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Road safety development evaluation in the ASEAN region

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Abstract. Catch a glimpse of the serious and severe traffic situation, it is conceivably that the systematic assessment of road safety in the dimension of national level is indispensable and extremely essential. In this connection, the main body of the article proposed a set of evaluation measure based on Entropy-TOPSIS-RSR. In addition, the reliability and scientific nature of this method were tested through robustness analysis. In conclusion, the proposal of the measure will definitely provide a scientific decision-making basis for the formulation of action plans and resource allocation in Southeast Asia in the future.

Keywords: Road safety; Evaluation; Entropy; TOPSIS; RSR; ASEAN

1. Introduction

According to World Health Organization, approximately 1.19million people die of traffic accident and 50million people get injured in traffic accident all over the world annually [1]. Additionally, the direct economical loss cause by traffic accident has reached average 3% of gross domestic production in every country. The situation is more severe in South-East Asia. According to the research, 92% of road deaths worldwide occur in low and middle-income countries, where vehicles account for only about 60% of the world's total and more than half of all road traffic deaths are caused by vulnerable road users, including pedestrians, cyclists, and motorcycle riders. Besides, Road traffic injuries are the main cause of death for children and young people aged 5 to 29 [2]. Generally speaking, the occurrence of this situation is linked to the backward ideological concepts in underdeveloped countries and regions. When young and middle-aged people die in a safety accident, the consequences cannot be underestimated. Because road traffic injuries always cause huge accompanied economic losses to individuals, families, and the entire country. These losses include the treatment costs of the deceased and injured, as well as the labor lost by the deceased, disabled individuals due to injuries, and family members who need to take up work or study time to take care of the injured. In this way, the vicious circle of traffic accident will constantly drag down the entire economic growth of developing countries especially in South-East Asia. Therefore, at the regional level, evaluating the development of traffic safety in various countries is of great significance for the formulation of subsequent action plans and the allocation of related resources.

In such severe and serious situation, a scientific and systematic evaluation measure is extremely necessary and indispensable in order to help these underdeveloped countries to deal with these problems in a scientific way. Nevertheless, selecting a reliable measure for evaluation from many measures libraries is obviously not easy. Therefore, it is extremely essential to choose the most appropriate method and conduct robustness testing on the method to verify the reliability of the method.

Therefore, this article proposes a set of evaluation methods based on Entropy TOPSIS-RSR to evaluate the traffic safety development of Southeast Asian countries. After comparison, the reliability of this method has been verified.

2. Data

Based on a large amount of literature review [3-5], a set of evaluation indicators that can reflect the comprehensive development level of national traffic safety is proposed based on the "human-vehicleroad-environment-management" system. These are the primary indicators for the evaluation system, with five factors being the most significant ones obtained from survey sampling. In the following data collection, this article searches and organizes the data according to these 20 data categories, and finally conducts problem analysis and argumentation through mathematical modeling.

