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FACULTY OF ENGINEERING

DEPARTMENT OF AGRICULTURAL MECHANIZATION AND IRRIGATION ENGINEERING

FINAL YEAR DISSERTATION

APPLICATION OF SWAT MODEL IN WATER RESOURCES ASSESSMENT TO GUIDE IRRIGATION DEVELOPMENT IN MALABA SUB CATCHMENT, UGANDA.

BY

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This master's thesis is submitted to the Directorate of Graduate School in partial fulfillment of the requirements for the award of the Degree of Master of Science in Irrigation and Drainage Engineering (MID) of Busitema University

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ABSTRACT

Human population increase, economic development, climate change and other drivers alter water resources availability and use resulting in increased risks of extreme low and high flows, drastically altered flow regimes, threats to water quality and water demands surpassing renewable supply.

In this research, water resources assessment of river Malaba sub-catchment was carried out using SWAT model, Irrigation Water requirement of rice crop determined using the CROPWAT 8.0 software, border strip irrigation design carried out accompanied with a simulation of border strip irrigation hydraulics using WinSRFR 4.1.3 software and the suitable sites for location of valley tanks executed using Multi criteria decision analysis in GIS environment. A sensitivity analysis was done in SWATCUP using observed data for 497 simulations. The 10 most sensitive parameters were used for calibration and validation of the model in SWAT-CUP using SUFI-2. SWAT model performance was based on the R^2 and NSI values of both calibration and validation. The R^2 value of 0.93 and 0.90 for calibration and validation respectively were obtained. The NSI of 0.90 and 0.89 for calibration and validation respectively were also obtained.

The crop water requirements were determined using 15year climatic data using CROPWAT 8.0. A gross irrigation requirement (GIR) of 29.76mm was obtained and IWR of each command area. A border strip irrigation system for the rice crop was designed and simulated using WinSRFR 4.1.3 software and an economical and hydraulically efficient trapezoidal channel was designed. Application efficiency of 59% and percentage runoff of 32% were generated from WinSRFR 4.1.3.

The suitable sites for location of valley tanks was done using a multi criteria decision analysis and pairwise comparison made for each criterion considered. These suitable sites were Kisoko, Ongere, Nawire, Nakwiga and Paya villages in Tororo district, Buyunda and Bugalama in Busia district and Butema, Namukonge and Bugalama in Bugiri districts.

Different blocks of irrigation command areas were delineated in arc GIS 10.1 using a multi criteria decision analysis and pairwise comparison made for each criterion considered. The delineated command area blocks were 5 having a total area of 7,835 hectares. 2 blocks can be irrigated by direct abstraction from river Malaba by gravity flow. 3 blocks can be irrigated by using valley tanks.

DECLARATION

I **ADONGO OWORA LEO**, declare that this dissertation is my own, original piece of work and has never been presented in any University/institution for an award. I further attest that the research carried out is unique and has never been conducted in the same area in Uganda.

NAME: **ADONGO OWORA LEO**

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APPROVAL

This is to certify that this dissertation was written by my own efforts under the guidance of advisors on the topic **"Application of The Soil and Water Assessment Tool (SWAT) Model in Water Resources Assessment to Guide Irrigation Development in Malaba Sub Catchment, Uganda."** and is now ready for submission to the Department of Agricultural Mechanization and Irrigation of Busitema University.

Dr. MUSINGUZI WILSON BABU

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DATE: 12/09/2019

Dr. SAMSON RWAHWIRE

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DEDICATION

This dissertation is dedicated to my children (Gloria, Michelle and Francis) and their beloved Mom Wafula Bilha.

ABREVIATIONS AND ACRONYMS

ARS	Agricultural research service
CWR	Crop water requirement
DEM	Digital Elevation Model
DSS	Decision Support System
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organization
GIS	Geographic/Geospatial Information Systems
GoU	Government of Uganda
HRUs	Hydrologic Response Units
IDP	Internally Displaced Persons
IFAD	International fund for Agricultural development
ILO	International Labor Organization
NARO	National Agricultural Research Organization
NDP	National Development Plan
NSI	Nash – Sutcliffe Index
NUARP	Northern Uganda Agricultural Recovery programme
QGIS	Quantum geographical information system
QSWAT	Quantum soil and water assessment tool
RALNUC	Restoration of Agricultural Livelihood in Northern Uganda
RAM	Readily Available Moisture
SCS-CN	Soil conservation service- Curve number.
SCS-CN	Soil Conservation Service Curve Number
SDGs	Sustainable Development Goals
SDSS	Spatial decision Support System
SMCE	Spatial Multiple Criteria Evaluation
SMDA	Spatial Multiple Decision Analysis
SMM	Sio-Malaba-Malakisi

SNHT	Standard Normal Homogeneity Test
SUFI-2	Sequential Uncertainty Fitting
SWAT	Soil and water assessment tool
SWAT-CUP	SWAT Calibration Uncertainty Procedure
TFR	Total fertility rate
UKAID	United Kingdom Agency for International Development
UN	United Nations
USAID	United States Agency for International Development
USDA	United states department of agriculture
WEAP	Water Evaluation and planning system
WLC	Weighted Linear Combination.

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CHAPTER ONE: INTRODUCTION

1.1 Background

Water is essential for human, animal and plant life. It supports all aspects of human livelihood. The past two decades have witnessed increasing global concern about the need for sustainable water and land management in an era of rapid change in land and water resources, and persistent water and food insecurity (Pahl-wostl *et al.*, 2013). Human population increase, economic development, climate change and other drivers alter water resources availability and use resulting in increased risks of extreme low and high flows, drastically altered flow regimes, threats to water quality, water demands surpassing renewable supply and famine that has become a common problem for the communities.

The quantity, quality and timing of water flows required to sustain ecosystems and the valuable services they provide are referred to as environmental flows (Securing Water for Ecosystems and Human Well-being : The Importance of Environmental Flows,2006), For river and wetland ecosystems, the flow regime is the most important determinant of ecosystem function and services provided by these functions. Flow features are determined by river size, geology, climate variation, topography and vegetation cover. The different components of an environmental flow regime contribute to different ecological processes. For instance, base flows help maintain water table levels in the flood plain and soil moisture for plants, high pulse flows shape the character of river channels and large floodplain aquifers. The water resources availability assessment requires detailed analysis of these hydrological processes.

An appropriate valley tank site location for storage of runoff from the sub -catchment for irrigation is fundamental. A suitable valley tank site location involves sensible decision making process comprising of various considerations of factors and criteria (Stemn and Kumi-boateng, 2016). It's evident that the factors considered for the valley tank site selection and also the physical appearances of the area are fundamentally geospatial in nature. This necessitates the use of GIS tools, concepts and technology in managing this data (Stemn and Kumi-boateng, 2016).

In this study, GIS, a Multi Criteria Decision Analysis (MCDA) technique has been preferred as a possible way of making optimal decisions in selecting a suitable site for valley tank location and SWAT tool has been used to assess the amount of runoff generated that can fill the identified valley tank sites.

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