

Suitability analysis of heritage corridor based on GIS and Remote Sensing — Case study of region along the Zhangzhou ancient post road

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Abstract

It's insufficient to singly select land types as resistance factor and thus fulfill the suitability analysis of Heritage Corridor. In order to assist Heritage Corridor Plan better, method of suitability analysis of Heritage Corridor based on GIS and Remote Sensing was proposed. Firstly, types of heritage resource were divided based on study area identity. Moreover, comprehensive resistance cost was constructed by selecting land types and terrain as resistance factors. Secondly, various types of landscape resistance surfaces were simulated based on heritage resources and comprehensive resistance costs. Thus comprehensive landscape resistance surface was constructed through the weighted-overlay of various landscape resistance surfaces, based on heritage resource weight obtained from electronic questionnaire. Finally, resistance values of turning points were extracted by analyzing the histogram of comprehensive landscape resistance surface. Thus the results of suitability analysis of Heritage Corridor were obtained by dividing suitability grades based on resistance values of turning points.

Key words: Heritage corridor; Suitability analysis; GIS; Remote Sensing

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1. Introduction

In China, the separation of plans such as Heritage Conservation Plan, Ecological Protection Planning and others caused the urban sustainable development to be confronted with dilemma. Therefore, the theories for integrating heritage protection, ecological protection and others into a whole, supporting or be applied to the practice of planning and design were particularly urgent.

Heritage Corridor theory originated from America and was the regional development strategy and planning approach having great impact on the world. Heritage Corridor not only could be the river, the canyon, the road and the railway line, but also could be the cultural greenway formed from connecting single heritage points (Zube et al., 1995; Wang et al., 2001; Li et al., 2010); Meanwhile, Heritage corridor was a comprehensive protection measure for integrating the heritage protection, the ecological protection and the culture and leisure activities into a whole. Therefore, the corridor not only could protect the cultural resources and linear heritage, but also had the functions of leisure tourism, ecological protection and so on. Thus such corridor could offer new perspective, strategy and route for regional development and heritage protection (Christina et al., 1993; Searns et al., 1995; Kimberly et al., 2005; Wang et al., 2010). The theory and practices of Heritage corridor in USA and Europe were more mature. And the representative Heritage corridor could be the Illinois and Michigan Canal National Heritage Corridor and Blackstone River Valley National Heritage Corridor originated from American congressional legislation. Thus such mature theory and practices could offer theoretical support for the mutual integration of Heritage Conservation Plan, Ecological Protection Planning and others (Jeske et al., 1988; Cour et al., 1991). However, the study of Heritage Corridor was still in the initial stage in China and part studies offered decision support for Heritage Corridor Plan through the method of Corridor Heritage suitability analysis. And the representative studies could be the Suitability analysis of Heritage Corridor in Taizhou City, the creation of Beijing-Shenyang-Qing Cultural Heritage Corridor, the construction of Heritage Corridor Network in the Ancient Capital of Luoyang and the suitability estimation and analysis of Heritage Corridor in Liling City (Yu et al., 2005; Wang et al., 2009; Sha, 2012). And the idea of suitability analysis method was that heritage conservation associated with ecological and recreational activities were considered as a horizontal movement process going across the landscape. And the spatial expansion of such process was simulated based on the different resistance distribution of land types and heritage resources. Thus the suitability

degree for each part landscape to the activities of heritage conservation, ecology and recreation would be distinguished through the resistance distribution. Based on such idea, the methods of Corridor Heritage suitability analysis contained four contents. In the content of heritage resources determination, heritage conservation sites, local landscape and others were considered as the same theme heritage resource according to the existing data and field survey. However, the theme of heritage resource was too single and the problem of different heritage resource having different weight wasn't be considered. In the content of resistance cost construction, considering the different resistance of different land types to landscape horizontal movement, land types was considered as the single resistance factor to construct the resistance cost. In the content of the simulation for landscape resistance surface, combining the spatial analysis technology of GIS and the model of Minimum Cumulative Resistance, comprehensive landscape resistance surface was simulated based on the comprehensive heritage resources and resistance cost. In the content of Corridor Heritage suitability analysis, resistance values of turning points were extracted by analyzing the histogram of comprehensive landscape resistance surface. Thus the result of suitability grades for Heritage Corridor was obtained based on the resistance values of turning points.

