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DESIGN AND PRACTICE OF THE ASSESSMENT SYSTEM OF HIGHWAY'S IMPACTS ON THE ECOLOGICAL ENVIRONMENTS

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ABSTRACT: *A comprehensive and systematic highway ecological environmental impact assessment index system has been established, and it's in line with China's national conditions. The index system is discussed from four aspects: surface vegetation index, biodiversity index, soil and water loss index, and ecological environmental impact assessment. With the VB as a development platform, using MO to develop the system of highway environmental impact assessment, it put into practice for the ecological environmental impact assessment of Liangzhong highway from two aspects: (1) environment impact forecast and environmental post-assessment, (2) the assessment results agree well with the actual results, which verified the feasibility of this method, and it is proved that the highway ecological environmental impact the evaluation system has the advantages of simple operation, high calculation efficiency and has good applicability*.

KEYWORDS: highway ecological environmental impact assessment, index system, quantitative model, Map Object

INTRODUCTION

Although starting late, the road construction grows rapidly in China. Since 1990s, highway developed hugely, and at the end of 2006 the total highway mileage reached 4.54 million km, ranking the second in the world. In 2008 newly built highway was 6433km, the total highway mileage reached 6.03 million km, remaining the second in the world. By 2020, the national highway network will be basically completed, and Chinese total highway mileage will reach 100 thousand km.Highway construction plays a positive role of society and national economy construction, and provides economic support for environmental protection, but at the same time, we must deeply realize that the environmental capacity is limited, the supply, regeneration and

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value-added of natural need time, once exceeded its limit, it is difficult to restore, sometimes irreversible. Therefore, the research on ecological environmental impact assessment of highway construction project, not only reduces the harm of highway construction project on the environment, but also has important practical significance: this research promotes the coordinated development of highway construction and social, economic and environmental benefits, and realizes the sustainable development of highway transportation.

LITERATURE REVIEW

The study on the influence of the highway environment began in 1970s, 1970, Dr. Hans Lorenz German first proposed the road design method ,which is closely related to the human and natural environment, and strive to design fast safe-driving beautiful streamline and good driving environment, including the measures of protection of landscape and wild animal etc.

In 1974 , Oxle and his colleagues made a research on the change of small mammals and wild animal habitat under the highway road influence studied, which regarded as the origin of highway ecology, at this time, researches mainly focused on the influence on the wild animal. By the end of twentieth Century, it has gradually expanded to the ecological environment of the landscape scale. Andrews、May and their colleagues had the first study of the influence on the natural habitat segmentation, interference and destruction from highway network and traffic corridor. In addition, the U.S. Department of transportation put forward the strategic goal of the harmonious development of man and nature in 2000-2005 transportation strategy. The goal is to improve the living environment, reduce transportation negative impact on the ecological and natural environment, promote the ability of the ecological environment development, and reduce the pollution caused by transportation. What's more, it accordingly puts forward the main measures to ensure the realization of goals.

With the ever increasing attention to the environment, the ecological problems caused by highway construction in China has attracted widespread attention from all sectors of society, the relevant departments of the state promulgated the corresponding technical guidelines for and the guidance of ecological environment assessment, some areas also carried out some highway ecological protection researches in varying degrees. For example, Yibin Qian put forward that the influence of Turpan-Urumqi-Dahuangshan highway construction and operation of the ecological environment is mainly manifested in four aspects: vegetation damage, and ecological areas have different damage type and damage degree; some animal populations shrink, and it mainly occurred in the bird migratory channel; the change and wind erosion in the physical and chemical properties of soil; disturbance in the original population's

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production and life, including land use, animal husbandry transitions route and living and office space relocation etc..

Yueguang Zong put the development of the highway network and landscape ecology together. He thinks that the road network influence on the other landscape is affected by point effect, the corridor effect, point-corridor-network superposition effect. This effect is proportional to road network density and road effect zone of range. Therefore, in order to minimize the interference of the road network to the natural ecosystem, he proposed 8 proposals of ecological highway network construction.

The Highway Ecological Environmental Impact Assessment and Quantitative Model Establishment

Highway ecological environmental impact assessment rating and evaluation scope

Highway construction projects, especially the high-grade highway construction projects, they have linear long distance, large geographical span, and their distribution of regional usually shows different ecological types and ecological sensitivity. The highway construction project changed the ecosystem composition or structure, it caused damage to ecological environment, and it belongs to the non pollution impact type, the evaluation levels shown in table 1.

Table1 The level and scope division of assessment work

Assessment level	Grading screening	Assessment scope
First-level assessment	There are wildlife protection habitats, native vegetation, provincial nature reserve, or scenic attraction in the assessment scope.	The distance to highway land is not less than 300m
Second-level assessment	There are desertification areas, large-and-middle-scale lakes, reservoirs or key areas of soil and water loss in the assessment scope, without including wildlife protection habitat, native vegetation, provincial nature reserve, or scenic attraction.	The distance to highway land is not less than 200m
Third-level assessment	There are no wildlife protection habitats, native vegetation, provincial nature reserve, or scenic attraction in the assessment scope desertification areas, without including large-and-middle-scale lakes, reservoirs or key areas of soil and water loss in the assessment scope, without including.	The distance to highway land is not less than 100m

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In addition, if there are natural Isolation landforms formed by high and steep slopes, isolated cliffs, rivers formed outside the scope of project construction, the evaluation scope can select these isolated objects as boundary; The distance which between the boundaries of the experimentation area in nature reserve(provincial and above level) and highway center line less than 5 km, can be attributed to the scope of ecological environment current situation investigation and determine further evaluation scope according to the survey results; The evaluation of original forest and secondary forest directly affected by engineering construction, its evaluation scope should be based on the integrity of the vegetation community.