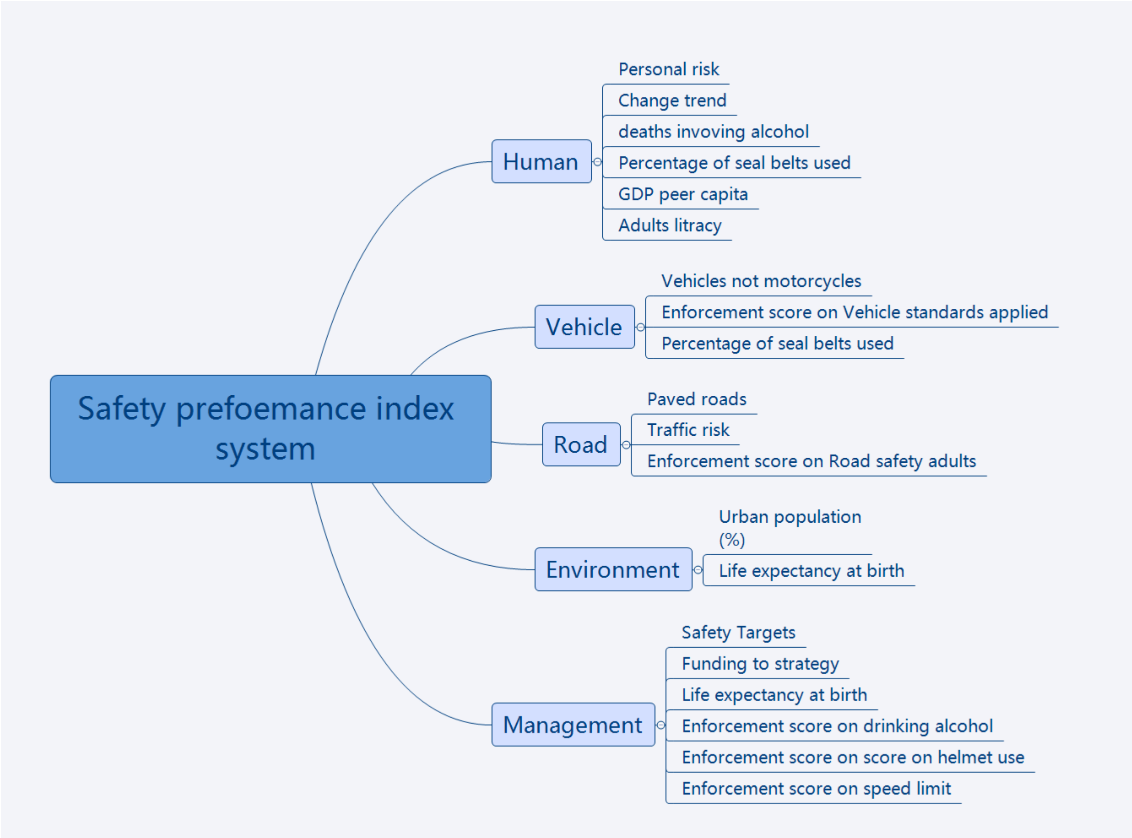


Figure 1 Safety performance indicators.

3. Methods

Step 1. Contributing initial matrix

Firstly, this article constructs initial matrix based on the collected data(The matrix contains M measures and N evaluating indictors). Assuming that the set of these multi-attribute decision-making schemes is $\mathbf{D = \{D_1, D_2, D_3, D_4 \ldots . D_m\}}$. The set of attribute variables that measure the quality of the plan is set as $\mathbf{X=\{X1, X2, X3 \ldots .Xn\}}$. Then the value of n of every $\mathbf{D_i}$ in the set of measures D will constitute vector $\mathbf{[a_{i1}, a_{i2} \ldots \ldots a_{in}]}$ which is be considered as point in N-dimension space, can uniquely characterize measure **D**.

Step 2. Indicators normalization

First of all, the normalization process will be taken for all data collected which aims to narrow down the range of data. The type of normalization in this measure Min-Max model. For a group of data, supposing that the maximum value is x_{max} and the minimum value is $\mathbf{x_{min}}$. Then for all $\mathbf{x_{ij}}$, there will be $\mathbf{x_{ij^*} = (x_{max} - x_{ij})/(x_{max} - x_{min})}$, $\mathbf{x_{ij^*}} \in [0,1]$.

Step 3. Indicators positively processing

The data to be filled in the matrix needs to undergo indicator attribute homogenization processing because of the existence of positive indicators negative indicator and neutral indicator. Different transformation will be taken for different indicators.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} a'_{ij} = \begin{cases} a_{ij} \\ 1/a_{ij} \\ 1-a_{ij} \\ M/\left(M+\left|a_{ij}-M\right|\right) \end{cases}$$

As shown in figure, all positive indicators will be unchanged. For negative indicators a_{ij} will be processed in the form $1-a_{ij}$. For neutral indicators $\mathbf{a_{ij}}$ and all kinds of indicators can be transformed to positive indicators.

Step 4. Calculation of weight coefficient

Entropy weighting method is taken to calculate the weight coefficient of the indicators in the matrix. Entropy weighting method aims to analyses the degree of variation of this group data. If the system is capable of being in various states, then the probability of the existence of every state is $\mathbf{P_i}$ **(i = 1, 2, 3….n)**. Then the entropy of the system is defined as

$$e = -\sum_{i=1}^{m} p_i \cdot \ln p_i$$

Now there are m evaluation objects and n evaluation indicators forming an original matrix $\mathbf{R = (r_{ij})_{m*n}}$.

