GIS Based Pipeline Route Selection by ArcGIS in Turkey

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Abstract

Determining the best route through an area is one of the oldest spatial problems. Till recently, route determination was created on the topographic maps manually. But nowadays, GIS technologies are used effectively in route determination process. Route selection is a critical first step in the process of pipeline design and construction and has a potential significantly impact the construction and operation of the pipelines. So, effective route selection process is very important for minimizing economic lost. With this study, in a test areas in the East Black Sea Region of Turkey, various thematic layers such as landslide, slope, geology, landuse, soil, stream, lithology, road, culture and protected areas were generated and integrated using RS-GIS techniques. Using ArcGIS Spatial Analysis module, firstly, acquired data layers were converted to raster format and than queries and analyses were performed. Consequently, in the undulating areas natural gas pipeline route was determined, and costs were calculated.

1.INTRODUCTION

Worldwide, pipelines transport natural gas, crude oil, and finished petroleum products over long distances within countries and across borders to meet energy needs. The overall objective in selecting a petroleum pipeline route is the connection of the crude/natural gas source to the refinery or utility company. Obviously, choosing the shortest, most direct route is always a goal for capital expenditure reasons, but many important goals exist simultaneously in the route selection project and at times these goals may conflict (Dey and Gupta, 1999). Geophysical, environmental, political, social, economic, and regulatory factors interact to define the route possibilities.

The importance of decisions in the petroleum pipeline industry is reflected in the magnitude and nature of the industry. The distances between the source of the petroleum product and the destination for energy processing can be hundreds of miles of varying terrain. This is particularly true as more exploration takes place in more remote areas of the world. Economies have become dependent upon the smooth flow of petroleum products to meet energy needs (Dey et al, 1998). Pipelines carrying petroleum products for extended distances are capital-intensive projects with goals of long life expectancy. The environment in which strategic decisions regarding pipeline planning are made is greatly influenced by external factors (Dey et al, 1996) These factors include government regulations, water depth, ground condition, and population growth. Whereas pipeline transportation of petroleum products is considered the safest form of product transportation, the hazardous nature of the product exposes risk for failures leading to environmental disasters and loss of human life (Dey et al, 1998).

Geographic Information System (GIS) technology is integrated into the decision-support system and utilized to provide the alternative routes. The intermediate level is composed of the broad goal categories of pipeline length, operability, maintainability, approachability,

feasibility of construction, and environmental friendliness. Each of these factors has subfactors, which are included in the analysis. Examples of the subfactors include minimizing environmental damage, ensuring accessibility, avoiding obstacles, avoiding routes parallel to high voltage transmission lines, using existing right-of ways if possible, avoiding densely populated areas, and keeping water and rail crossings to a minimum (Dey and Gupta, 1999).

2.CURRENT SITUATION IN TURKEY

Turkey has an important geographical position in the World. And it is most important passing way from Middle East to Europe to transport rich petroleum and natural gas sources. Existing pipelines and projects in progress are indicators for this. In this content, in route determination process, the criterions such as environmental, sociological, economical and safety have must been evaluated altogether. But, so far, efficient systems are not used for route determination in Turkey.

Natural gas and other pipeline activities are implemented by the BOTAS which Turkey's Petroleum Pipeline Corporation in Turkey. This government-owned company dominates the natural gas sector in Turkey, controlling the pipeline infrastructure for oil and gas transmission, liquefied natural gas (LNG) terminals, and gas distribution. BOTAS has monopoly rights on gas imports and exports and on wholesale trading, transmission, and storage activities. The most important activities are;

Nabucco gas pipeline project: It will connect Turkey with Austria via Bulgaria Romania and Hungary. Total length of pipeline will be approximately 1999 km. (Turkey Passing). The total budget of the project is estimated as 4,6 billion Euro.
South European Gas Ring Project (SEGR): It will connect Middle East and Caspian Countries to Greece and other European Countries, via Turkey. Total length of pipeline will be approximately 211 km. (Turkey Passing). The total budget of the project is estimated as 135 million Euro.
Also, Russian Federation-Turkey Natural Gas Main Transmission Line and Samsun-Ceyhan petrolum pipeline are the most important pipeline project for the other countries in Europe.