3.2 Highway ecological environmental impact assessment index system

On the basis of reading a lot of references and thoughtful analysis, the paper followed the principle of ecological environment effect evaluation, and finally chose these indexes to reflect the impact of highway construction projects , these include the influence of project construction period and operation period on regional surface vegetation, the influence of project construction period on biodiversity, evaluation of soil and water loss during construction period and operational period, the influence of project construction period and operation period on the agricultural ecological environment and so on. Index system diagram is shown in figure1.

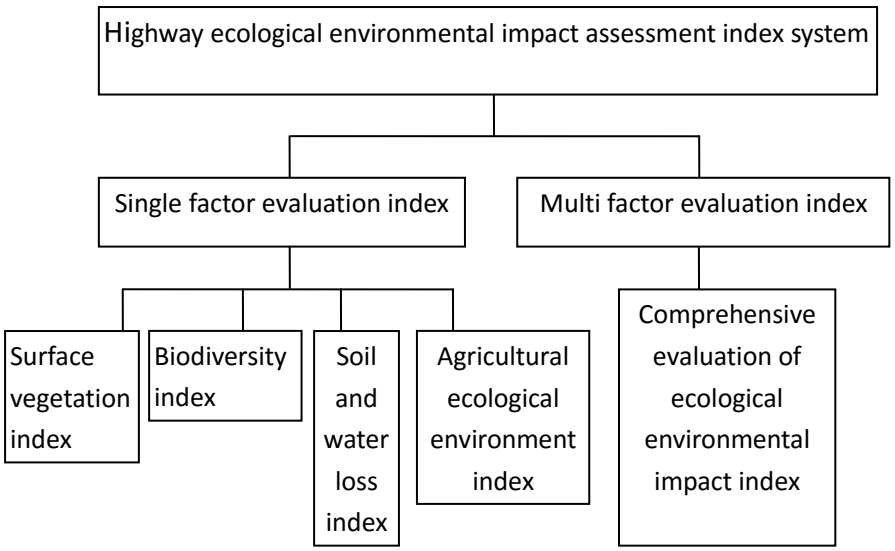

Figure1 Highway ecological environmental impact assessment index system

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Surface vegetation index

Highway subgrade excavation disturbed soil layer, and it removed topsoil, which harmed the original vegetation due to losing soil conditions of surviving; at the same time, construction waste abandoned in the highway construction process (such as asphalt, lime, cement and other polluting) contaminated vegetation, resulted in their death; In the process of Road construction, cutting mountain and building road through the forest, need to cut part of forest; After the completion of the highway, original vegetation's living pressure is gradually increasing due to the increase of human activities.

The formula for the change of green equivalent is used to evaluate the surface vegetation influence, and analyze the overall influence of highway construction on the surface vegetation. The estimation method of green equivalent change caused by highway construction is:

(1) According to the vegetation distribution influenced by the highway construction project, the main types and the number of the vegetation, the loss of vegetation in the construction period are analyzed; (2) According to the proposed green equivalent conversion coefficient in Yongwen Mao's "Introduction to the ecological environmental impact assessment", see Table 2, the vegetation restoration and compensation after the completion of highway are calculated.

Table 2 Green equivalent recommended values for a variety of vegetation

Vegetation types	The measure of area	Green equivalent
Dense grassland	$1m^2$	1
The flower bed	$1m^2$	0.7
1m long hedge	$0.5m^2$	0.8
Wall vertical greening	$1m^2$	0.6
Large shrub or small tree	unit	1.5
Grape trellis	$1m^2$	0.6
More than 5 years of coral	$9/1.33=6.8m^2$	2.5×6.8
Vegetable plot (full year planted)	$1m^2$	0.4
Double cropping rice field	$1m^2$	0.8

The relative change rate of vegetation restoration and compensation in the operation

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period and vegetation loss in construction period is used as an index to judge the change of green equivalent caused by highway construction, and then analyze the potential impact on the ecosystem. The calculation formula for the change of green equivalent caused by highway construction is:

$$G_v = \frac{\sum_{i=1}^{n}\left(A_{ai}N_i - A_{bi}N_i\right)}{\sum_{i=1}^{n}A_{bi}N_i} \quad (1)$$

G_V ——The relative change rate of green equivalent caused by highway construction；

N_i ——The green equivalent of an i type of vegetation；

A_{ai} ——The number of i type vegetation's restoration and compensation after the completion of the highway；

A_{bi} ——The number of i type vegetation's loss during the construction period.

Biodiversity index

Biodiversity refers to the living organisms and the diversity and variability of ecological complex, including all animal, plants, microorganisms and their genes and environment on the earth biosphere.