The practices of suitability analysis method to support Heritage Corridor Plan had made some progress. And scholars singly selected land types as resistance factor and thus fulfill the suitability analysis of Heritage Corridor. However, in the undulating terrain area, the horizontal expansion process of heritage conservation activities and others was not only affected by land types, but also affected by terrain. Therefore, considering land types as single resistance factor was insufficient and the selection for resistance factor needed to be improved. In order to assist the Heritage Corridor Plan better, method of suitability analysis of Heritage Corridor based on GIS and Remote Sensing was proposed. Firstly, types of heritage resource were divided based on the identity of study area. Moreover, comprehensive cost was constructed by selecting land types and terrain as resistance factors. Secondly, various types of landscape resistance surfaces were simulated based on heritage resources and comprehensive cost. Thus comprehensive landscape resistance surface was constructed through the weighted-overlay of various types of landscape resistance surfaces. Finally, resistance values of turning points were extracted by analyzing the histogram of comprehensive landscape resistance surface. Thus the result of suitability grades for Heritage Corridor was obtained based on the resistance values of turning points.

2. Methodology

2.1 Technical Roadmap

The method of Heritage Corridor suitability analysis based on GIS and Remote Sensing contained four contents, heritage resources determination, resistance cost construction, simulation for landscape resistance surfaces and Corridor Heritage suitability analysis. And the special technical flowchart could be shown in Fig.1, including technical flowcharts of the past studies and this study.

- Heritage resources determination

As shown in Fig.1, in the content of heritage resources determination, the past studies did not fulfill the theme classification and weight determination for heritage resources. However, the attraction of different heritage resources to subjects overcoming resistance to experience heritage resources was various. Thus the past studies in the content of heritage resources determination needed to be improved. Therefore, heritage resources was divided into four themes containing cultural landscape, natural landscape, custom landscape and rural landscape based on the identity of study area in this study. Meanwhile, the theme weight of different heritage resources was obtained from electronic questionnaire.

- Resistance cost construction

As shown in Fig.1, in the content of resistance cost construction, the past studies singly selecting land types as resistance factor to construct resistance cost needed to be improved. Therefore, resistance cost was constructed through selecting land types and terrain as resistance factors in this study. Since the preferences of different regional residents to land types and terrain were various, different slopes and land types were given different resistance values based on electronic questionnaire and the past research. Thus the resistance costs of land types and terrain were obtained. And the comprehensive resistance cost would be obtained through the equal weighted-overlay of land types and terrain cost.

- Simulation for landscape resistance surface

As shown in Fig.1, in the content of simulation for landscape resistance surface, the past studies directly simulating the landscape resistance surface based on the unclassified heritage resources and the resistance cost needed to be improved. Therefore, landscape resistance surfaces of rural, custom, nature and culture would be respectively simulated based on the four thematic heritage resources and the comprehensive resistance cost in

this study. Thus the comprehensive landscape resistance surface would be obtained through the different weighted-overlay of four landscape resistance surfaces.

- Corridor Heritage suitability analysis

As shown in Fig.1, in the content of Corridor Heritage suitability analysis, the methods for the past studies and this study were identical. And there was not clear classification basis for the Corridor Heritage suitability analysis at present. Therefore, resistance values of turning points were extracted through analyzing the histogram of comprehensive landscape resistance surface by most of scholars. Thus the result of suitability grades for Heritage Corridor would be obtained based on the resistance values of turning points (Yu et al., 2005; Yuan et al., 2014).