3.GIS BASED NATURAL GAS PIPELINE ROUTE SELECTION

The oil and gas industry is increasingly using GIS technology in sitting new pipelines as a tool to reduce both construction and operational costs. The themes and variables used as input in this process mainly address direct construction costs and pipeline efficiency once the pipeline has been completed. Some of the variables examined include (Jones and Barron, 2005):

- shortest distance from source to market
- least grading (removal of trees, etc.)
- costs associated with right of way
- slope of terrain
- number of stream, road, and railroad crossings
- substrate (rock, soils, etc., associated with burial)
- existing laws and regulations (wetlands, etc.)
- proximity to population centers, etc.
- utilization of existing utility corridors and easements
- other engineering factors.

3.1.Conceptual Model

A long distance gas pipeline is a complex system. It relates closely to geographic location, environment, geological condition and many other factors as a geographic object with continuous distributive character. There will be many different data, diagrams, figures, files and other information, which are difficult to use and update them together and effective on each step of pipeline planning, construction, operation and management by manual method (Xaoge and Wentong, 2005). So, there is a need to raster datasets for GIS based route determination. In this process, the most important step is database design. After this, optimum route are generated via intermediate processes and produced data. In this study, firstly a conceptual model is composed (figure 1).

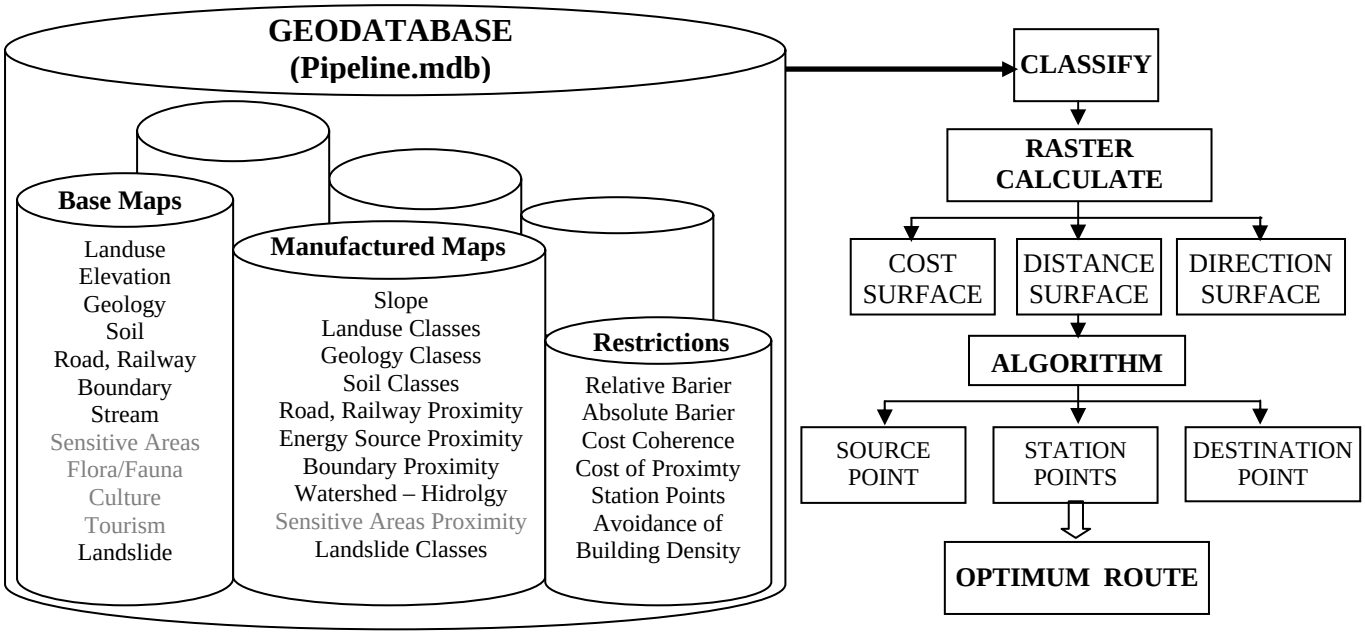

Figure 1. A conceptual model for optimum pipeline route.