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & r_{m3} & r_{m4} \end{pmatrix}_{m \times n}$$

Calculation of the weight $\mathbf{p_{ij}}$ of the **i** item of j indicator:

$$p_{ij} = r_{ij} \Big/ \sum_{i=1}^{m} r_{ij}$$

Calaulation of the entropy value of j indicator:

$$e_j = -k \sum_{i=1}^{m} p_{ij} \cdot \ln p_{ij}$$

$$\mathbf{k = 1/\ln m, if\ p_{ij} = 0,\ p_{ij} * \ln p_{ij} = 0}$$

Calculation of the entropy-weight of j indicator:

$$w_j = (1-e_j) \Big/ \sum_{j=1}^{n} (1-e_j)$$

Determine the comprehensive weight of indicators:

Assuming the we weight the importance of indicators is determined as a_j (j=1,2,... n). Combined with the entropy weight of the indicator, we can obtain the index weight of target j:

$$\beta_j = \frac{\alpha_j w_j}{\sum_{i=q}^{n} \alpha_q w_q}$$

Step 5. Determine the positive ideal solution and negative ideal solution

The positive ideal solution C^+ is composed by the maximum value in every list of C.

$$\mathbf{C^+ = (maxc_{i1}, maxc_{i2}, \ldots, maxc_{in}).}$$

Vice versa, the negative ideal solution

$$\mathbf{C^- = (minc_{i1}, minc_{i2}, \ldots, minc_{in}).}$$

Step 6. Determine the Euclidean distance from every solution to ideal solution.

The distance from D_i to positive ideal solution C^+ is:

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(c_{ij} - c_j^+)^2}, i = 1,2,\cdots,m$$

The distance from D_i to negative ideal solution C^- is:

$$D_i^- = \sqrt{\sum_{j=1}^{n}(c_{ij} - c_j^-)^2}, i = 1,2,\cdots,m$$

Step 7. Calculate the comprehensive evaluation index of every solution

The comprehensive eavluation index is the closeness of each evaluation object to the optimal solution:

$$F_i = D_i^- / (D_i^- + D_i^+)$$

When the value of F_i increases, it proves that the solution d_i is further from negative ideal solution which is closer to the positive ideal solution which means solution d_i is better.

4. Results

4.1 Countries ranking

Table 1 shows the countries' rankings over the four years (2009, 2012, 2015, 2018).

Table 1 Rankings of countries.

	2018		2015		2012		2009	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Brunei	0.572	3	0.575	3	0.566	2	0.624	3
Indonesia	0.554	4	0.492	6	0.514	6	0.476	5
Cambodia	0.333	9	0.255	11	0.327	10	0.376	11
Laos	0.373	8	0.464	7	0.358	8	0.402	9
Myanmar	0.305	10	0.456	9	0.388	9	0.378	8
Malaysia	0.592	2	0.667	1	0.582	3	0.536	2
Philippines	0.501	6	0.462	8	0.465	5	0.505	6
Singapore	0.620	1	0.666	2	0.601	1	0.635	1
Thailand	0.503	5	0.493	5	0.460	7	0.457	7
Timor-Leste	0.231	11	0.311	10	0.328	11	0.300	10
Vietnam	0.492	7	0.517	4	0.529	4	0.512	4

Overall, the rankings of the eleven Southeast Asian countries in TOPSIS-Entropy method are relatively stable, with only slight fluctuations. The ranking gap for four years has fluctuated within two places, and there has been no significant shift in the country's ranking.

Taking Singapore, Brunei, Malaysia comparative well-developed countries as examples, these three countries firmly occupy the top of the list, leading other countries to occupy the top three in four years. In contrast, countries such as East Timor and Cambodia are mostly at the bottom of this list, with slightly higher scores but no change in ranking. In terms of TOPSIS-Entropy scores, there have been fluctuations in each country over the past four years in different scale. Usually, countries at the top of the rankings have less fluctuation in the interval. Vice versa, lower ranked countries for example Laos and Vietnan will have vigorous fluctuations with the scale of 1.0. In addition, these fluctuations are usually a sharp decline in scores.

4.2 Countries grouping

Table 2 shows the countries' groupings over the four years (2009, 2012, 2015, 2018).

Table 2 Grouping of countries.

