

# COMPREHENSIVE EVALUATION OF THE INFLUENCE OF THE ENVIRONMENT ON HIGHWAY CONSTRUCTION

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## Abstract

In this essay, the estimate system on the environment influence from highway construction in China is introduced. Through the combination of quantitative and qualitative indexes, a comprehensive estimating method for the highway environment influence is put forward with the system method and fuzzy mathematical theory.

## Introduction

As far as the implementation of all the specifications, planning and decision is concerned in highway construction, environment problems should be seriously taken into consideration. There is a need to protect natural and social environment and to carry out possible continuous development. Highway environment estimate is a mixture of very important, complex, fuzzy and changing subjects. It is affected by many factors. If the environmental influence from highway is estimated objectively and scientifically, it will lead to correct highway (network) planning and construction and it will provide a scientific basis and guarantee for the environment. It will also combine the environmental, social and economical effects together. With the fuzzy, comprehensive principle and the system analysis method, a comprehensive estimate of highway environment impact has been made through quantitative and qualitative analysis.

## Estimating the System of Highway Environmental Influence

According to the current "Estimate specification of environment influence of highway construction" by the Ministry of Communications, the environmental estimate includes four aspects, i.e. social

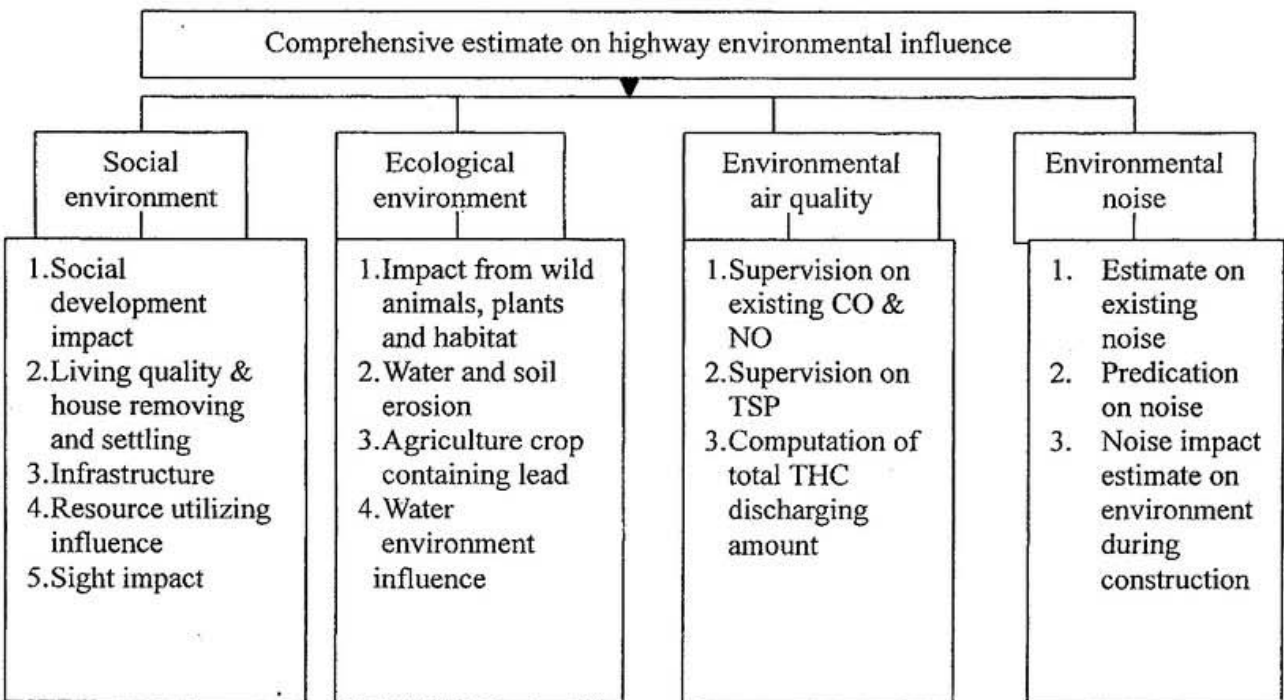


Fig.1. Structure of estimating system of environment influence

environment, ecological environment, environmental air quality and environmental noise. Furthermore, each aspect has several factors. Therefore, the estimating will be classified into two steps. First, a comprehensive judgement on subgroup factors will be made. Then a comprehensive estimate will be carried out at a higher level, to estimate the four aspects as shown in Fig.1.

