BUSITEMA UNIVERSITY

FACULTY OF ENGINEERING

DEPARTMENT OF WATER RESOURCES AND MINING ENGINEERING

FINAL YEAR PROJECT REPORT

APPLICATION OF SWAT MODEL IN ASSESSING THE EFFECT OF CLIMATE CHANGE ON WATER QUANTITY AND QUALITY

Case study: RIVER MALABA CATCHMENT

BY

NAME: OMANYO LAWRENCE

REG NO: BU/UP/2014/621

PHONE NUMBER: +256781797040

E-Mail: lawrenceomanyo@gmail.com

SUPERVISOR(S)

Main Supervisor**: MRS. HOPE NJUKI NAKABUYE**

Co-Supervisor**: MR. MUGISHA MOSES**

A final year project proposal Report submitted in partial fulfillment of the requirements for the award of a Bachelor of Science degree in water resources engineering of Busitema University

ABSTRACT

In this study case, nutrients were considered to be an important water quality concern in the River Malaba due to high eutrophication problem of Malaba river. Nitrogen and phosphorus are the two major nutrients originating from subsistence agriculture and livestock grazing. Increased N and P fertilizer application has enlarged N and P river Malaba through runoff and leaching making river Malaba water quality vulnerable to climate change and land use. Quantitatively, Malaba River is very vulnerable to climate change because it relies heavily on rainfall as its main flow contributor. This study's main objective was to assess the effect of climate change on water quantity and quality in Malaba River Catchment, Uganda and it was achieved by simulating the climate variables with calibrated SWAT model inputs for a period of 35 years from 1979 to 2013. The trend analysis was done by Regression test and its significance was determined using the T-test approach. SWAT model was successfully calibrated and validated with NSE of 0.93 and 0.90 respectively. Therefore, the Ministry of Water and Environment Uganda and other stake holders will be empowered with these results to carry out water resources management plan to prevent the effects that might rise from the high and low flows and also deterioration of water quality.

DECLARATION

I **OMANYO LAWRENCE** solemnly declare that this final year project proposal report is a result of my own efforts and tremendous work done during the research period and it has never been submitted to Busitema University or any other institution of higher learning for any academic award.

NAME: OMANYO LAWRENCE

REG NO: BU/UP/2014/621

SIGNATURE: …………………………….

DATE: ………………………………….

APPROVAL

This is to certify that this project proposal report was written under the guidance of my supervisors on the topic ***"Application of SWAT Model in Assessing the Effect of Climate Change On Water Quantity and Quality"*** and is now ready for submission to the department of Busitema University.

Mrs. HOPE NJUKI NAKABUYE

Main supervisor

Sign: ……………………………….

DATE: ……………………...

Mr. MUGISHA MOSES

Co-supervisor

Sign: ………………………………

DATE: ………………………

ACKNOWLEDGEMENT

I would like to extend my sincere thanks to the almighty GOD who has gifted me with life and has enabled me to reach this academic height as he has been the provider of all the necessary requirements.

Great thanks to my beloved parents Mrs. **Akoth Jenipher** and the late Mr. **Epyat Benardo** for their financial and moral support, my uncles and family members I owe you a lot.

Let me convey my heartfelt appreciation to my supervisors, Mrs. Hope Njuki Nakabuye and Mr. Mugisha Moses for their advice as well their guidance during the preparation of this report.

Not forgetting my classmates

LIST OF ACRONYMS

DWRM - Directorate of Water Resources Management

DEM - Digital Elevation Model

GLUE - Generalized Likelihood Uncertainty Estimation

HRU - Hydrological Response Unit

IPCC - Intergovernmental Panel on Climate Change

ISRIC - International Soils Reference and Information Centre

LH-OAT - Latin Hypercube One-factor-At-a-Time

MCMC - Markov chain Monte Carlo

IS- Importance Sampling

MWE - Ministry of Water and Environment

NBI - Nile basin Initiative

NSE - Nash-Sutcliffe Efficiency

NSI – Nash- Sutcliffe Index

ParaSol - Parameter Solution

PBias - Percentage Bias

PSO - Particle Swarm Optimization

R^2 - Coefficient of Determination

RMSE - Root Mean Square Error

SUFI - Sequential Uncertainty Fitting

SWAT - Soil and Water Assessment Tool

SWAT-CUP - SWAT Calibration and Uncertainty Programs

UNEP - United Nations Environment Programme

UNESCO - United Nations Educational Scientific and Cultural

WMO - World Meteorological Organization

FAO- Food and Agricultural Organization

NARO – National Agricultural Research Organization

GHG - Green House Gas

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION

1.0 INTRODUCTION

This chapter includes the following; back ground to the study, statement of the problem, purpose of the study, objectives of the study, research questions, scope of the study which includes the conceptual scope, geographical scope and time scope and finally the significance of the study.

