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Research and Application on the Key Technology of Ecological Route Selection in the Mountain Area of Northern Guangdong Province

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Abstract: Based on the express way from Huizhou to Qingyuan section in Guangdong province, this study used the “3S” technology to collect the eco-environmental factors in the mountain area of northern Guangdong province. By quantified analysis, various eco-environmental indexes were assigned and standardized. In addition, the analytic hierarchy process was used to set up the weight of respective index factor, as well as to establish the regional ecological evaluation criteria system of the mountain area in northern Guangdong province. It consisted of two primary criteria and ten secondary criteria. As a result, this method was proved to be an available method on route planning for highways in different areas, which was worthy of promotion and utilization.

1. Introduction

In the “Construction Outline of Powerful Nation in Transport”, it proposed that, “the eco-environmental ideas should be implemented throughout the planning, construction, operation and maintenance of the transport infrastructure. It aims to promote the ecological selection of routes and sites, reinforce the eco-environmental design as well as to avoid the cultivated land, the forest land, the wet land and else prominently ecological national land”. With an increasing awareness of the environmental protection every year, in addition to the environmental assessment on the planning of regional highway network and the assessment on the environmental influence from the roads in the midst of the highway engineering and construction, relevant transport sectors have advanced intensive requirements on the selection of specific routes, ecological routes and ecological sites. Therefore, on basis of GIS and Remote System, it concentrated on the ecological service value in the mountain area of northern Guangdong province in China. By centering on the express way from Huizhou to Qingyuan section in Guangdong province, it built up an assessment criteria system of the ecological route selection for the express way in the mountain area of northern Guangdong province. Furthermore, it applied the system on the express way from Huizhou to Qingyuan section in Guangdong province.

In recent years, with the development of information technology, the Remote System (also known as RS) and the geographic information system (also known as GIS) were increasingly used in the eco-environmental protection and also widely used in transport environmental protection. A plenty of scholars at home and abroad used 3S technology for highway route selection. Through building the ecological assessment criteria system for the northern Guangdong mountain area, it undertook the assessment on ecological suitability and provided favorable technical support on ecological selection of routes and corridors for the highway design sectors.



2. Methods of Research

2.1 Areas of Research

The Huizhou-to-Qingyuan section in the Shanzhan express way is located in the central part of Guangdong province. It is also known as the essential part of the “bi-horizontal lines”-Shanzhan express way in the planning of Guangdong express way network. The overall length of the route is 125.277 kilometers. In January 2017, the Huiqing express way was chosen in the second collection of typical ecological highway demonstration projects by the Ministry of Transport. It is also an important main road of tourism industry and landscape channel. Along the route, it has abundant tourism and ecological resources including the South Kunshan tourism area, the Conghua new hot spring forest park, the Qingyuan Bijia mountain along with dozens of scenic spots, natural reserves, ecological strict control areas and forest parks.

The project is located in the northern part of Guangdong province which belongs to the sub-tropical monsoon climate. In this area, it has apparent monsoon, sufficient sunshine and plentiful rainfall. The average rainfall throughout the year is between 1695mm and 2258.0mm. The maximum rainfall is between 2325.4mm and 2732mm. The rain season is mainly from April to July.



Figure 1 Geographical Location Map of the Researched Region

2.2 Methods and Statistics

(1). Analytic Hierarchy Process

In the regional ecological assessment criteria system, some index factors are more important than others. Based upon the ecological protection value, the contribution level of these factors on route selection is different as well. Thereupon the analytic hierarchy process (also known as AHP) was used to implement the analysis of weight on various index factors in accordance with the status of ecological environment in specific region. Consequently, the elements which were correlated with the policy decision were separated into objective, principle, solution and other different levels. On this basis, it fulfilled the quantified analysis on policy decision.

(2). Weight Assignment

The relative comparison method is a type of subjective weighting method. Its basic ideas are: classifying all indexes first and then grouping them into a square-shaped table. In the light of the tri-level proportional scale, the indexes are compared in pairs, and then the comparison scores are recorded in the table. Finally, it sums the scores as per line and obtains the corresponding weight assignment after normalization.

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} = (a_{ij})_{m \times n}$$

Suppose it has m workable solutions S_1, S_2, \dots, S_m , and n decision-making indexes G_1, G_2, \dots, G_n . These indexes constitute below index matrix.

In accordance with the scoring criterion of tri-level proportional scale, every two indexes were compared and scored. Set the score value as q_{ij} , the weight coefficient of the indexes G_1, G_2, \dots and G_m were:

$$\varpi_j = \frac{\sum_{i=1}^m q_{ij}}{\sum_{j=1}^n \sum_{i=1}^m q_{ij}}$$

The relative comparison method can be used only when any two indexes possess comparability in terms of relative importance and meanwhile meet the requirements of transitivity.

(3). Establishing the criteria system

In the light of the eco-environment condition in researched area, it conducted the gradation and standardized assignment of the ecological protection values on the importance of vegetation patterns, the importance of land use patterns, the soil erosion grades, the water function division grades, the ecological function area division grades, the national reserve importance and more indexes.

