BUSITEMA UNIVERSITY
Pursuing Excellence

FACULTY OF ENGINEERING

DEPARTMENT OF WATER RESOURCES AND MINING ENGINEERING

APPLICATION OF GIS IN OPTIMAL PIPELINE ROUTING

CASE STUDY-MANAFWA District-Eastern Uganda.

BY

TEBUGULWA DAN

BU/UP/2014/634

Email: dantebtd67@gmail.com

Tel: 0704983580/0785419870

Supervisors

Main supervisor: Mr. Oketcho Yoronimo

Co-supervisor: Mr. Mugisha Moses.

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ABSTRACT

This report shows how the Geographical Information Systems (GIS) techniques were applied in generating an optimal pipeline route in Manafwa District from J. Quarters water point(source) to Bunambale village(destination). The project aims to ensure the generated route has the highest utility to the public, in addition to minimizing harmful impacts to people and the natural environment. Inputs from pipeline host communities where the pipelines will pass were seriously considered when determining the relative preferences of the various factors affecting the route (Weightings).

This involved deriving weights for the variables using Analytical Hierarchy Process (AHP) and modeling the routing process using them. A model developed incorporating topography, geology, soil types, roads, land use, and protected areas 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 approach significantly increases the reliability and acceptability of the generated route. ESRI's ArcGIS spatial analyst tool was deployed for data analysis and interpretation.

DECLARATION

I TEBUGULWA DAN declare that the work presented in this project is as a result of my own research and has never been submitted to any institution of higher learning for any award whatsoever.

Signature..

Date............31/05/2018......

APPROVAL

This project on the **APPLICATION OF GIS IN OPTIMAL PIPELINE ROUTING CASE STUDY-MANAFWA District-Eastern Uganda** has been written under the supervision of;

Main supervisor

Mr. OKETCHO YORONIMO

Signature …………....……………………………

Date…………………………………………….....

Co-supervisor

Mr. MUGISHA MOSES

Signature …………....……………………………

Date……31/05/18……………………………….....

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Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AHP – Analytical hierarchy process

DEM – Digital Elevation Model

DGSM – Directorate of Geological Survey and Mines

DWD – Directorate of Water Development

DWRM – Directorate of Water Resources Management

UBOS - Uganda Bureau of Statistics

GIS – Geographical Information System

MWE – Ministry of Water and Environment

NARO – National Agricultural Research Organization

SRTM - Shuttle Radar Topography Mission

NFA – National Forestry Authority

USGS – United States Geological Survey

UTM – Universal Transverse Mercator

WIOA – Weighted Index Overlay Analysis

GA – Genetic Algorithm

VTDT – Variable Topography Distance Transform

CHAPTER ONE

This chapter outlines the following; background to the study, problem statement, justification, objectives of the study, purpose of the study and the scope of the study.

1.0 Background

Water is a basic human right. Without it societies wither and people die (Joanne, 2000). The major problem affecting developing countries is the inadequate supply of safe water to its natives.
There can be no state of positive health and well-being without safe water (Aderibigbe, 2008). The various purposes of water to man include, drinking, cooking, bathing, recreation, irrigation, and industrial uses amongst uses. A study in 1990 estimated that more than 1 billion people in developing countries lacked access to safe drinking water (WHO, 1995) .Washing hands after visiting the latrine and before preparing food is of particular importance in reducing disease transmission, but without abundant water in or near homes, hygiene becomes difficult or impossible (Park, 2002). Many cities and municipalities are facing steady population increases and community growth which, as a result, exerts greater strain on these cities' resources. Affordable municipal water strategies are necessary to meet the growing water demand. Some of these strategies include large-scale projects that involve pumping water through a series of pipelines spanning large tracts of land and requiring an extensive infrastructure of reservoirs and pumping stations. Indeed, siting the route of a pipeline is a crucial component that will later influence its design, construction and maintenance which will then determine some of the environmental impacts (Marshall, 1983) . Cross et al (2007) noted that it is important that these envy consequences of pipeline construction are clearly defined and understood to better assess the effectiveness and drawbacks of its construction.

A major objective in selecting a pipeline route is to ensure the chosen route has the highest utility to the public, in addition to minimizing harmful impacts to people and the natural environment. (C.N. Nonis, 2007)

Manual pipeline route planning uses available maps, surveys and experience and is seriously constrained due to lack of updated data and quantitative approach. This is inadequate for complex

References

Aderibigbe, S. A. (2008). Availability, Adequacy and Quality of Water Supply in Ilorin Metropolis, Nigeria. *Nigeria. European Journal of Scientific Research*, 23(4):528-536.