1.1 BACKGROUND OF STUDY

Water resources throughout the world are vital to socio-economic status, public health, quality of life and environmental sustainability of nations. However, the water resources are experiencing great stress due to global climate change and its awareness is being raised. Long-term climate change has been experienced at global, regional, and ocean basin scales, due to increasing concentration of greenhouse gases most especially carbon dioxide. These include changes in precipitation amounts and timings, arctic temperatures and different types of extreme weather like heavy rainfall, drought, and heat waves (IPCC, 2014)

The pattern of rainfall is unevenly distributed across the world and is governed by atmospheric circulation patterns and moisture availability. These two factors are affected by temperature so the pattern of rainfall is expected to change due to changing temperature. The changes include the type of precipitation, the amount, the intensity and the frequency. Rainfall has increased by 0.2 to 0.3% for every decade in the African tropics (10°N to 10°S) with a decrease in the Northern Hemisphere subtropics (10°N to 30°N) throughout the 20th century by approximately 0.3% per decade. Rise in temperatures has caused the melting of ice and glaciers on mountain tops. Mountain Rwenzori is one of a few mountains in Africa with a permanent ice-cap. Current studies have exposed that the ice cap on this mountain has decreased significantly. About 82% of the Mt Kilimanjaro 1912 ice cap in Kenya has melted and by 1990, 40% of Mt Rwenzori had receded Compared to 1955 recorded cover (United Nations Environment Programme, 2013). These changes have been attributed to global warming (Trenberth *et al.*, 2013). Increasing global average air and ocean temperature can change the type of rainfall during winter season (Mantua, Tohver and Hamlet, 2010)

Several climate change standards and classifications have been developed to evaluate and quantify these issues over the past two decades. The Intergovernmental Panel on Climate Change(IPCC)

REFERENCES

Abbaspour, K. C. *et al.* (2007) 'SWAT-CUP Calibration and Uncertainty Programs for SWAT', *The fourth International SWAT conference*, pp. 1596–1602. doi: 10.1007/s00402-009-1032-4.

Alamdari, N. *et al.* (no date) 'Assessing the Effects of Climate Change on Water Quantity and Quality in an Urban Watershed Using a Calibrated Stormwater Model'. doi: 10.3390/w9070464.

Arnold, J. G. *et al.* (2012) 'SWAT : Model use , calibration , and validation'.

Bartlett, M. S. *et al.* (2015) 'Stochastic rainfall-runoff model with explicit soil moisture dynamics', *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Science*, 471(2183), p. 20150389. doi: 10.1098/rspa.2015.0389.

Beven, K. (2012) 'Hydrological Similarity, Distribution Functions and Semi-Distributed Rainfall–Runoff Models', *Rainfall-Runoff Modelling*, pp. 185–229. doi: 10.1002/9781119951001.ch6.

Beven, K. J. (2000) 'On the future of distributed modelling in hydrology.', *Hydrological Processes*, 14(16–17), pp. 3183–3184. doi: 10.1002/hyp.325.

Change, C. and Heritage, W. (no date) 'reports 22'.

Delespaul, P. (2013) 'Consensus over de definitie van mensen met een ernstige psychische aandoening (EPA) en hun aantal in Nederland', *Tijdschrift voor Psychiatrie*, 55(6), pp. 427–438. doi: 10.1176/appi.ps.201500058.

Fukunaga, D. C. *et al.* (2015) 'Application of the SWAT hydrologic model to a tropical watershed at Brazil', *Catena*, 125, pp. 206–213. doi: 10.1016/j.catena.2014.10.032.

Golmohammadi, G. *et al.* (2014) 'Evaluating Three Hydrological Distributed Watershed Models: MIKE-SHE, APEX, SWAT', *Hydrology*, 1(1), pp. 20–39. doi: 10.3390/hydrology1010020.

Gupta, H. V. and Kling, H. (2011) 'On typical range, sensitivity, and normalization of Mean Squared Error and Nash-Sutcliffe Efficiency type metrics', *Water Resources Research*, 47(10). doi: 10.1029/2011WR010962.

Hammouri, N., Abdulla, F. and Abu, H. (2015) 'ASSESSING THE IMPACTS OF CLIMATE CHANGE ON WATER', (c).