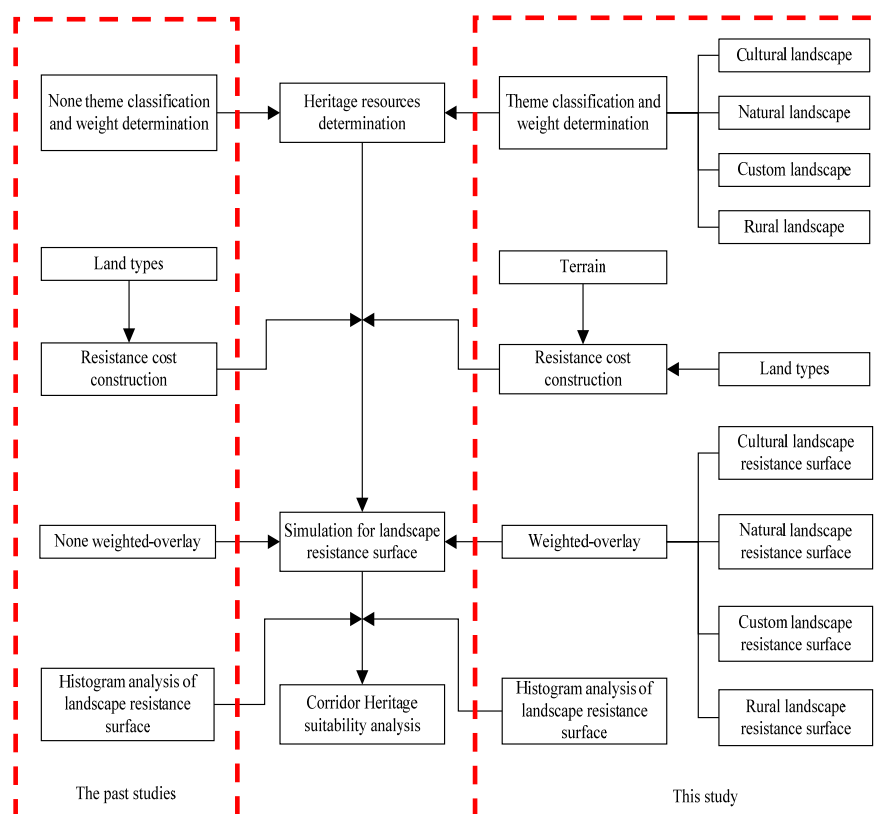


Fig. 1 Technical flowcharts of the past studies and this study

2.2 Study Area

Region along the Zhangzhou Ancient post road is located in the middle of national historic city of Zhangzhou. Such region covering 4220 square kilometers, now is the district along the Jingcheng Town-Pantuo Town session of State Road 324 by way of Jingcheng Town, Jiuhu Town, Chengxi Town, Flower garden, Changqiao Town and others (see in Fig.1). And the region not only has the undulating terrain, but also has the various thematic heritage resources containing the rural, the custom, the natural and the cultural.

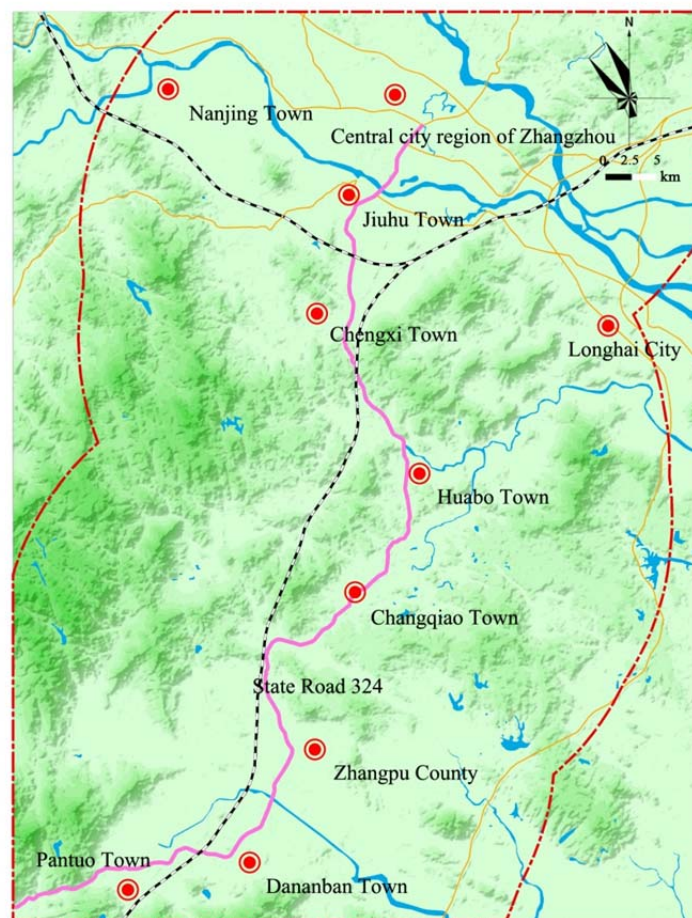


Fig. 2 Region along the Zhangzhou ancient post road

2.3 Data Preparation

Data for Heritage Corridor suitability analysis contained DEM and remote sensing image of 2014 obtained from Geospatial Data Cloud and Bigmap Image Platform, heritage resources distribution obtained from the Planning and Design Institute of Zhangzhou City, heritage resources weight and land types preferences obtained from electronic questionnaire. And data preparation has been made as follows:

- The basic database of suitability analysis was established based on remote sensing image of 2014 and Arcgis10.0. And the better geographic spatial database could be constructed, through the techniques of projection and geographical registration to adding the data of DEM and heritage resources into the basic database.
- Land types containing core heritage sites, rivers, greens, farmlands, freeways, railways, main road and built-up area were classified based on the remote sensing image of 2014, the supervised classification technique and the artificial optimization.
- The theme weight of different heritage resources could be obtained from electronic questionnaire of residential preferences to different heritage resources (see in Table 1). And the resistance values of land types could be obtained from electronic questionnaire of residential preferences to different land types (see in Table 2).

