Relative importance scoring of pairwise comparison on sub-criterion factor (under Environmental and social factor criterion) affecting road accidents.

Sub-criterion A	Sub-criterion A is more importance compared to sub-criterion B	=*	Sub-criterion B is more importance compared to sub-criterion A	Sub-criterion B
Medical Services	5 4 3 2	1	2 3 4 5	Quality of Life
Medical Services	5 4 3 2	1	2 3 4 5	Public Service
Medical Services	5 4 3 2	1	2 3 4 5	Bicycle Commuting
Quality of Life	5 4 3 2	1	2 3 4 5	Public Service
Quality of Life	5 4 3 2	1	2 3 4 5	Bicycle Commuting
Public Service	5 4 3 2	1	2 3 4 5	Bicycle Commuting

* = referring to equal importance of sub-criterion A and sub-criterion B.

Table 7: Relative importance scoring of pairwise comparison on sub-criterion (under Safety management factor criterion) affecting road accidents.

Sub-criterion A	Sub-criterion A is more importance compared to sub-criterion B	=*	Sub-criterion B is more importance compared to sub-criterion A	Sub-criterion B
Law Enforcement	5 4 3 2	1	2 3 4 5	Quality of Accident Data
Law Enforcement	5 4 3 2	1	2 3 4 5	Road Users' Knowledge of Road Rules
Quality of Accident Data	5 4 3 2	1	2 3 4 5	Road Users' Knowledge of Road Rules

* = referring to equal importance of sub-criterion A and sub-criterion B.

4. Study Result and Discussion

From the analysis of questionnaire survey using AHP, it is found that in overall safety management factor gets the important factor in the respondents' viewpoint, while the least important factor affecting road accidents is economics. Figure 3 shows prioritized criterion, with percentage of each factor.

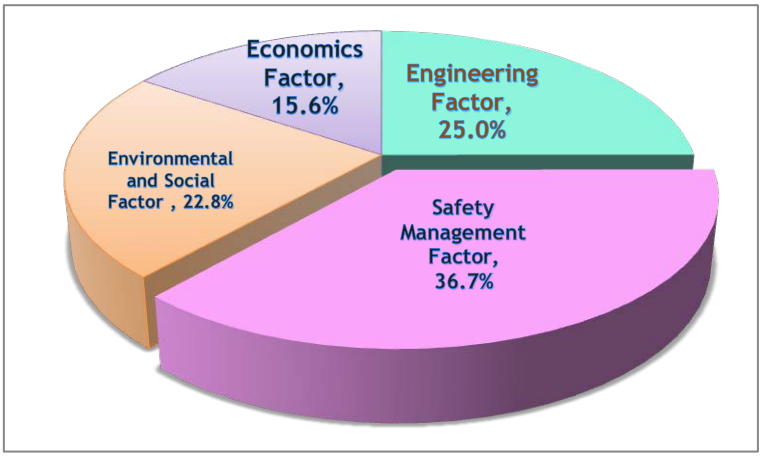

Figure 3: Prioritized criterion

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With AHP analysis of all 100 respondents, prioritization of all sub-criteria is displayed in Figure 4. Respondents give importance to law enforcement as a critical factor to road safety. This corresponds to the well-known fact of weak law enforcement of Thai police officers to control traffics and accidents. This causes many drivers fail to follow the traffic laws. If stricter traffic laws are enforced, then there will be fewer injuries and deaths.

Figure 4, the second importance sub-criterion is road users' knowledge of road rules. Peoples who operate the vehicles must know the exact road rules. Involved agencies should continue having campaigns to give awareness to public, to strictly follow the road rules. Look at Thailand accidents data from year 2014 classified by ages, it is found that people ages between 0-22 year olds take 55.50%, *see* Figure 5. Therefore it is suggested to add road knowledge of road rules into educational learning of all levels. Bicycle commuting sub-criterion gets least importance due to that the bicycle paths are available only in some areas and people feel unsafe about using bicycles.

