GIS Analysis and Spatial Modelling for Optimal Oil Pipeline Route Location: A Case Study of Proposed Isiolo Nakuru Pipeline Route

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Abstract: *Large reserves of commercially viable oil have been discovered in Turkana Kenya. In order to accrue benefits sustainably, optimize supply, and satisfy oil demands in the region, there is a need for an optimal oil pipeline distribution system that strikes a balance among environmental, engineering, technical and social factors. Using Isiolo and Nakuru town as start and end nodes, this study utilized spatial modeling and Geospatial Information System (GIS) analysis to come up with an optimal oil pipeline route. This involved deriving weights for the variables using Analytical Hierarchy Process (AHP) and modeling the routing process using them. A model was developed incorporating pipeline length, topography, geology, soil types, populated areas, game parks, forests, rivers, wetlands, roads, ground water points, rail-line and roads to identify an optimal route. GIS was used for spatial modeling, analysis and data overlay. The variables were weighted using AHP to determine their relative preferences. This was achieved by running questionnaires to various stake holders and experts and professionals. The output for weighting showed high levels of preference given to environmental factors, followed by social factors and engineering factors having least preference. The mean of the weights resulted to the optimal route. The route proposed by the engineers was the best alternative identified by use of standard deviation. The optimal route realized savings by avoiding higher cost environmental and populated centers cells. The results of this analysis demonstrated the benefits of integrating various data sources with GIS analysis as a first look for pipeline routing. The benefits of combining GIS and AHP as a decision support system for the oil pipeline routing process was depicted. This can be applied in routing of other linear structures in Kenya.*

Keywords: AHP, GIS, Modeling, Pipeline Route Selection.

1. Introduction

The world's demand for oil has overtaken its supply, Kenya being inclusive. Turkana in Kenya holds large quantities of oil. Alongside the discovered oil, tests have been continually carried out to the oil reserves to establish commercial viability [1].

The Kenyan government plans to satisfy oil demand in Kenya through products processed at a refinery to be put up in Isiolo town [2]. Several options have been suggested on where to refine the oil and the means of transportation. This research explored one of the options; constructing a pipeline from Isiolo to Nakuru town.

Pipelines are needed to transport the oil for refining and distribution over long distances to meet the demand. They are the most efficient, cost effective and environmentally friendly means of fluid transport [3]. The evaluation of the best route is a complex multicriteria problem with conflicting objectives that need balancing. This research used spatial modelling and GIS analysis to derive an optimal route together with deriving a weighting criterion using AHP and modeling using the derived weightages.

Routing a pipeline is an important task thus proper planning is essential in-order to maximize the benefits derivable from the use of pipelines. With the scientific planning of a route, cost, time, and operating expenses can be saved, ensuring longer operational life and minimizing environmental fallouts

[3]. The use of pipelines reduces the probability of oil spillage and eases traffic congestion due to road transport.

The inefficient and traditional methods of optimal routing in pipelines are mainly based on expensive and protracted methods. These methods utilize static paper maps which are huge and bulky, furthermore, they are not precise and the role of all effective parameters in pipeline routings cannot be easily considered. Technical, economic and environmental concerns are not observed in designed paths as a result of these outdated methods. GIS tools bring new approaches to routing enabling all factors affecting the route be considered and weighted under one umbrella. GIS includes scientific tools that enable the integration of data from different sources into a centralized database from which the data is modeled and analyzed. GIS-based tools and processes addresses the challenges of optimizing routes based on the collection, processing and analysis of spatial data. It's an approach routing that is systematic and effective.

The GIS approach to pipeline routing optimization is based on relative rankings and weights assigned to project specific factors that affect the potential route. This results to an optimal path between the start and the destination point [4]. The factors influencing pipeline route selection are technical and engineering requirements, environmental considerations, and population density [5].

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