The impacts of highway construction on biodiversity are mainly vegetation destruction, construction noise, channel blocking and operating light and so on. There is a "corridor effect" after the highway is completed, it makes the landscape fragmentation, cuts natural habitats into isolated blocks, and divides the biological activities territories. So that the living environment is affected, which resulting in species decrease and degradation;

Meanwhile, the opening of the highway increases the flow of people and logistics strength in lineside areas, and also expands the scope of human activities, so it makes many areas formerly difficult to reach or enter become reachable and easy to enter, which constitutes a great threat to the protection of rare resources. The noise and lighting caused by the highway project construction and later operation will destroy the normal habitat and reproduction of wild animals, causing the deterioration of the habitat environment.

Biodiversity is characterized by three indexes, which are biodiversity index, evenness and dominance index.

（1）（Shannon-Wiener）Biodiversity index

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$$H = -\sum P_i \log_2 P_i \qquad i = 1,2,3,\cdots, \ n \qquad (2)$$

P_i——Ratio of the number of i species to the number of total species, that is $P_i = n_i / N$。

（2）Evenness index.

$$E = \frac{H}{H_{\max}} \qquad (3)$$

$H_{\max}$——Maximum diversity. Suppose the total number of species in the community is T, when all species are in the same proportion (1/T), there will be the maximum diversity, that is $H_{\max} = \log_2 T$。

（3）Dominance index

$$D = \log_2 T + \sum P_i \log_2 P_i \qquad (4)$$

T——Total richness, that is the total number of species in the community.

Index of soil and water loss

The destruction of vegetation in highway construction led to soil and water loss, and it mainly affected in the construction period. Construction changed the original landform and vegetation along the road, disturbed the balance between topsoil and vegetation, messed up the soil structure. The land surface in excavation face exposed without vegetation cover, soil erosion resistance decreased, the slow natural soil erosion process quickly transformed into strong engineering accelerated erosion in a very short period of time, it's prone to occur collapse and landslide under the action of gravity, causing soil and water loss;

In the construction process and a few years after construction finished, the vegetation has not been fully restored, the surface of construction land is exposed, so the topsoil will be lost under the action of the wind force. During the operation period, some factors affecting soil and water loss gradually disappear after the implementation of soil and water conservation measures, such as side slope protection, drainage works and landscaping, etc.

As an evaluation model of soil erosion, the universal soil loss equation (USLE) is commonly used in highway construction. USLE is an empirical model based on soil erosion theory and a large number of observed data, has also been widely used in China, and puts forward the corresponding parameters according to the national conditions of our country. The empirical model of our country is mainly aimed at

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some of the main factors in USLE, it is a statistical model based on the analysis of the experimental data:

$$A = R * K * LS * C * P \quad (5)$$

A——The amount of soil loss o， $t/\left(\mathrm{km}^2 \bullet year\right)$；

R——Rainfall erosivity， J/m^2 ；

K——Soil erosion factor；

LS——Slope length-slope factor. L is the slope length factor, in the same conditions of other factors, it is the ratio of a certain length of slope soil erosion to standard plot of soil erosion; S is the slope factor, it is the ratio of known slope soil erosion to standard plot of soil erosion;

C——Vegetation cover factor, in the same conditions of other factors, it is the ratio of soil loss on the specific vegetation and management plots to the soil loss in the standard plot；

P——Water and soil conservation factor。

Comprehensive evaluation of ecological environmental impact of highway

The model that reflects the comprehensive influence of expressway construction project on ecological environment is as follows:

$$P = \sum X_i * F_i * C_i \quad (6)$$

P——A comprehensive evaluation index of regional ecological environmental impact;

X_i——The weight of evaluation factor;

F_i——The score of evaluation factor under the condition of evaluation;

C_i——A project management factor, reflects the implementation degree of mitigation measures to factor , takes values from small to large according to previous work experience and mitigation measures operability.

According to the comprehensive evaluation index of ecological environment, the ecological environment is divided into five levels, namely, excellent, good, general, poor and relatively poor. See Table 3:

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Table3 Classification of ecological environment

Level	Excellent	Good	General	Poor	Relatively poor
Index	$P \geq 75$	$55 \leq P < 75$	$35 \leq P < 55$	$20 \leq P < 35$	$P < 20$
Condition	The highest vegetation coverage, the richest biodiversity, the most stable ecosystem, the most suitable for human survival.	The higher vegetation coverage, the richer biodiversity, the more stable ecosystem, the more suitable for human survival.	The average level of vegetation coverage, the general level of biological diversity, more suitable for human survival, but there are the restrictive factors which not suitable for human survival.	Poor vegetation cover, severe drought and little rain, fewer species, there is a obvious factor limiting the survival of mankind.	The condition is severe, human living environment is poor.

Design and Practice of the Assessment System of Highway's Ecological Environmental Impacts Based on the MO.

The design of highway environmental assessment system

The function of this system is to realize the systematization, standardization and automation in the highway environment evaluation system, and the system function is divided into the following as shown in figure 2.