	2018	2015	2012	2009
Brunei	2	1	2	1
Indonesia	1	2	2	2
Cambodia	3	3	3	3
Laos	2	3	3	2
Myanmar	3	3	3	2
Malaysia	2	1	2	1
Philippines	2	3	2	2
Singapore	1	1	1	1
Thailand	2	2	2	2
Timor-Leste	3	3	3	3
Vietnam	2	2	1	2

The grouping situation of these eleven countries in this grouping is very stable. Firstly, in general, the situation of each country is basically consistent with the score of the TOPSIS-Entropy method, and there is no significant jump in the grouping of any country (A country entered three groups in four years).

For the green group (Countries are leading traffic safety system and reasonable domestic allocation of resources), the composition of team members is relatively stable. Singapore, Brunei and Malaysia are in the green group in most of the time which means the traffic safety of these countries has been superior in the long term. Only Indonesia entered the green group once in 2018. Reviewing Indonesia's score, score indicates that Indonesia has shown an overall steady upward trend over the four years, and entering the green group is not accidental.

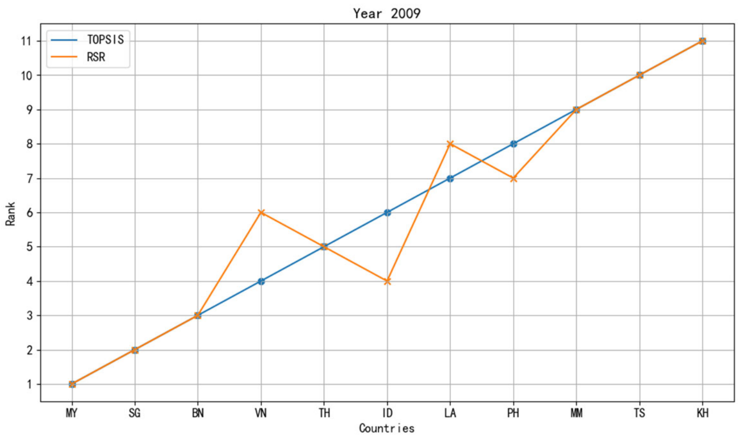
For the orange group (Countries whose traffic safety system is at a moderate level). This group has the largest number of countries than other groups. Except for Indonesia, the fluctuations in the four years have mitigated in countries than those countries in other groups but they have always been in the middle of the queue, so they have always been in the orange group. For example, Thailand and Vietnam have been divided into orange group for 4 years. The score of these two countries is within 0.5 and so do the ranking of two countries.

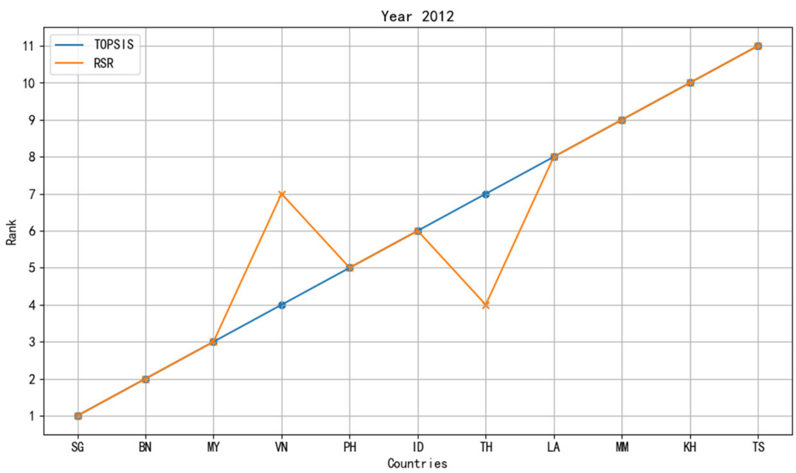
For the red group (Countries fall behind other countries in the field of traffic safety systems). For this group of countries, their scores fluctuate greatly and generally decline. This has led to these countries consistently being in the red group in their grouping, and also represents their great progress in traffic safety systems, which urgently requires help from other countries. Our country also needs to make many improvements in this regard. Take Timor-Leste and Cambodia as examples, the difference between the maximum and minimum scores of the two countries is around one, indicating that the governments of these two countries do not have sound management measures for traffic safety systems, and the allocation of resources is also very unreasonable, which is why this phenomenon occurs.