Table 1 The assessment criteria system table of ecological suitability

Target	Criteria	Index	Weight
Ecological suitability	Ecological service	NDVI	0.123
		Animal suitability	0.246
	Ecological sensitivity	Nature reserve	0.132
		To protect the species	0.066
	Climate weather	Rainfall	0.074
		Dry degree	0.134
		Rainstorm runoff	0.040
	Soil sensitivity	The thickness of the soil	0.032
		The soil fertility	0.064
	Water resource sensitivity	Drainage	0.045
		Water function protection area	0.072
	Topography	Slope	0.051
		Aspect	0.017
		Elevation	0.136

3. Results

(1). NDVI

It combined the technologies of remote sensing and geographical information system to process the ecological background information. By this means, not only will the efficiency of information data processing be improved, it can also reflect the ecological background in an objective and scientific way.

As the main criterion for various ecological systems, the vegetation coverage level is used to weigh the changes of ecological system and vegetation coverage. It can also reflect the influence of human activities towards ecological environment. In view that the native plants and vegetation in sub-tropical mountain areas suffer from relatively greater damage, the South Kunshan forest park maintains quite complete vegetation. Therefore, the South Kunshan forest park possesses essential guiding

significance for the ecological route in sub-tropical areas. It launched investigation on the pattern, distribution and coverage level of the vegetation alongside the road in mountain area.

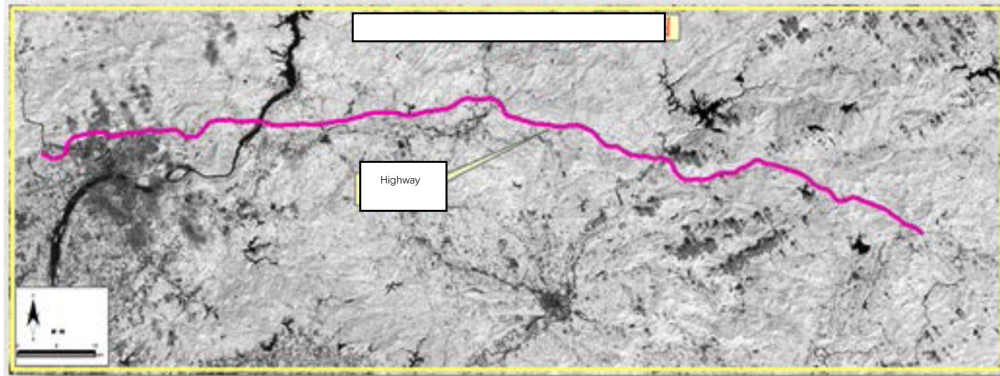


Figure 2 The distribution map of vegetation index alongside the Huiqing express way

(2). DEM

The terrain slope is a key index to reflect the landform. It plays a significant role in route selection, construction, maintenance and operation of the highways. In addition, all kinds of road disasters are correlated with the terrain and landform. The terrain slope partly reflects the human activity interference with the sub-tropical mountains, which may directly change the structure and function of the ecological environment in subtropics. In the meantime, the pattern of land use is also very important factor for road design, construction and maintenance references.

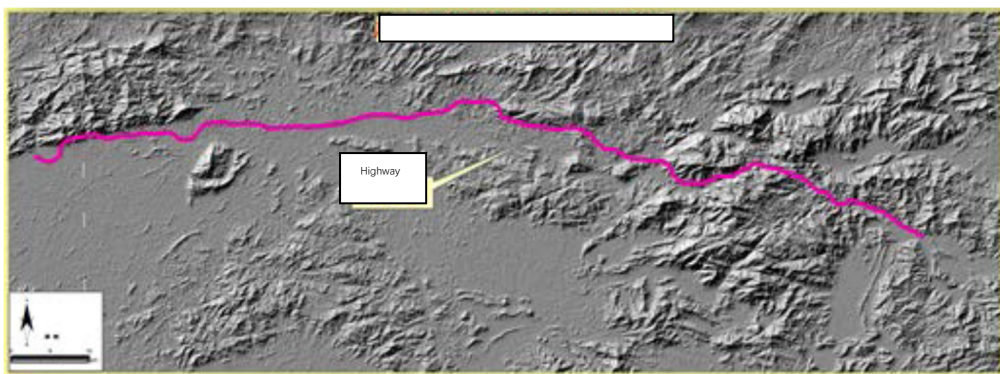


Figure 3 The shadow map of mountain alongside the Huiqing express way

(3). Soil and Water Loss

In the sub-tropical mountain areas, the soil formation is rather slow. Thereupon in areas of serious soil erosion as well as the areas of stacked soil, the construction waste land, the construction waste and the domestic garbage in the midst of highway construction and operation, the development level and soil mass form of the original soils is seriously destroyed; even the soil structure, soil quality and else soil properties are affected.