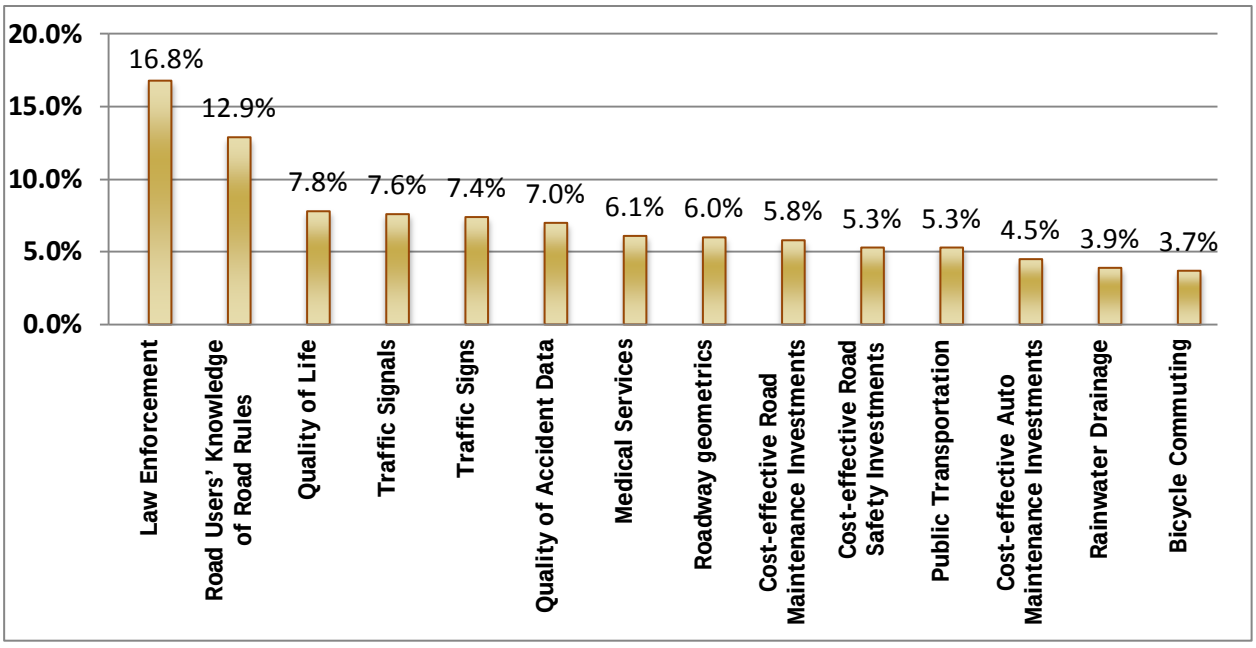

Figure 4: Prioritized sub-criterion**.**

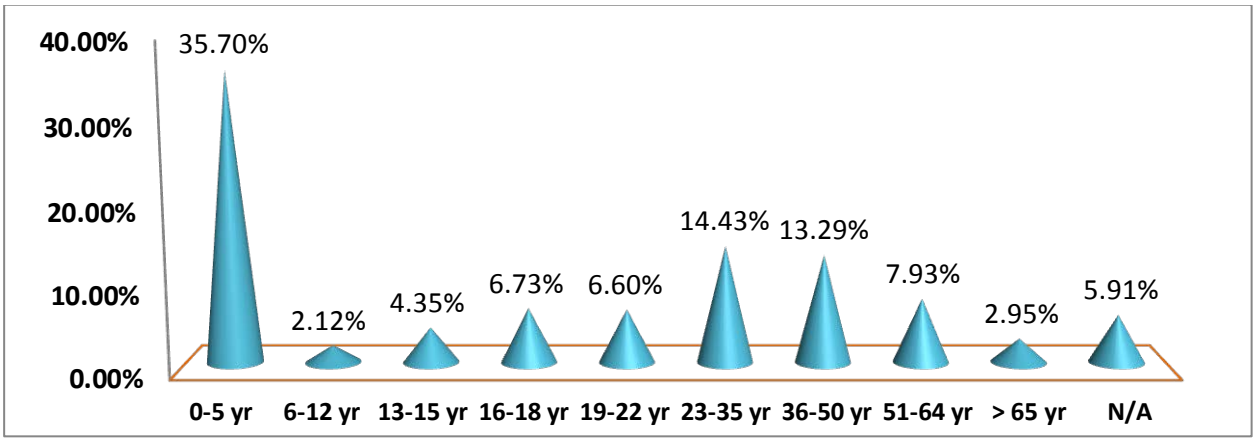

Figure 5: Thailand 2014 road accidents classified by ages (data from ThaiRSC, 2015).

5. Conclusion

The World Health Organisation (WHO) has urged Thailand to strengthen the enforcement of traffic regulations to improve road safety. This study evaluates opinions regarding factors of road accidents using pairwise comparison questionnaire to ask selected groups of policemen, health care staffs (physicians and nurses), highway department personnel, and academic and engineering staffs, with total 100 respondents. Criteria and sub-criteria are adapted from White Paper for Safe Roads in 2050 of UN (2010), with total four criteria. With AHP analysis, the first prioritized criterion is safety management factor. This corresponds to AHP sub-criterion analysis that law enforcement and road users' knowledge of road rules are the most prioritized factors that need the highest attention.

6. Acknowledgements

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