Table 1. The weight of heritage resources

Types of heritage resources	Cultural landscape	Custom landscape	Natural landscape	Rural landscape
Weight	0.4	0.3	0.15	0.15

Table 2. Resistance values of land types

Code	Land type	Relative resistance value
1	Core heritage sites	10
2	Greens	20
3	Rivers	40
4	Farmlands	150
5	Freeways	400
6	Railways	500
7	Main road	300
8	Built-up area	250

2.4 Algorithms

Suitability analysis theory of Heritage Corridor evolved from the suitability analysis theory proposed by McHarg and the Greenway suitability analysis theory proposed by Miller (McHarg et al., 1969; Miller et al., 1998). And the suitability analysis towards Heritage Corridor could be fulfilled by the model of Minimum Cumulative Resistance, initially proposed by Knaapen (Knaapen et al., 1992). Based on the model, the distributions of spatial resistance overcome by various landscape elements to reach the heritage resources could be simulated. And the higher spatial resistance for one area, the lower suitability of Heritage Corridor for the area. And the equation for the model of Minimum Cumulative Resistance could be defined as follows:

$$MCR = \int \min \sum_{j=n}^{i=m} (D_{ij} \times R_i) \quad (1.1)$$

Where MCR denotes the value of minimum cumulative resistance, denotes the positive correlation between the minimum cumulative resistances and movement process, D_{ij} denotes the distance for heritage site j to reach landscape elements i , R_i denotes the resistance for site i to heritage movement.

3. Results

3.1 Heritage resources determination

Heritage resources could be divided into four themes containing cultural landscape, natural landscape, custom landscape and rural landscape based on the identity of study area (see in Fig.3). And the heritage resources of cultural landscape contained the Holy King temple, Nanjing temple, historic district of Ming-Qing dynasty, historic Site of Renjia, Huangdao tomb and other cultural relic protection units.

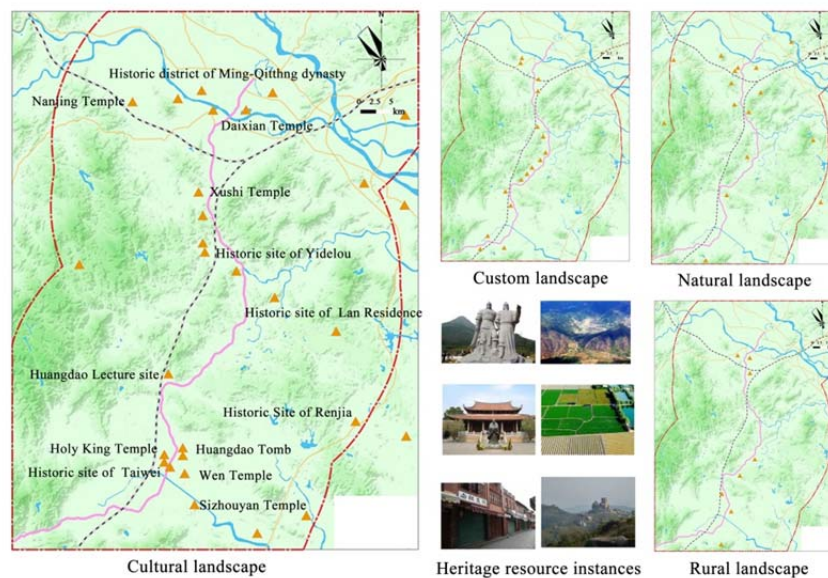


Fig. 3 Heritage resources classification

3.2 Resistance cost construction

Based on the function of Slope and Reclassify in Arcgis10.0, the resistance cost of slope could be constructed through the data of DEM and slope resistance values. Meanwhile, resistance cost of land types could be constructed through the data of land classification and land resistance values. Based on the function of Weighted Sum in Arcgis10.0, the comprehensive resistance cost could be constructed through the weighted-overlay of slope and land types resistance costs (see in Fig.4).