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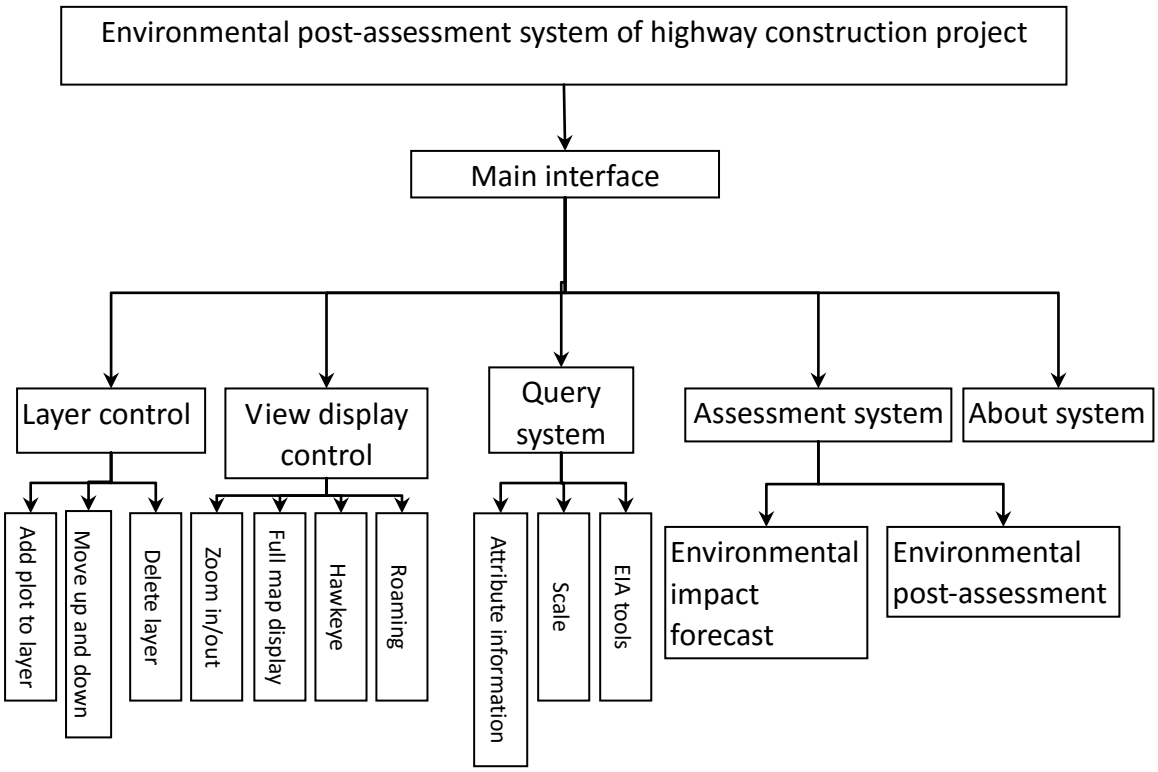

Figure2 Schematic diagram of system structure and function

Figure 3 is the main interface of the highway ecological environment assessment system, and the main menu module of the system. The main menu consists of six items, including documents, views, environmental impact forecast, environmental post-assessment, environmental impact assessment tools and help. This module provides the man-machine conversation interface, so that the user can control the layer, select the various functions in this system. The main menu module also provides the automatic link for the subsystem menu for convenience of the user.

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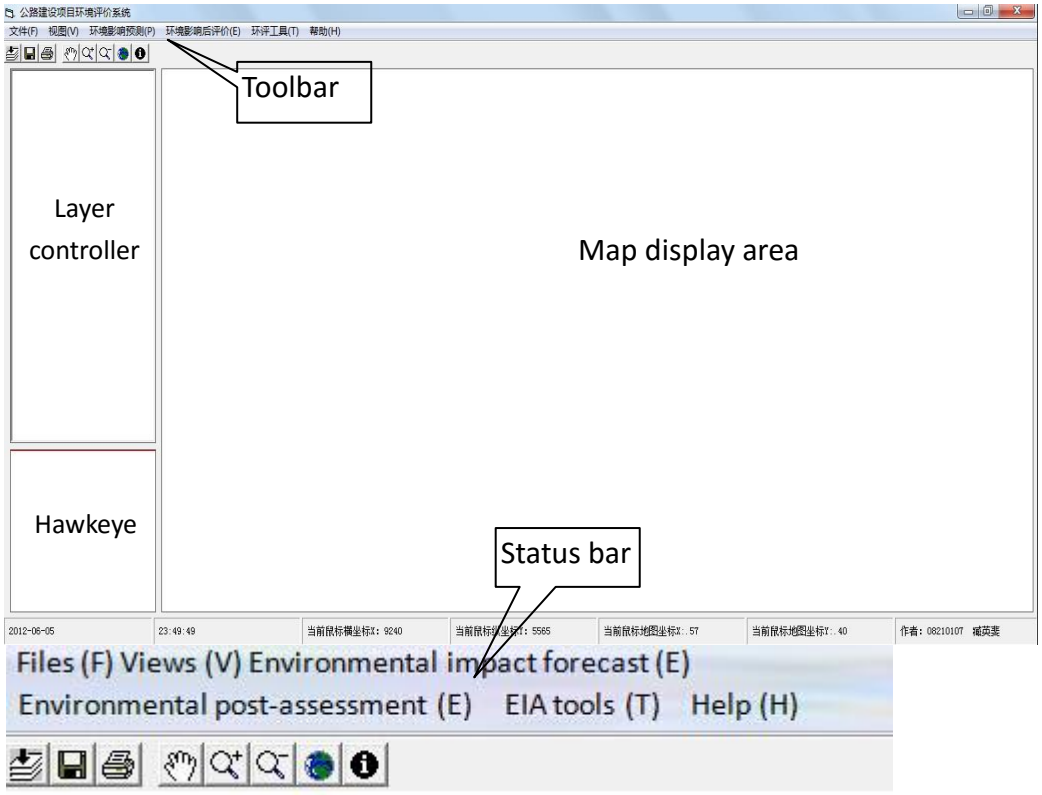

