

## *Environmental consideration in railway route selection with GIS* (Case study: Rasht-Anzali railway in Iran)

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### **Abstract:**

In order to minimize environmental impacts and to achieve sustainable development in route construction projects, environmental parameters must be considered. To achieve this goal, use of GIS for route selection was proposed. This research was undertaken for Rasht-Anzali railway in north of Iran as a case study. At first, environmental parameters that affect railway route selection were identified. These parameters include slope, geology, soil, landcover, rivers, roads and Cultural heritage. Data related to these parameters were gathered or in some cases produced. Slope, rivers and road map extracted from digital topographical map at the scale of 1:25000. Landcover map was produced from Landsat7 ETM+ data dated on May 2000. Rectification of satellite data was implemented using ground control points method. To achieve a better resolution, the multispectral bands were fused with ETM-Pan. Image classification was performed using a new approach (digital and visual). Maps such as geology, soil and cultural heritage were digitized.

In order to determine the relative importance of the parameters in route selection, environmental and civil expert's views collected from a questionnaire that has been designed for this aim. These views were used in pairwise comparison method to determine weight of map layers that related to these parameters. These weighted layers overlaid and friction maps were created according to different scenarios and automatically 4 routes resulted in GIS. Analytical Hierarchy Process was used to determine optimum routes in comparison with that produced in traditional method.

Results indicate that the routes, which were designed using GIS method, are more environmentally sound than traditional one and represent a significant benefit for the decision maker. According to the results of this investigation, applying GIS technology and inclusion of environmental expert's views are recommended to minimize environmental liabilities.

The main data analysis software for this study were IDRISIW 2, Expertchoice and ArcView3.2

### **1. Introduction**

Transportation network expansion is a key factor for realization of economic and social development, particularly in developing countries. Railways for having comparative merits such as high level safety and energy saving has a desirable place among different transportation

modes. For particular condition of Iran, its extent and position in Middle East, sprawl of settlement and distance of growth poles, development of railway systems is vital. In conventional railway route selection, economic and technical parameters were mere determinant factors in which environmental impacts of projects were completely neglected.

Minimization of environmental impact and liabilities requires consideration of environmental criteria in initial planning and railway route selection. Consideration of environmental parameters, in addition of economic and social ones by increasing required data, make more complex process of route selection in traditional mode. Emerging complexity of decision making process in new situation that involve much more data and consideration of different type of criteria, urge investigator and planner to utilize of more effective technologies such as GIS to help analyzing a great volume of data. GIS make possible to analyze and process data as quickly and precisely as possible.

Over the past few years, an increasing number of investigations on GIS-base route selection became available. Feldman et al (1995) used remotely sensed data and GIS for pipeline routing in a small section of the proposed Caspian oil pipeline. For this mean a model was developed incorporating pipeline length, topography, geology, land use, stream, wetland, road and railroad crossing to identify least cost pathway. In another study (Jacobs and Vuong, 2001) that was done in USA, GIS technology was successfully applied for routing High Speed Railway (HST) in Minnesota Province. The purpose of this study was to develop a linear facility-siting method especially for a HST route. The key factor and constraints that affect land suitability for a HST route identified by this study were soil type, slope, roads and highways crossing, wetlands, lakes and streams and urban areas. Multi Criteria Evaluation (MCE) was used to identify suitable lands. The least cost pathway was also used to create a potential zone in which to locate a route.

## **2. Methodology**

### **2.1. Study area**

An area in the Gilan province in north of Iran was selected for this study (Figure 1). Gilan province due to having some character such as existence of agricultural land, forest, wetlands, grand rivers and sea shores is one of the very important wildlife habitats and scenic landscapes in the world and regional scale that presents fragile and vulnerable nature against development of human activities. So Rasht-Anzali railway is of national level significance. Nowadays Rasht city plays an important role as an industrial and agricultural pole of region and Anzali port is also an import-export center in the north of Iran. Environmental characteristics of Gilan attract a large number of tourists and related human activities in parallel, that all require a clean and safe transportation system.