3.2. Study Area

The study area is selected in Trabzon which is situated in the Black Sea Region of Turkey In this area, existing pipeline route is optimized. Source point is Macka County, Cayirlar Village (in the southern part) and target point is Bulak Village (in the northern part). Route length is approximately 38 km. (Figure 2).

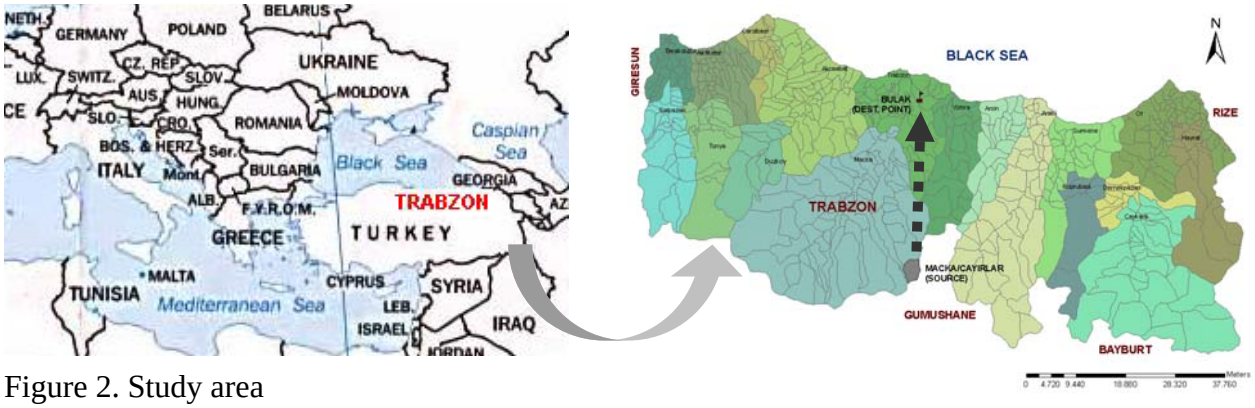

Figure 2. Study area

3.3. Using ArcGIS Spatial Analysis

ArcGIS™ Spatial Analyst provides a broad range of powerful spatial modeling and analysis features. Using ArcGIS Spatial Analyst, GIS users can create, query, map and analyze cell-based raster data; perform integrated raster/vector analysis; derive new information from existing data; query information across multiple data layers; and fully integrate cell-based raster data with traditional vector data sources. ArcGIS Spatial Analyst is integrated into the ArcGIS interface so the user can take advantage of all the advanced functionality in ArcGIS as well as work with other extensions such as ArcGIS Geostatistical Analyst and ArcGIS 3D Analyst™. Using ArcGIS Spatial Analyst, GIS users can derive information about geospatial data such as terrain analysis, spatial relationships, suitable locations, and the accumulated cost of traveling from one point to another. ArcGIS Spatial Analyst integrates real-world variables such as elevation into the geospatial environment to help solve complex problems. ArcGIS spatial analyst provides new functionality for advanced customization and interoperability. Using a common architecture and incorporating customization within any Component Object Model (COM) – compliant programming language, users cab create more advanced raster models for their analysis.

3.4. Network Analysis and Queries

In this implementation, the best route is found for a new gas-pipeline. The steps to produce such a path are outlined below. Path is performed using ArcGIS 9.2 Spatial Analysis Module.