Figure3 The main interface and menu of the highway ecological environment assessment system

The Assessment Subsystem

Ecological and environmental impact forecast

The forecast uses green equivalent calculation to show the overall impact of highway construction on the surface vegetation in this area，green equivalent is the amount of vegetation quantity to compensate for some unit of pollutant.

The running interface is shown in figure 4.

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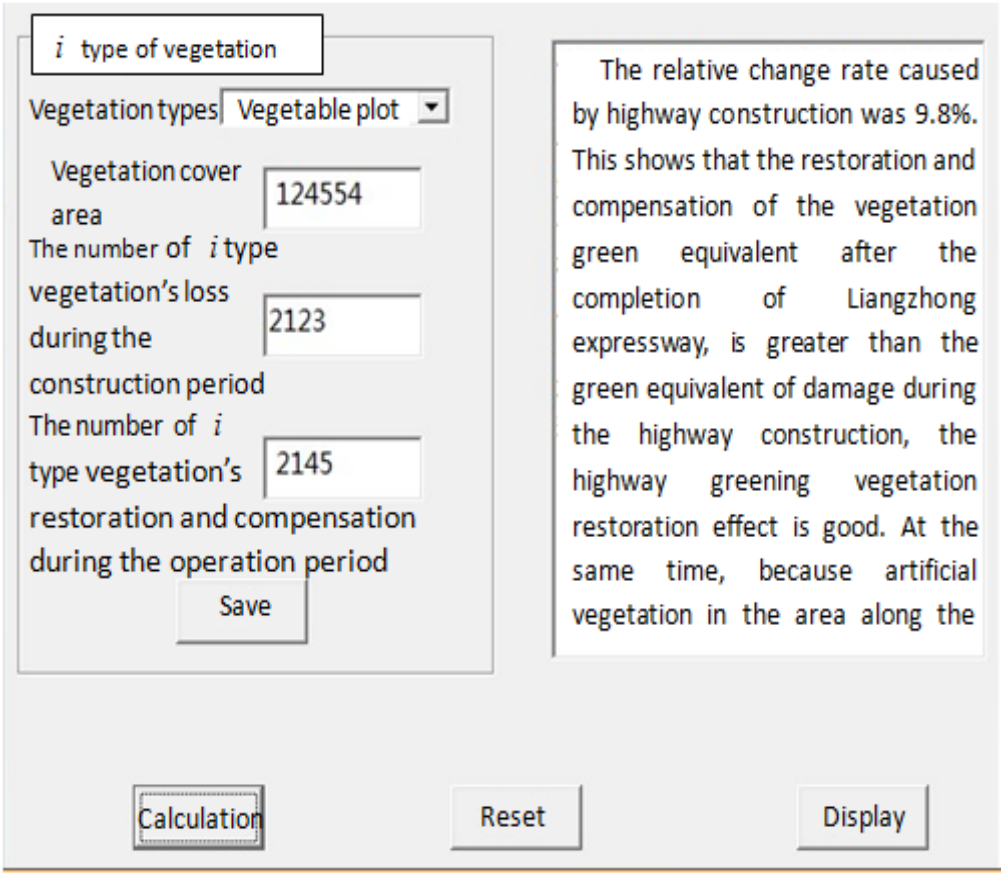

Figure4 Environmental impact forecast

The relative change rate caused by highway construction was 9.8%. This shows that the restoration and compensation of the vegetation green equivalent after the completion of Liangzhong expressway, is greater than the green equivalent of damage during the highway construction, the highway greening vegetation restoration effect is good. At the same time, because artificial vegetation in the area along the highway is widely distributed, the proportion of the vegetation area occupied by the permanent highway construction is small, so the highway operation will not lead to the change of system structure of regional vegetation.

Ecological environment post-assessment

The concrete implementation of post-assessment is through the spot monitoring and the key investigation in some aspects, such as biological abundance, vegetation coverage, water density, land degradation and others in affected areas of the first grade highway. Analysis and evaluation of the environmental quality of the highway project is after taking the environmental protection measures. The running interface is shown in Figure 5.