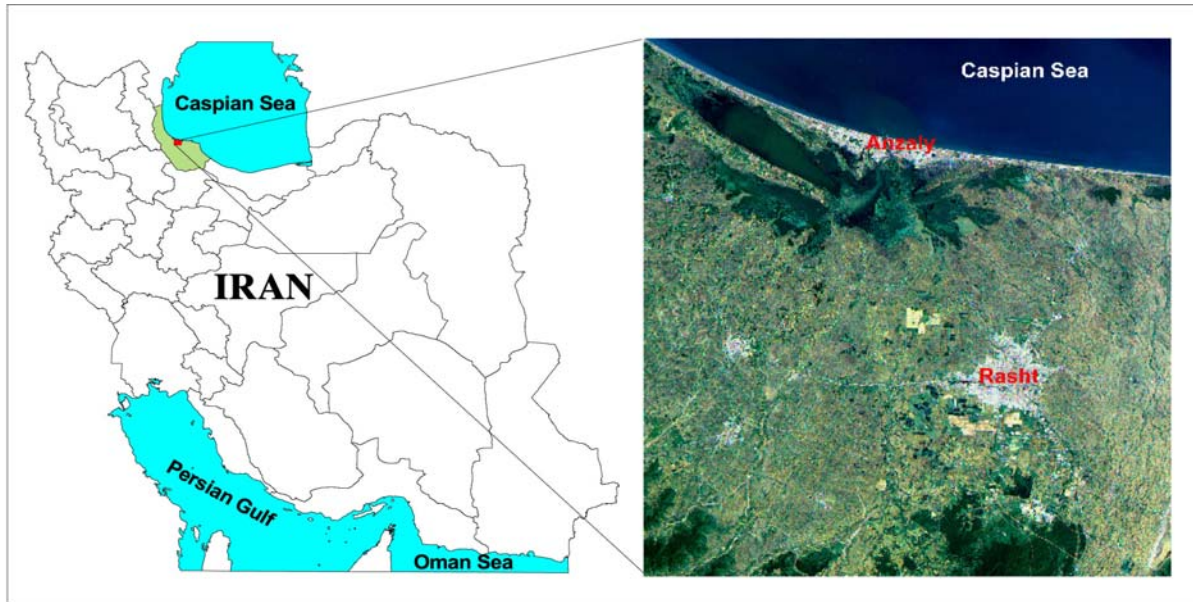


Figure 1: Location of the study area in Iran and its Landsat color composite image 321(RGB)

## 2.2. Environmental parameters and data acquisition

To achieve research goal, effective parameters in railway route selection must be identified. Following parameters indicate those items are considered in current study.

**Land cover:** land cover maps provide information on general cover that may be used in railway route selection. To produce this map a subset of Landsat-7 ETM data dated on May 2000 was analyzed. Rectification of satellite data was implemented using ground control points method. To achieve a better resolution the multispectral bands were fused with ETM-Pan. Suitable spectral transformations and color composites were performed on the satellite data. Image classification was performed using a new approach (digital and visual). The land use map checked for accuracy by field study.

**River:** For minimization environmental impact, routes should be far from rivers. Railway construction costs will be increased to fill in or build bridges over rivers, ponds or sections of lakes too. The map of the rivers was extracted from digital topographic map at the scale of 1:25000.

**Road:** Reduction of intersection of railway with existing road, decrease construction cost and increase safety of transportation. For this aim map, of roads was produced base of the existing digital map.

**Cultural heritage:** Cultural heritage forms identity of each society and nation. So people should try to preserve and enhance their place and conditions in the environment. To create a map about the heritage, documents and existing maps were studied.

**Geology:** Geological studies were done for recognition of resistance of rocks underlying superficial layers. For this aim, maps of geology related to the study area digitized.

**Soil:** Susceptible soils to erosion and unconsolidated material need much cost for rail construction than consolidated types. For this aim, a reliable soil map of the area digitized and used for producing desired classified soil map.

### **2.3. Evaluation of effective parameters in railway route selection**

In order to minimize environmental impacts and to achieve sustainable development in route construction projects, it is essential to determine the relative importance of the considered parameters. There are some methods for this aim. Selection of a method depends on the trade-offs between ease of use, accuracy, the degree of understanding on the part the decision maker, and the theoretical foundation underlying a given method, the availability of computer software, and the way the method can be incorporated into GIS-based multicriteria decision analysis. Empirical applications suggest that the pairwise comparison method is one of the most effective techniques for spatial decision-making including GIS-based approaches (Malczewski 1999). This method was developed by Saaty (1980) in the context of the Analytical Hierarchy Process (AHP). This method involves pairwise comparisons to create a ratio matrix. As input, it takes the pairwise comparisons of the parameters and produces their relative weights as output.

It is recommended to consider environmental and civil expert's views regarding to relative priority of the parameters. In this study, it was collected from a questionnaire that has been designed for this aim. Weights of parameters calculated according to these views and prioritized in this order: cultural heritage, land covers and land use, slope, soil type, geology, rivers and roads.