Helton, J. C. and Davis, F. J. (2002) 'Illustration of sampling-based methods for uncertainty and sensitivity analysis', in *Risk Analysis*, pp. 591–622. doi: 10.1111/0272-4332.00041.

Ipcc (2013) 'Working Group I Contribution to the IPCC Fifth Assessment Report, Climate Change 2013: The Physical Science Basis', *Ipcc*, AR5(March 2013), p. 2014. doi: 10.1017/CBO9781107415324.Summary.

IPCC (2014) 'Climate Change 2014 Synthesis Report Summary Chapter for Policymakers', *Ipcc*, p. 31. doi: 10.1017/CBO9781107415324.

Lederer, J. *et al.* (2015) 'The generation of stakeholder's knowledge for solid waste management planning through action research: A case study from Busia, Uganda', *Habitat International*, 50, pp. 99–109. doi: 10.1016/j.habitatint.2015.08.015.

Liu, Y. and Gupta, H. V. (2007) 'Uncertainty in hydrologic modeling: Toward an integrated data assimilation framework', *Water Resources Research*. doi: 10.1029/2006WR005756.

Mantua, N., Tohver, I. and Hamlet, A. (2010) 'Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State', *Climatic Change*, 102(1–2), pp. 187–223. doi: 10.1007/s10584-010-9845-2.

Matsuno, T. (1966) 'Quasi-geostrophic motions in the equatorial area', *Journal of the Meteorological Society of Japan*, 44(February), pp. 25–43. doi: 10.1002/qj.49710644905.

'Ministry of Water and Environment Water and Environment Sector Performance Report' (2016).

Nandozi, C. S. *et al.* (2012) 'Regional climate model performance and prediction of seasonal rainfall and surface temperature of uganda', *African Crop Science Journal*, 20(s2), pp. 213–225.

Nkonge, L. K. *et al.* (2014) 'Comparison of two Calibration-uncertainty Methods for Soil and Water Assessment Tool in Stream Flow Modeling', 1(2), pp. 40–44.

Nsubuga, F. N. W., Namutebi, E. N. and Nsubuga-Ssenfuma, M. (2014) 'Water Resources of Uganda: An Assessment and Review', *Journal of Water Resource and Protection Water Resources of Uganda: An Assessment and Review. Journal of Water Resource and Protection*, 6(6), pp. 1297–1315. doi: 10.4236/jwarp.2014.614120.

Van Overschee, P. and De Moor, B. (1994) 'N4SID: Subspace algorithms for the identification of combined deterministic-stochastic systems', *Automatica*, 30(1), pp. 75–93. doi: 10.1016/0005-1098(94)90230-5.

Qiang, C. *et al.* (2010) 'Analysis of SWAT 2005 Parameter Sensitivity with LH-OAT Method', *HKIE Transactions Hong Kong Institution of Engineers*, 17(3), pp. 1–7. doi: 10.1080/1023697X.2010.10668197.

'Quantitative risk assessment of the effects of climate change on selected causes of death , 2030s and 2050s' (no date).

Sellami, H. *et al.* (2013) 'Parameter and rating curve uncertainty propagation analysis of the SWAT model for two small Mediterranean catchments', *Hydrological Sciences Journal*, 58(8), pp. 1635–1657. doi: 10.1080/02626667.2013.837222.

Srinivasan, R. *et al.* (2012) 'Swat: m', 55(4), pp. 1491–1508.

Suliman, A. H. A. *et al.* (2015) 'Comparison of Semi-Distributed, GIS-Based Hydrological Models for the Prediction of Streamflow in a Large Catchment', *Water Resources Management*, 29(9), pp. 3095–3110. doi: 10.1007/s11269-015-0984-0.

Tadross, M. *et al.* (2009) 'Growing-season rainfall and scenarios of future change in southeast

Africa: Implications for cultivating maize', *Climate Research*, 40(2–3), pp. 147–161. doi: 10.3354/cr00821.

Trenberth, K. E. (2011) 'Changes in precipitation with climate change', *Climate Research*, 47(1–2), pp. 123–138. doi: 10.3354/cr00953.

Trenberth, K. E. *et al.* (2013) 'Global warming and changes in drought', *Nature Climate Change*, 4(1), pp. 17–22. doi: 10.1038/nclimate2067.

United Nations Environment Programme (2013) 'Africa without ice and snow', *Environmental Development*, 5(1), pp. 146–155. doi: 10.1016/j.envdev.2012.10.003.

Zhang, D. *et al.* (2015) 'Improved calibration scheme of SWAT by separating wet and dry seasons', *Ecological Modelling*, 301, pp. 54–61. doi: 10.1016/j.ecolmodel.2015.01.018.