1- Create Source, Destination and Cost Datasets
2- Generate A Thematic Cost Map (Classify and Weighting)
3- Perform Cost Weighted Distance
4- Create Direction Datasets and Perform Shortest Path

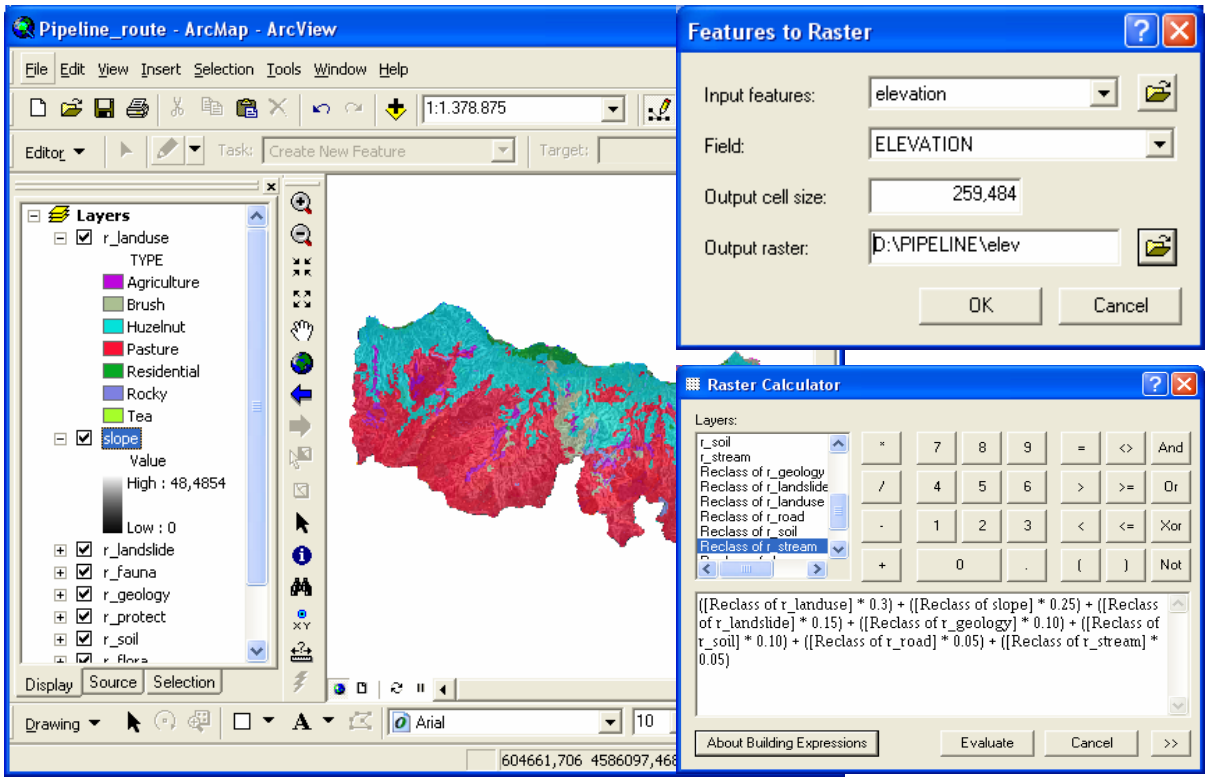

Figure 3. Convert to features and raster calculate for this implementation.

