FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF AGRICULTURAL MECHANISATION & IRRIGATION ENGINEERING

GROUNDWATER AVAILABILTY AND SUITABILITY EVALUATION FOR IRRIGATED AGRICULTURE IN MBALE DISTRICT

By

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BU/GS21/MID/13

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ABSTRACT

In the last years, farmers have been affected by drought in Mbale district and this has been attributed to climate change which causes variations in temperature and rainfall. This study aimed at evaluating groundwater availability and suitability for irrigated agriculture to mitigate drought. The study considered the potential, quality and vulnerability of groundwater. Groundwater potential was assessed using geospatial technique through Analytical Hierarchy Process (AHP) model. Thematic layers were prepared namely: land use and land cover, slope, soil, rainfall, lineament density, lithology, geomorphology and drainage density. All layers were integrated using the Mulvariate Clustering (MLC) technique. Ranking of each parameter was performed using Weighted Overlay Index Analysis (WOIA). Weights were assigned to each subject class basing on AHP results. The consistency of the outputs was tested by computation of Consistency Ratio (CR) and was at a reasonable acceptable level (0.029 < 0.1). Groundwater potential was delineated basing on the values of Groundwater Potential Index. Groundwater quality was determined using Irrigation Water Quality Index (IWQI) method. Thirty-three water samples were collected. Five chemical parameters were tested in the laboratory: chloride, electrical conductivity, bicarbonate, sodium and Sodium Adsorption Ratio (SAR) to generate the water quality database using Kriging interpolation technique. Computation of IWQI values for each source was made and was used to generate the IWQI map using the weighted summation. DRATIC method was used to delineate vulnerability of groundwater. Layers were generated using the following parameters: depth to groundwater, net recharge, aquifer media, topography, vadose zone impacts, and hydraulic conductivity. The aquifer vulnerability map was prepared by overlaying layers. Three different vulnerability zones were determined according to DRASTIC scores low (<100), medium (100-140) and high (>140). Integration of maps of quality, vulnerability and potential of groundwater was made using an unsupervised MLC classification method. The resulting clustered map was classified into five categories with their respective regions: 17.58% very poor (36.56km^2), 13.84% poor (28.77km^2), 12.69% good (26.39km^2), 31.46% very good (65.39km^2) and 24.43 % excellent (50.78km^2). The sub counties in Mbale district that have inadequate and unsuitable groundwater where irrigated agriculture cannot be practiced are Budwale, Wanale, Busano, Bubyangu, Bufumbo and Nyondo since they belong to the zones of very poor and poor. The remaining sub counties belong to the zones of good, very good and excellent which implies that irrigated agriculture can be successfully practiced there.

DECLARATION

I the undersigned, declare that this dissertation is my original work, except where due acknowledgement has been made. I declare that this work has never been submitted to this University or to any other institution for funding or for partial fulfilment for any award.

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SUPERVISORS' APPROVAL

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DEDICATION

I dedicate this study to my parents Rev. Michael and Mrs. Allen Nanyuma, My wife Hellen and Children: Emmanuel, Mathew, Sheila and Faith. Also, to my brother Wangota Godfrey and all the staff of Busitema University.

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ABBREVIATIONS

AHP - Analytical Hierarchy Process

ASTER – Advanced Spaceborne Thermal Emission and Reflection

CI – Consistency Index

cm – centimeter

CR – Consistency Ratio

DEM - Digital Elevation Model

GIS - Geographical information systems

GWPI - Ground water quality index

ha - hectares

IRWR - Internal Renewable Water Resource

Iso – Iterative self-organizing

IWQI - Irrigation Water Quality Index

LULC- Land Use Land Cover

MAAIF - Ministry of agriculture animal industry and fisheries

MCDA - multi-criteria decision-making analysis

Mha - Million hectares

MLC - Mulvariate Clustering

RS - Remote Sensing

SAR - Sodium Adsorption Ratio

UMA – Uganda meteorological authority

UN - United Nations

US – United States

USGS – United States Geographical System

UTM - Universal transverse meridian

WGS – world geographical system

WOIA - Weighted Overlay Index Analysis

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Agriculture is a water intensive process, therefore crop production needs plenty of water (Khan et al., 2021). An estimated 80% of the world's farmers face high threats to water scarcity (Vörösmarty et al., 2010) and this has caused food production risk since they practice rainfed agriculture which depends on the water from limited and variable rainfall patterns (Smith et al., 2023). To mitigate this challenge, irrigation is attaining an increasing importance in the world to enhance crop production for the growing demand for food by a rapidly growing world population (Wanyama et al., 2017). The water for irrigation is obtained from surface and groundwater sources (Jurik et al., 2019). Equating both sources, groundwater stands extensively distributed and comparatively safer (Guppy *et al*., 2018).

Groundwater is a substantial component of global water cycle and it's a vital resource for domestic, agricultural and industrial development water globally (Frappart & Ramillien 2018). However, the availability and suitability of groundwater for irrigation varies widely across regions and countries (Madramootoo, 2012). The extent of areas irrigated with groundwater source has been inventoried globally (Siebert et al., 2010). Irrigation requirement for the agricultural sector now sums to in excess of 70% of universal water withdrawals and around 85% of universal resource ingestion and the prediction is that groundwater reserves offer 43% of water consumed for irrigation (Liu *et al*., 2017). Groundwater is more established in North America and South Asia where accessibility is 57% and 54% respectively of total water for irrigation (Meier et al., 2018). In the previous thirty years enormous growth in the creation of irrigation water wells has been done for instance they currently control 19 Mha in China, 39 Mha of irrigated land in India, 17 Mha in the United States of America and massive parts of Pakistan and Bangladesh (Angelakıs, *et al*., 2020). These have enabled key remunerations for masses of moderate agriculturalists as mitigation to increased temperature and rainfall variation (Munyaradzi, *et al*., 2022). Groundwater serves as a vital resource for irrigated agriculture, providing a reliable water source for crop production in many regions around the world. However, assessing the availability and suitability of groundwater for irrigation requires a comprehensive understanding of hydrogeological characteristics, water quantity, quality, and sustainability (Gorelick & Zheng, 2015).

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