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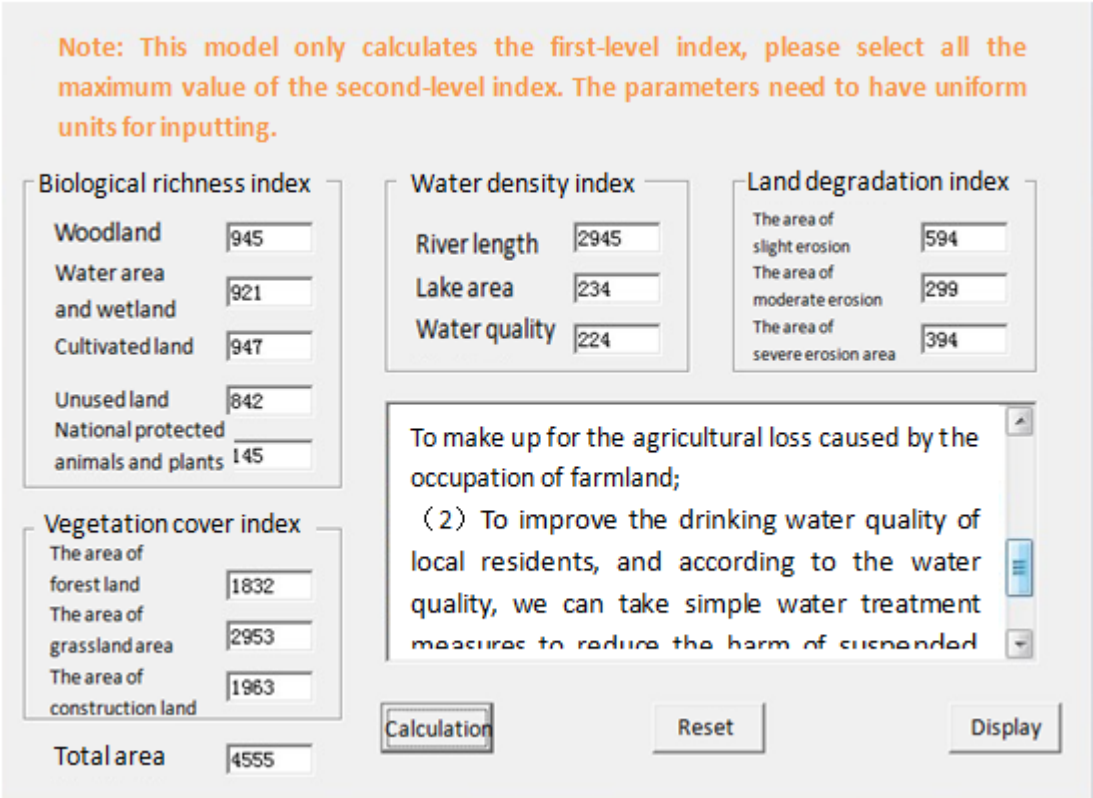

Figure 5 Ecological environmental post-assessment

To improve the drinking water quality of local residents, and according to the water quality, we can take simple water treatment measures to reduce the harm of suspended matter and organic matter in Liangzhong highway operation period. Environmental quality monitoring must be carried out every year, Monitoring frequency is in accordance with the relevant environmental monitoring requirements of National Environmental Protection Bureau. To compile annual environmental quality monitoring reports, and update monitor results to the relevant state departments.

Rendering

In the assessment subsystem described above, each main interface has a display button, which shows the affected areas and the degree of pollution, the results are shown in Figure 6 and figure 7.

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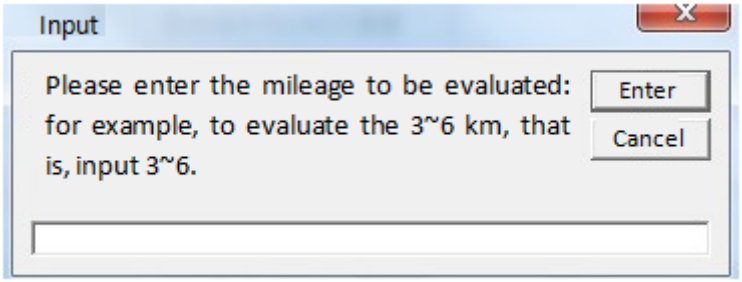