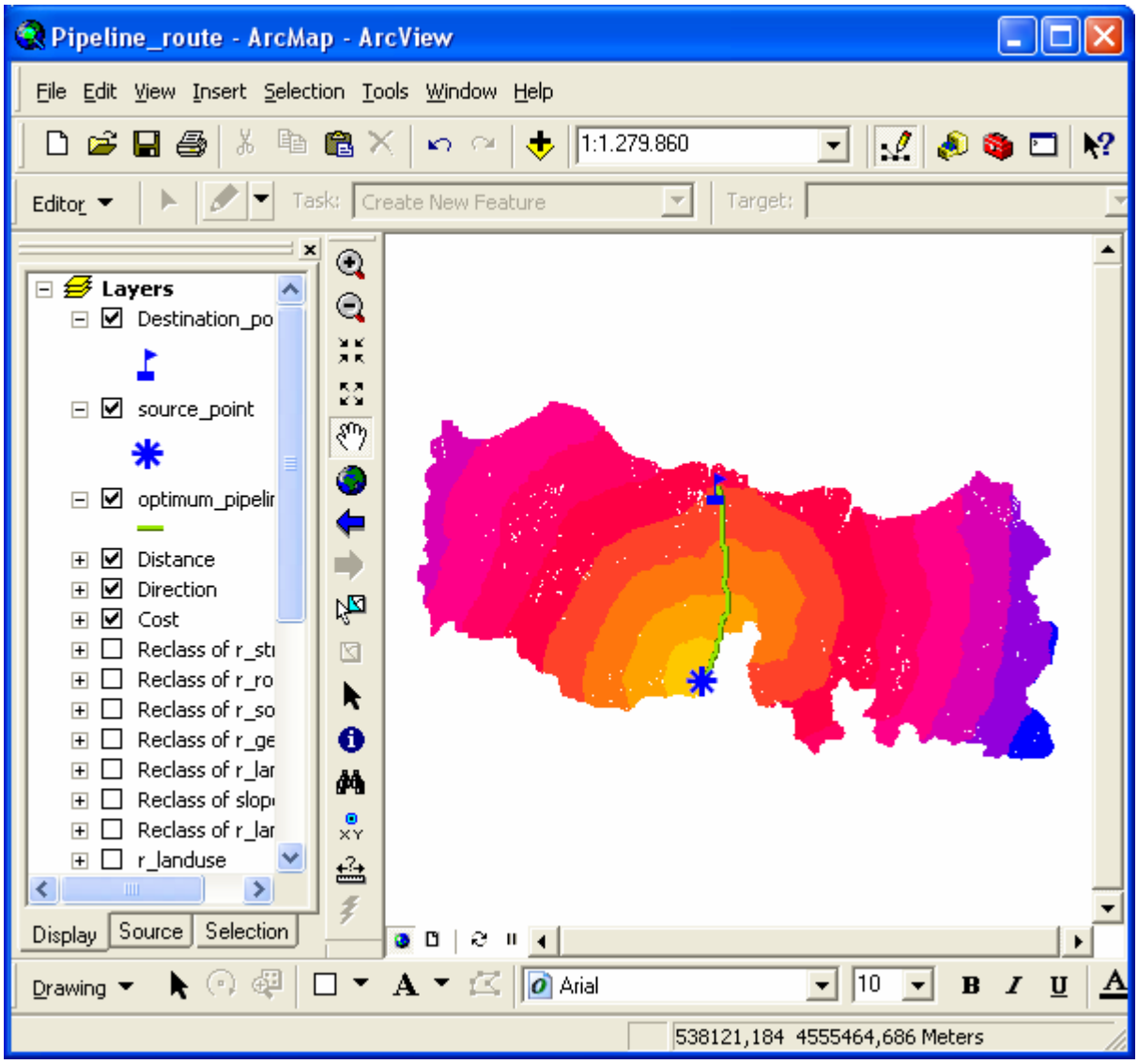

Figure 4. Finding optimum route using ArcGIS 9.2 Spatial Analyst

Findings

Pipeline Length	: 37.7 km.
Construction Site	: 1.508 km^2
Road Crossing	: 10
Stream Crossing	: 8
Landslide Crossing	: None
Protected Area Crossing	: None
Fauna Crossing	: None
Pasture Crossing	: 15.4 km.
Brush Crossing	: 18.2 km.
Hazelnut Crossing	: 4.1 km.

3.CONCLUSION

Linear projects in developing world are human rights and environmental protection. Pipelines and similar large scale energy projects undertaken in majority countries are rarely vetted through a process of environmental or social impact assessment. But this study, by incorporating both the environmental and traditional sets of criteria an optimal route could be achieved.

Safer and cheaper pipeline transportation of energy resources is a major concern for the public and the pipeline industry. Today, the pipeline owners and operators are under increasing pressure to produce accurate maps of pipeline routes to assure safety in design, construction, operation, maintenance, and emergency response of pipeline facilities. While demonstrated in this paper, ArcGIS 9.2 Spatial Analyst module can be used in the optimum route selection of pipeline process to minimize impacts to environmental and costly aspects during construction.

4. REFERENCES

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