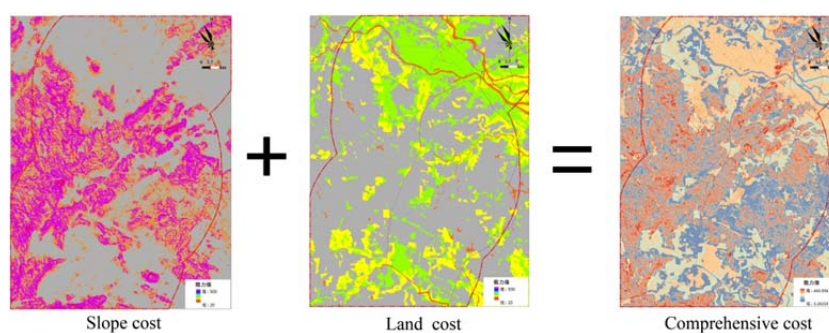


Fig.4 The single and comprehensive resistance cost

3.3 Simulation for landscape resistance surface

Based on the function of Cost-distance in Arcgis10.0, The landscape resistance surfaces of rural, custom, nature and culture would be respectively simulated based upon the previous results containing four thematic heritage resources and comprehensive resistance cost. Thus the comprehensive landscape resistance surface would be obtained through the weighted-overlay of four single resistance surfaces (see in Fig.5).

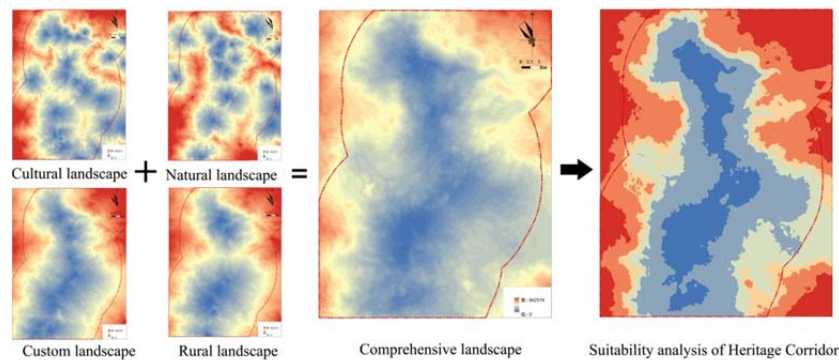


Fig.5 The single and comprehensive landscape resistance surface and the suitability analysis for Corridor Heritage

3.4 Corridor Heritage suitability analysis

Based on the function of Geostatistical Analyst in ArcGIS 10.0, the resistance values of turning points were extracted by analyzing the histogram of comprehensive landscape resistance surface. Thus the result of suitability grades for Heritage Corridor was obtained based on the resistance values of turning points(see in Fig.5). And the higher resistance value for one area, the lower suitability grade of Heritage Corridor for the area. Thus the suitability grades decreased from blue area to red area in Fig.5.

4. Discussion and conclusions

Method of suitability analysis of Heritage Corridor based on GIS and Remote Sensing was proposed in this study. And the method contained four contents, the heritage resources determination, the resistance cost construction, the simulation for landscape resistance surface and the Heritage Corridor suitability analysis. Compared to the past studies

towards suitability analysis of Heritage Corridor, the improvements of this study could be summarized as follows:

- In the content of heritage resources determination, the past studies didn't fulfill the theme classification and weight determination for heritage resources. However, the attraction of different heritage resources to subjects overcoming resistance to experience heritage resources was various. Therefore, based on the identity of study area, heritage resources was divided into four themes and thus the four thematic heritage resources were given different weight in this study.
- In the content of resistance cost construction, this paper synthetically considered terrain and the land types as resistance factors to construct comprehensive resistance cost and thus remedied the shortage for singly selecting land types as resistance factor.
- In the content of simulation for landscape resistance surface, the past studies directly simulating the landscape resistance surface based on the unclassified heritage resources and the resistance cost needed to be improved. Therefore, four landscape resistance surfaces were respectively simulated and thus the comprehensive landscape resistance surface was obtained through the weighted-overlay of four landscape resistance surfaces.

However, this method also has its weaknesses. Firstly, because of the lack of unified resistance values for land types in the world, resistance values of land types obtained from cases and electronic questionnaire were relative. Therefore, the accuracy of resistance values need to be improved. Secondly, heritage resources preferences for residents living in different region were various. Thus the weight of thematic heritage resources obtained from electronic questionnaire was not universal. Such aspects could be improved in the future research.

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