Figure 6 enter the mileage to be evaluated

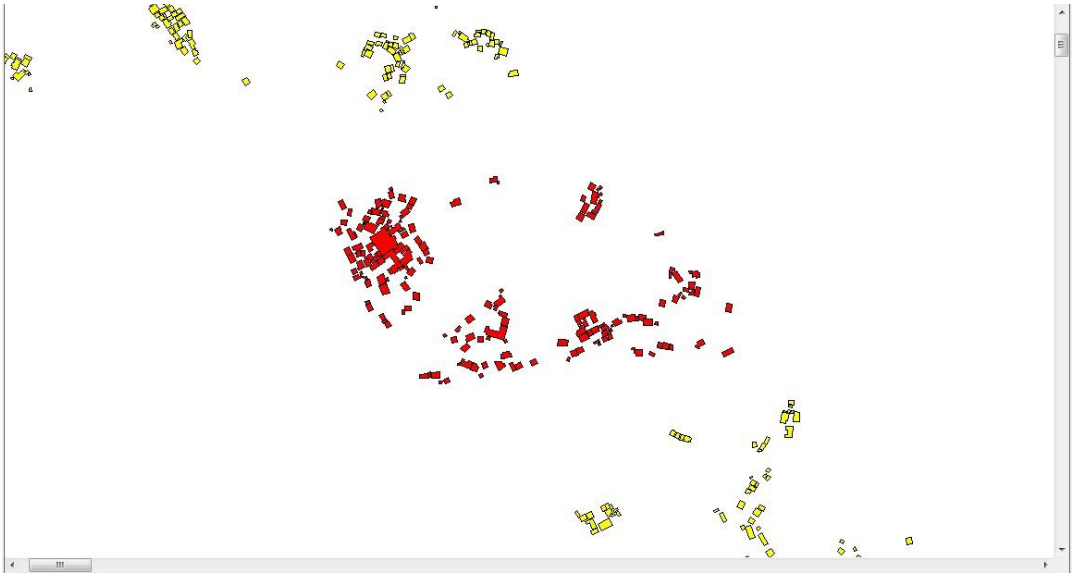

Figure7 Affected areas

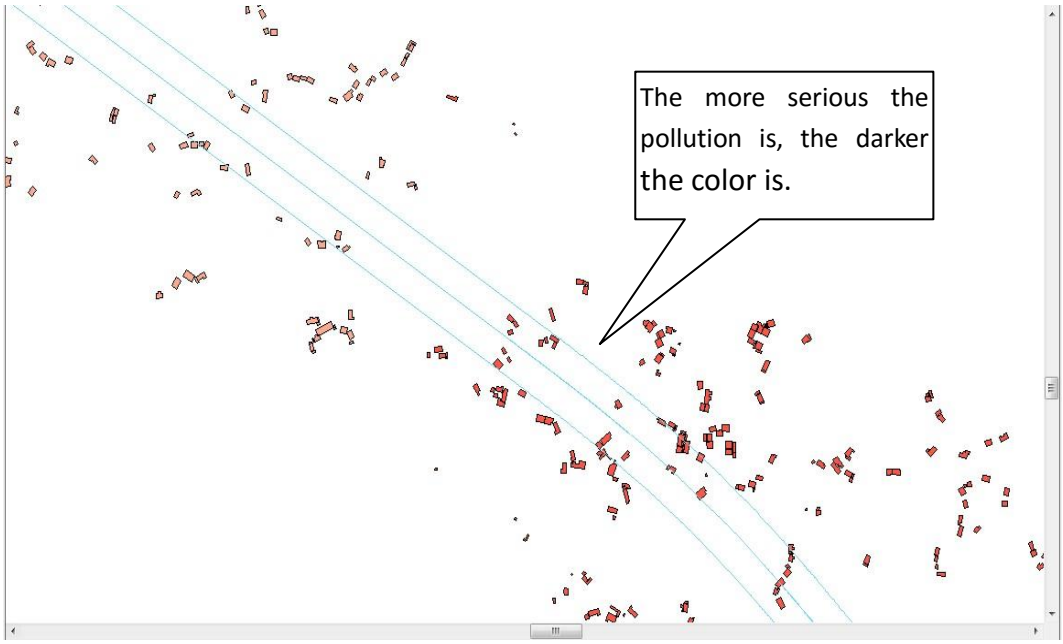

Figure8 The degree of pollution

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The Ecological Environmental Impact Assessment of Liangzhong Expressway

Liangzhong expressway's area belongs to the transitional monsoon climate region between Central Asia and North Asia tropic. It has adequate solar and hot resources, long frost-free period and short frost period, it also has plentiful rainfall and four distinctive seasons. In here, spring is damp and wet, summer is hot and rainy, while autumn is likely to drought, and winter is less cold. The main geomorphic units are hilly areas, mountainous areas, and alluvial plain.

Vegetation protection is an important measure to protect the ecosystem and control non-point source pollution. It is important to prevent the destruction of surface vegetation, strengthen the greening of expressway, improve the ecological environment and conserve water resources. By analyzing the influence degree of the surface vegetation in the project construction period, the vegetation restoration measures are evaluated. In this paper, the total effect of highway construction on the surface vegetation in the area is calculated and analyzed by using the change of green equivalent.

Table4 The vegetation types and quantity of the loss

during the construction period in Liang Chung Expressway (area: hm^2)

Name	Paddy field	Dry land	Orchard	Pine forest	Economic forest	Shrubwood	Grassland
Permanent land acquisition	448.85	114.21	119.44	130.98	144.23	26.89	-
Temporary land occupation	75.36	-	-	54.4	93.78	-	4.25

Table5 The types and quantities of vegetation restoration and compensation in Liang Chung Expressway

Trees	Shrubs	Flowers	Grassland（10 thousand m^3）
32.2	351.4	4.6	905.15

10000 units

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According to the data in Table 4 and Table 5, combined with the formula of green equivalent change, we calculated the relative change rate was 9.8%, which was greater than zero. This shows that the restoration and compensation of the vegetation green equivalent after the completion of Liangzhong expressway, is greater than the green equivalent of damage during the highway construction, the highway greening vegetation restoration effect is good. The recovery rate reached more than 90%. At the same time, because artificial vegetation in the area along the highway is widely distributed, the proportion of the vegetation area occupied by the permanent highway construction is small, so the highway operation will not lead to the change of system structure of regional vegetation.