5. Discussion

5.1 Comparison of ranking

These four charts compare the rankings of RSR and TOPSIS Entropy methods. In terms of overall shape, there are many overlapping points between the TOPSIS ranking line and RSR in the four years, especially in 2009 and 2012, the degree of overlap between the two lines was relatively high, but there was a slight decline in the following two years. Nevertheless, this does not affect the high degree of compatibility between the two methods, which can be said to coincide with the basic ones where the intersection and overlap of the two lines are relatively dense. Based on the calculation correlation coefficient The correlation coefficient for 2009 was 0.955, 2012 was 0.918, 2015 was 0.909, 2018 was 0.954. The four-year average correlation coefficient is 0.934. The correlation coefficients for four years have a small dispersion and are all above 0.9, which also proves that RSR and TOPSIS-Entropy both have stability and are highly credible.





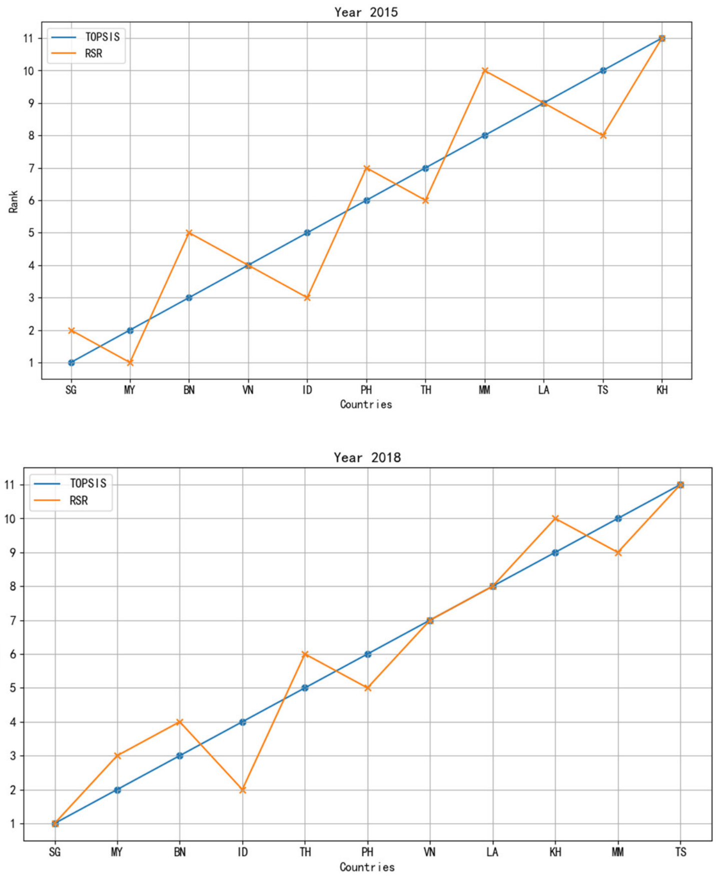


Figure 2 Comparisons of rankings by TOPSIS and RSR.

5.2 Comparison of grouping

Table 3 Comparison of grouping

	2018		2015		2012		2009	
	RSR	HDI	RSR	HDI	RSR	HDI	RSR	HDI
Brunei	1	0..853	1	0.852	1	0.852	1	0.842
Indonesia	2	0.694	2	0.686	2	0.675	2	0.656
Cambodia	3	0.582	3	0.571	3	0.553	3	0.521
Laos	3	0.601	3	0.593	3	0.569	2	0.539
Myanmar	3	0.578	3	0.569	3	0.549	2	0.519
Malaysia	2	0.802	2	0.795	2	0.781	1	0.765
Philippines	2	0.699	2	0.693	2	0.677	2	0.659
Singapore	1	0.932	1	0.929	1	0.920	1	0.884
Thailand	2	0.755	2	0.741	2	0.731	2	0.718
Timor-Leste	3	0.625	3	0.630	3	0.599	3	0.610
Vietnam	2	0.694	2	0.684	2	00.670	2	0.656

This chart was drawn based on HDI data published by the United Nations, and its significance lies in testing the practicality of the TOPSIS method in this paper through robustness analysis. But what can be seen is that the scores of each country in HDI have increased for 0.2 to 0.3. However, there have been no significant changes in the rankings of each country and the overall grouping of Southeast Asian countries, indicating that the TOPSIS method is highly reliable.