Adewumi., R. (2006). Developing Nigerian Oil and Gas Pipeline Using MCDA. *Nigerian Engineering Conference and Annual General Meeting (Gateway).* Abuja,: Technological and National Content Development for Economic Self-Reliance. .

Aissi, C. a. (2012). GIS-based Multicriteria Evaluation Approach for Corridor Siting. *Environment and Planning B-Planning & Design 39 (2)*, 287–307.

Barron, R. J. (2005). *Site selection of Petroleum Pipelines*. Retrieved from A GIS Approach to Minimize Environmental : http://gis2.esri.com/library/userconf/proc99/proceed/papers/pap350/p350.htm, ESRI

Berger, J. a. (2004). A parallel hybrid genetic algorithm for the vehicle routing problem with time windows. *Comput. Operat. Res*, 2037-2053.

Bevilacqua, M. A. (2004). A Multi-Criteria Decision Approach toChoosing The Optimal Blanching-Freezing System. *Journal of Food Engineering*, 63, 253-263.

Bouyssou, D. M. (2000). *Evaluation Models: A Critical Perspective.* Boston: Kluwer.

C.N. Nonis, K. V. (2007). Investigation of an AHP based Multi Criteria Weighting Scheme for GIS. *24th International Symposium on Automation & Robotics in Construction (ISARC)*.

Chang, D. Y. (1992). Extent Analysis and Synthetic Decision. In *Optimization Techniques and Applications* (pp. 1, 352). Singapore: World Scientific.

Cheng, C. H. (1999). Evaluating Attack Helicopters by AHP Based on Linguistic Variable Weight. *European Journal of Operational Research*, 116, 423-435.

Collischonn, W. J. (2000). A Direction Dependent Least-costpath Algorithm for Roads and Canals. *International Journal of Geographical Information Science*.

De Smith, M. (2004). Distance transforms as a new tool in spatial analysis, urban planning, and GIS. *Environment and Planning, B: Planning and design*, 85-104.

Dijkstra, E. W. (1959). A Note on Two Problems in Connexion with Graphs. *Numerische Mathematik 1*, 269–71.

Dubey, R. (2005, 07 24). *A remote Sensing and GIS based least cost routing of pipelines.* Retrieved from http://www.gisdevelopment.net/application/Utility/transport/utilitytr0025pf.htm.

Feldman, S. C. (1995). A Prototype for Pipeline Routing Using Remotely Sensed Data and Geographic Information System Analysis. *Remote Sensing of Environment.*

Ghose, M. A. (2006). A GIS based transportation model for solid waste disposal: A case study on Asansol municipality. *Waste Manage*, 1287-1293.

Goodchild, M. (1976). An evualation of lattice solutions to the problem of corridor location.

Gupta., P. D. (1999). Decision Support System for Pipeline Route Selection. *International Journal of Project.*, 41(10): 29-35 .

Joanne, G. (2000). Global Environment Outlook. *United Nations Environment Programme (UNEP).*

Lee, Jay, Dan Stucky. (1998). On Applying View-shed Analysis for Determining Leastcost Paths on Digital Elevation Models. *International Journal of Geographical Information Science.*

Leung, L. C. (2000). On Consistency and Ranking of Alternatives in Fuzzy AHP. *European Journal of Operational Research*, 124, 102-113.

Luettinger, C. (2005). Geographic Information System-based Pipeline Route Selection Process. *Journal of Water Resources Planning & Management.*

Maheen Iqbal, F. S. (2006). IEEE, Planning a Least Cost Gas Pipeline Route A GIS & SDSS Integration Approach.

Marshall, R. a. (1983). Geotechnical aspects of pipeline construction in Alberta. *Canadian Geotechnical Journal*, 20: 1-10.

Özdağoğlu, A. (2007). Comparison of AHP and fuzzy AHP for the Multi- Criteria Decision making processes with Linguistic Evaluations. 65-85.

Park. (2002). Environment and Health in: Park's Textbook of Preventive and Social Medicine. *Eds. (17).*

Peters, T. a. (2003). *Plant Design and Economics for Chemical Engineers.* McGraw-Hill Companies Inc.

Rees, W.G. (2004). Least-cost Paths in Mountainous Terrain. *Computers & Geosciences.2003.*

Saaty, T. L. (1980). *The Analytic Hierarchy Process.* New York: McGraw Hill.

Saha, A. K. (2005). GIS•based Route Planning in Landslide Prone Areas. *(International Journal of Geographical Information Science 19 (10)*, 1149–1175.