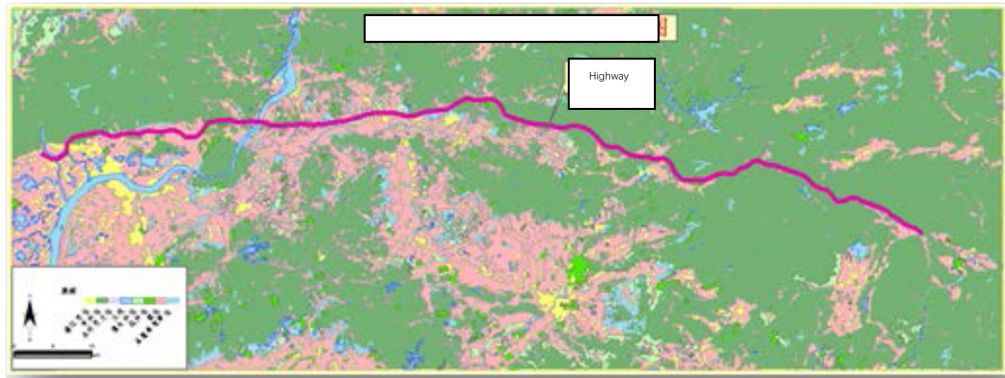


Figure 4 The land use diagram alongside the Huiqing express way

(4). Assessment of the Ecological Suitability

The assessment of hierarchy process (also known as AHP) method was used in various aspects of researches including the ecology, the environmental protection, the resource development, the regional planning, the social economy and else. It divided the elements into assessment system; then built the judgment matrix to calculate and compare the judgments in pairs, thus obtaining the weight of respective factor. At last, the uniformity of judgment was tested. Suppose the matrix value $CR < 0.1$, it indicated that the uniformity is acceptable. The medium indicator assessment system is complicated and it possesses huge dimension difference, so the comparability is not sufficient. Therefore, it is necessary to normalize all the factors in the assessment. In this study, the indexes of assessment were normalized. Firstly, it determined all the indexes in the light of their status values and the assessment norm; then the layering and merging method was used to assign weights step by step as well as calculate the ecological suitability and systematic sensitivity of the highway land use. The specific calculating formula was shown as below:

$$P = \sum_{i=1}^n \sum_{j=1}^m w_{ij} H_{ij}$$

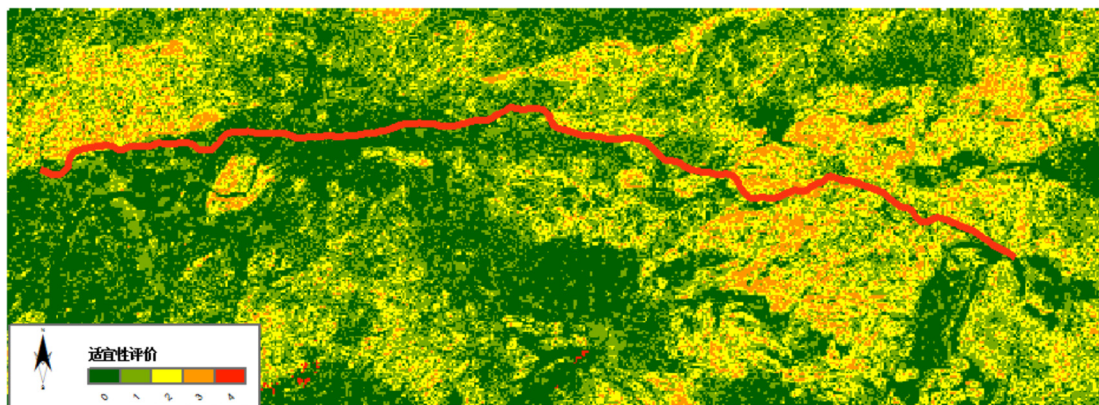


Figure 5 Assessment diagram of the ecological suitability alongside the Huiqing express way

4. Conclusions

(1). This thesis discussed the vulnerability of the ecological factors in mountain area and analyzed the influence on the ecological surroundings in mountain area, the vegetation, the water environment, the terrain slope, the soil erosion and the pattern of land use when the highway was constructed.

(2) On basis of the hierarchy analysis method and the grey correlation theory, it presented the method of weight calculation for measuring the ecological assessment indexes and thus determined respective index weight. By using the GIS technology, five thematic maps were studied by overlay

analysis, furthermore, a comprehensive analysis on the ecological background conditions were developed.

(3) In this thesis, it identified the sensitive ecological area and the non-sensitive ecological area in researched region; consequently, it found out the routes and corridors that have minimum impact on the surroundings. Moreover, the road CAD software was used to design feasible solutions. The optimal solution was then selected to finally determine the most coordinated route for the ecological environment.

The ecological suitability assessment on route selection stems from the evaluation on land ecological suitability. The eco-suitability of route and road selection can be regarded as the ecological system suitability in typical form of land use, the highway construction. In accordance with the regional eco-system characteristics, the route was selected after appropriate ecological analysis. The weights of various factors were judged in terms of highway construction. Simultaneously, in view of the ecological protection, it took into account of the stability and restore ability of regional eco-system engineering and construction. Therefore, the ecological suitability analysis on route selection is able to provide scientific foundation for highway planning and route selecting. It also possesses great significance for improving policy-making levels of the highway planning and construction management.

Author

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