### Establishment of a Mathematical Model for Comprehensive Estimate

#### Determination of Factors and Estimating Aggregation

a) Supposing the following as the evaluation factor aggregation:

$$M = \{M_1, M_2, M_3, M_4\}$$

$M_1, M_2, M_3, M_4$  represent social environment, ecological environment, environmental air quality and environmental noise separately, and there are several subgroup factors in each factor (as shown in Fig. 1), i.e.

$$M_1 = \{M_{11}, M_{12}, M_{13}, M_{14}, M_{15}\}$$

$$M_2 = \{M_{21}, M_{22}, M_{23}, M_{24}\}$$

$$M_3 = \{M_{31}, M_{32}, M_{33}\}$$

$$M_4 = \{M_{41}, M_{42}, M_{43}\}$$

b) Supposing the evaluation aggregation as follows:

$$V = (V_1, V_2, V_3)$$

in which  $V_1$  stands for the positive influence, such as evaluating factor of positive influence of social development, social environment and infrastructure.  $V_2$  represents qualification (or the negative influence is within the allowed values, such as quantitative analysis on noise, situation of air pollution and lead content).  $V_3$  is the negative influence (or the impact of exceeding the standard, such as the evaluation on water and sight). Value of assignment of the estimate group: 100, 85, 70.

Each subgroup factor will be evaluated and scored in line with the "Estimate specification on environment influence of highway construction projects" by the Ministry of Communications. The evaluation value will be combined closely with the value assignment of the evaluation group. The scores of some of the evaluating factors will be obtained from the relative model formula, while some of the indexes cannot be computed through model formula. They will be estimated by scoring only, or scoring by many experts with the consideration of the estimating group. The method of average will be applied for the scores on factors.

#### Determination on Weight of Evaluation Factors

The nature of weight is shown in the quantity of different factors on objects at different levels, i.e. the different influence from all aspects on the environment. Each weight should be decided separately. The layer analysis of the system analysis will be employed, i.e. with the AHP method to compute each weight of factors. The AHP method will analyse every factor in complex problems and their relationship. The problems will be broken down into different factors and layers. The steps of the AHP method are as follows: First, the structural figure in ladder layers will be set up. The target layer, standard layer and index layer will be built. The contrast relationship between two factors is shown as follows:

$$P_1 \ P_2 \ P_3 \ \dots \ P_n$$

$$P_1 \ b_{11} \ b_{12} \ b_{13} \ \dots \ b_{1n}$$

$$P_2 \ b_{21} \ b_{22} \ b_{23} \ \dots \ b_{2n}$$

$$P_3 \ b_{31} \ b_{32} \ b_{33} \ \dots \ b_{3n}$$

$$\vdots \ \vdots \ \vdots \ \dots \ \vdots$$

$$P_n \ b_{n1} \ b_{n2} \ b_{n3} \ \dots \ b_{nn}$$

The predication matrix will be reached,  $B = \begin{pmatrix} b_{11} & b_{12} & b_{13} & \dots & b_{1n} \\ b_{21} & b_{22} & b_{23} & \dots & b_{2n} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ b_{n1} & b_{n2} & b_{n3} & \dots & b_{nn} \end{pmatrix}$

The value of the matrix coefficient  $b_{ij}$  is determined as follows:

$b_{ij}$	Description of definition
1	$P_i$ & $P_j$ are the same.
3	$P_i$ is a little better than $P_j$ .
5	$P_i$ is superior to $P_j$ .
7	$P_i$ is a lot better than $P_j$ .
9	$P_i$ is much better than $P_j$ .
2,4,6,8	The medium value between two scaling values

As far as the judgement matrix B is concerned, obviously there exists  $b_{ij} = 1 \square i = j \square \square$

$$b_{ij} = \frac{1}{b_{ji}} \square i, j = 1, 2, \dots, n$$

Therefore for the matrix at n stage, only the different factors of  $\frac{n(n-1)}{2}$  will be reached. As to  $b_{ij}$ , it will be determined according to information, experts' opinions and experiences.