For the green group, which is the group with a higher ranking and scores is the group with the least fluctuation and the most stable among the three groups. Among them, Singapore, Brunei, and Malaysia have consistently maintained high scores and rankings throughout the year, and are mostly in the green group. This indicates that the traffic safety coefficient scores of these three countries are stable and of high quality, which can serve as a model sample for improving transportation problems in Southeast Asian countries

For the middle group, which is the orange group, there is a slight difference in the data obtained from the original TOPSIS method, mainly reflected in the slight increase in scores of countries such as Thailand, the Philippines, and Indonesia. One of the expected results is that the number of members in the orange group in the TOPSIS method has decreased, and more countries have been included in the green group. In practical terms, according to HDI data, some countries with moderate scores will perform better. Overall, even though these countries have slightly increased their scores in HDI data, they do not meet the classification requirements of the green group, so their traffic safety still needs to be improved.

For the Red Group, the traffic safety issues in these countries are all urgent to solve. The scores of the four countries highlighted in red in the two charts remain unchanged, indicating that these countries do indeed have serious traffic safety issues. It is worth mentioning that there has been a significant change in the relative ranking within the group. Timor Leste's score and ranking in the TOPSIS method are at the bottom of the team every year, but it has risen to the top position in the red group in the HDI ranking. However, this has not changed the fact that Timor Leste's traffic safety is precarious. So these four countries still need to learn and improve their domestic traffic safety from countries in higher rankings.

6. Conclusion

Overall, based on extensive research and scientific analysis, this study proposes a road traffic safety assessment method system based on Entropy TOPSIS RSR. Firstly, this article compiles the indicators required for the systematic evaluation of traffic safety factors and extensively searches for the required data online. Secondly, this article used the TOPSIS method to calculate the scores of various countries in terms of traffic safety factors. Then this article divides eleven Southeast Asian countries into three groups at each time period: excellent, good, and qualified. The excellent group represents the opportunity to serve as a role model for other countries in this field, with most of the time located in excellent countries such as Brunei, Singapore, and Malaysia. A good group represents the need for these countries to make certain improvements in domestic traffic safety development, including Thailand, Vietnam, the Philippines, and Indonesia. And qualified countries represent the serious traffic safety issues within these countries that need to be resolved as soon as possible, including Myanmar, Timor-Leste, Cambodia, and Laos. This evaluation system first conducted a systematic evaluation of the traffic safety development of Southeast Asian countries, which includes helping these countries calculate scores and digitizing traffic safety data. Secondly, the second point provides a reliable scientific basis for the formulation of action plans and resource allocation at the level of Southeast Asian countries. This article has developed charts to assist these countries in grouping, so that in the future, these countries can choose their own reference objects for learning and improvement.

This article mainly contributes to traffic safety in Southeast Asia in three aspects. Firstly, the mathematical model presented in this article has a high level of scientific validity, providing a rational analysis of the safety factor in Southeast Asia from an objective perspective. Secondly, the conclusion of this article clearly points out the reference objects needed by each country, which can help Southeast Asian countries significantly reduce time and trial and error costs, and improve this problem with the least amount of time. Therefore, these countries can effectively reduce their economic losses caused by traffic safety issues. The final point is that the validation in this article is very rigorous. At the end of the article, HDI data was detected and robustness analysis was used, effectively verifying the reliability of this method. So the model will also provide a comprehensive policy tool for the future development of traffic safety in Southeast Asia, to help the governments of these countries effectively and quickly allocate resources reasonably to achieve maximum benefits

References

[1] WHO, Global status report on road safety 2018. 2018, World Health Organization (WHO): Geneva, Switzerland.

[2] WHO, Global status report on road safety 2023. 2023, World Health Organization.

[3] Chen, F., et al., Monitoring road safety development at regional level: A case study in the ASEAN region. Accident Analysis & Prevention, 2017. 106: p. 437-449.

[4] Wegman, F., et al., SUNflowerNext: Towards a composite road safety performance index. 2008, SWOV Institute for Road Safety Research: Leidschendam.

[5] Tešić, M., et al., Identifying the most significant indicators of the total road safety performance index. Accident Analysis & Prevention, 2018. 113: p. 263-278.