Surface erosion of hydraulic erosion is the main type of soil erosion in the area along the Liangzhong expressway, which accounts for about 90% of the total loss area. See Table 6, it is the situation of soil and water loss along the Liangzhong expressway.

Table 6 The situation of soil and water loss along the Liangzhong expressway

Name	Loss area									Soil erosion amount $t/km^2 \bullet a$
	Total	Severe		Intencive		Moderate		Light		
	Area km^2	Area km^2	Proportion%	Area km^2	Proportion%	Area km^2	Proportion%	Area km^2	Proportion%	
Liang Zhong highway	524	41.3	7.9	132.9	25.3	154.2	29.4	195.9	37.4	500

According to the "classification and gradation of soil erosion" (SL190-2007), this project area belongs to the red soil hilly region in South China, soil loss tolerance is $500\,t/km^2 \bullet a$ .The soil and water conservation measures of Liang Zhong expressway are mainly based on engineering measures（including drainage engineering, soft-base reinforcement project, side-slope protection project etc.）and plant measure（including side-slope biological protection，main greening etc.），temporary protective measures are used as supplement. The statistical data shows that: Liangzhong highway is located in the subtropical monsoon climate zone, and the lineside area has abundant rainfall , solar and hot resources, plants in there grow fast, the natural vegetation restoration ability is stronger; Liangzhong highway construction took more comprehensive measures in drainage, protection and greening. The soil and water

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conservation measures have already began to play a role in the completion of the highway, effectively intercepted the loss of soil in the process of construction. The implementation of soil and water conservation and plant measures, effectively control the water and soil loss within the scope of highway control responsibility.

Highway ecological environmental impact post-assessment is to analyze and evaluate thee related ecological factors along the highway. In order to better reflect the comprehensive influence of highway construction on the ecological environment, ecological comprehensive assessment index method is adopted.

The assessment level is "good", which showed that Liang Zhong expressway construction and operation period caused less damage to the assessment area's ecological environment, the ecological compensation and recovery measures were implemented well. These measures maintained regional ecological integrity of natural system, weakened the destructive effects of human activities on the ecological environment, reduced damage at least.

Table7 The result of the ecological environmental comprehensive assessment in the operation period of Liang Zhong Expressway

	Biological richness	Surface vegetation	Water density	Water and soil loss
Score	90.2	83.3	80.0	83.3
P			74.1	
Judgement			good	

According to the above survey results, the Liangzhong highway project carried out the construction project environmental impact assessment system, environmental protection "three simultaneous" system and completion acceptance of environmental protection system, took effective measures for pollution control and ecological protection. Project environmental impact report, environmental protection measures and recommendations in engineering design and approved opinions and requirements of the State Environmental Protection Administration have been put forward in good implementation, did not cause environmental impacts during the operation.

At present, the main environmental problems is some prefabricated field, mixing station and other temporary facilities in construction period are not in a timely recovery, and part of the side-slope protection has risk in reinforce. Specific recommendations are as follows:

(1) The local government should actively promote agriculture through science and

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technology, and guide farmers to upgrade low and medium yield farmland, in order to improve the economic benefits of land, make up for the agricultural loss caused by the occupation of farmland;

(2) To improve the drinking water quality of local residents, and according to the water quality, we can take simple water treatment measures to reduce the harm of suspended matter and organic matter in Liangzhong highway operation period.

(3) Environmental quality monitoring must be carried out every year, Monitoring frequency is in accordance with the relevant environmental monitoring requirements of National Environmental Protection Bureau. To compile annual environmental quality monitoring report, and update monitor results to the relevant state departments, this method can be of reference to the similar project. According to the environmental monitoring report, it will further improve environmental protection facilities, constantly beautify the environment along the highway, and mix highway and natural environment together.

CONCLUSION

Highway environment impact assessment is an important part of highway environment assessment, and it is an indispensable information feedback in the management cycle. This paper improved and tested the highway environmental impact index system and the quantitative model and use MapObject to achieve visualization, the specific research conclusions are as follows:

(1) From the concept of sustainable development, the paper discussed the importance of building the highway environmental impact assessment index system and quantitative model in the perspective of environmental protection and circular economy.

(2) Under the guidance of the index system basic concept, the selection principle and the scope of the index are analyzed, which provides reference for the construction of highway environmental impact assessment index system and quantitative model.

(3) There is no uniform index system and quantitative model of highway environmental impact assessment in China at present, which cannot form comparable quantitative data of the system, so this paper constructed the index system and quantitative evaluation model of highway environmental impact.

(4) Through the analysis of the calculation of the single factor index and the comprehensive assessment method, using visual development language VB, combined with the Map space provided by MapObject, highway environment evaluation system has been developed. According to the characteristics of highway environment, the system can realize the function of layer control, input editing, environmental impact forecast and environmental impact post-assessment.

In a word, through the practical experience of designing and implementing highway

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environmental assessment system and the research of development methods, all this has a promoting effect on the application extension of MapObject, and it expands the application scope field of geographic information system.

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