### **2.4. Automatic route selection in GIS**

After determination comparative weight of parameters, these derived weights were attributed to relevant maps. Then to produce a friction map all weighted map layers overlaid in GIS environment. Friction map is a raster map in which each cell has a value that refers partial or absolute obstacle in determination of the route. Friction map inhibits the route selection through the area. For automatic route selection, two origins (Rasht city) and two destination points (Anzaly city) were determined. Different cost surfaces were derived from the friction map and the above mentioned points using Least Cost Pathway Analysis (Eastman R. J., 1995). Four routes were defined based on the different seniors (Figure 2).

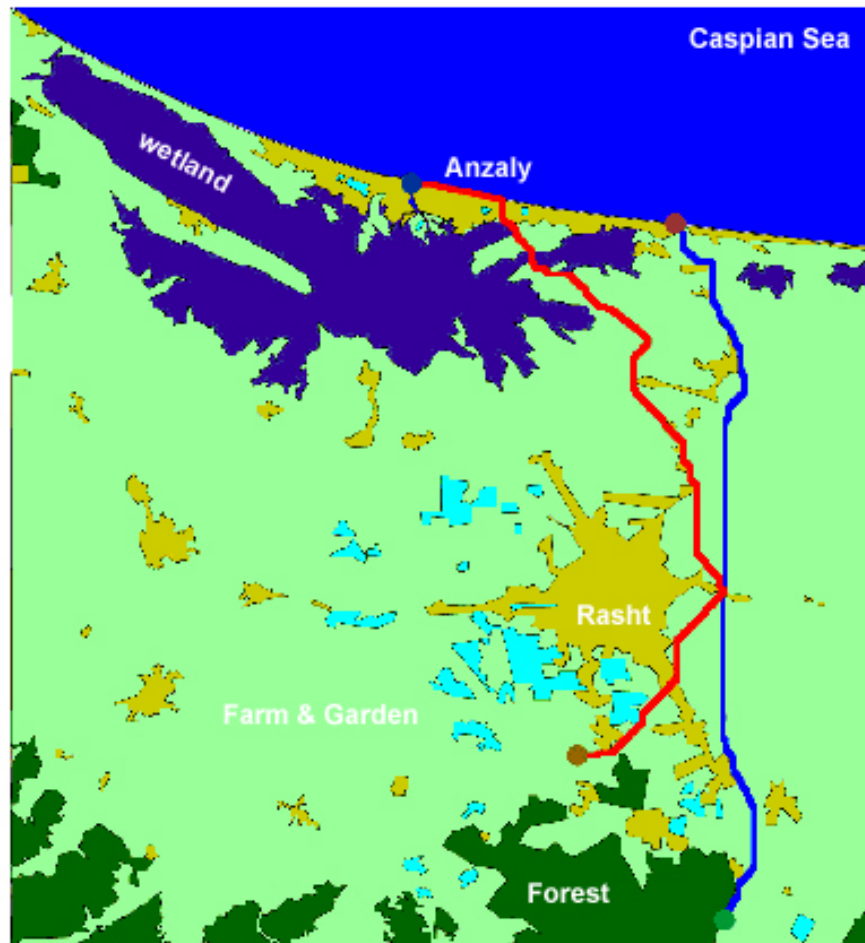


Figure 2. Two Rasht-Anzali alternative railway routes (computed in GIS) overlaid on the Land cover map of the study area

### 2.5. Comparison of routes and optimal route selection

After automatic designation of routes in GIS, each route must be evaluated in respect to environmental considerations. This lets us to choose a route, which has minimal environmental impacts. In this study, Analytical Hierarchy Process (AHP) was applied for choosing optimal alternative. Using this method conventionally designed routes and those determined by automatic method in GIS were compared and optimal route was chosen.

### 3. Results and conclusions

The purpose of this study was to develop a tool to locate a suitable railway route between Rasht and Anzaly cities in Gilan province. The GIS approach using environmental parameters and least cost pathway analysis proved to be successful in achieving this goal. Using a GIS approach was very important in this study. GIS tools allow incorporation of digital data layers of various different scales. In this research railway routes that resulted from traditional method were compared with GIS method. Results indicate the routes that were designed with applying GIS

method are more environmentally sound than traditional one. According to the results of this investigation, applying GIS technology and inclusion of environmental expert's views are recommended to minimize environmental liabilities. The approach developed in this study is very general and it is recommended to use it as a guide for future studies.

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