In the AHP method, the characteristic root will be obtained by computing the judgement matrix. The maximum characteristic value will be worked out  $\lambda_{\max}$ . B. The relative character vector will be found.  $W_j$  is the relative important sequence weight of the factor from the same layer to that from the above layer and is carrying out the coherent verification.

### Mathematical Models

Supposing the factor of evaluation index as  $X^T = \{x_1, x_2, \dots, x_n\}$ , the evaluation value  $Y = \{y_1, y_2, y_3\}$  named as matrix.

$$R = \begin{pmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & r_{n3} \end{pmatrix} \text{ Fuzzy subject relationship matrix above } X^T \text{ OY}$$

in which: n is the number of items for evaluating factor group. As for the total evaluation, there are four important factors. As to the social environment only, there are five factors. Therefore  $n = 5$ , the element  $r_{ij}$  in  $\square$  shows the subject relation the factor No. i to the evaluation No. j in  $X^T$ .

As far as the environment evaluation is concerned, the subject relation will be decided with the trapezoidal method, i.e. to suppose  $V_j$  and  $V_{j+1}$  as the grade criterions for the neighbouring two grades (such as 100, 80 and 70 scores). Obviously  $V_j > V_{j+1}$

$$\text{The subject function of } V_j \text{ is as follows: } r(x) = \begin{cases} \frac{x - V_{j+1}}{V_j - V_{j+1}} & V_{j+1} \leq x \leq V_j \\ 0 & x < V_{j+1}, x < V_j \end{cases}$$

The subject function of  $V_{j+1}$  is as follows: 
$$r(x) = \begin{cases} \frac{V_j - x}{V_j - V_{j+1}} & V_{j+1} \leq x \leq V_j \\ 0 & x > V_j, x < V_{j+1} \end{cases}$$

$A = [\partial_1, \partial_2, \dots, \partial_n]$  is the fuzzy vector of weight distribution in  $X^T$  aggregation.

in which  $\partial_i$  is the weight of Factor  $x_i$  in  $X^T$ , and  $\sum_{i=1}^n \partial_i = 1$

Supposing  $B = AR = [b_1, b_2, b_3]$  and again supposing  $b^* = b_1 + b_2 + b_3$ , then  $B^*$  is the mathematical model of evaluation: 
$$B^* = \left[ \frac{b_1}{b^*}, \frac{b_2}{b^*}, \frac{b_3}{b^*} \right]$$

During evaluation the total score will be used to express the whole situation so as to generate a horizontal comparison. The general scores of the value assignment will be (100, 85, 70):

$$P = YB^{*T}$$

As mentioned above, the highway environment influence will be evaluated in two classes. The first estimate is as follows:

$$B_k = A_k R_k \quad (k = 1, 2, 3, 4)$$

$$A_1 = [\partial_{11}, \partial_{12}, \partial_{13}, \partial_{14}, \partial_{15}]$$

$$A_2 = [\partial_{21}, \partial_{22}, \partial_{23}, \partial_{24}]$$

$$A_3 = [\partial_{31}, \partial_{32}, \partial_{33}]$$

$$A_4 = [\partial_{41}, \partial_{42}, \partial_{43}] \text{ in which } \sum_{k=1}^n \partial_{ik} = \partial_i$$

After the normalization of  $B_k, B_k^*$  is reached.

The II evaluation will be implemented: 
$$B = AR = A \begin{pmatrix} B_1^* \\ B_2^* \\ B_3^* \\ B_4^* \end{pmatrix}$$

The value of the estimating Y will be assigned (100, 85, 70), and the final total comprehensive score will be:

$$P = YB^T$$

## Conclusion

The above computation will be worked out with computers and with the reference of the evaluation method on road sight mentioned above and the prediction of evaluation technology of traffic noise and strength of air pollution. Through the combination of quantity and quality, a comprehensive estimate will be made on highway environment impact. Obviously, the estimate will evaluate the highway environment in a scientific, comprehensive and objective way. According to the above computation, every programme will be in order and optimized. As for built roads, fuzzy comprehensive evaluation on road environment influence will be conducted. The shortcoming of the simple weighting method of average is overcome by this method. The quality and quantity analyses will be made with the fuzzy comprehensive evaluation, and a quantitative estimate on the evaluation results will be made. Therefore, this method has explored a new way of evaluating highway environment influence.

## References

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