BUSITEMA UNIVERSITY
Pursuing Excellence
Department of Agricultural Mechanization and Irrigation Engineering

P.O. Box 236, Tororo, Uganda
Gen: +256 - 45 444 8838
Fax: +256 - 45 4436517
Email: info@adm.busitema.ac.ug
www.busitema.ac.ug

FACULTY OF ENGINEERING

DEPARTMENT OF AGRICULTURAL MECHANIZATION & IRRIGATION ENGINEERING

A FINAL YEAR UNDERGRADUATE THESIS

IMPROVING IRRIGATION WATER USE AND MANAGEMENT IN LARGE PADDY RICE FIELD USING SWAT MODEL

(The Case of Doho Rice Scheme, Butaleja District)

BY

MUHINDO FATUMA

REG.NO: BU/UG/2018/2301

TEL.NO: +256778610385

EMAIL: fatmuhindo@gmail.com

PROJECT SUPERVISOR

Dr. Otim Daniel

A final Year Undergraduate Thesis Submitted in Partial Fulfillment for the Award of the Bachelor of Science in Agricultural Mechanization and Irrigation Engineering Degree at Busitema University

JANUARY 18/ 2023

ABSTRACT

Paddy fields are designed ponding systems whose hydrological processes are impacted by water management practices. This is similar case with large paddy fields in Doho rice scheme, Butaleja district, Uganda. The scheme water sources originate from Manafwa River Catchment in Uganda which have been constrained by floods due to the increasing land use changes affecting the rice growing activities. These contributes to silt deposition of the channels in Doho rice scheme. Soil and Water Assessment Tool (SWAT) simplifies hydrological processes in such large paddy fields. In this research SWAT Model was used to assess water management, hydrologic modelling, irrigation water uses and evaluate sustainable management strategies through simulation for period of 2015 to 2050 for future use demand. The hydrology of the catchment was studied using Soil and Water Assessment Tool (SWAT). SWAT model was calibrated by SWAT-CUP using data from 2002 to 2008 and then validated using data from 2009 to 2013. The model was successfully calibrated with Nash-Sutcliffe Efficiency (NSE) of 0.77 and the coefficient of determination (R2) 0.79 and for validation with NSE of 0.55 and 0.7 for the R2. The calibrated model was then used to check the performance of the model and the results showed it was reliable. This study also applied SWAT output viewer to analyse scenarios on water use in Manafwa river catchment. The pothole impoundment module was proved by SWAT output viewer to improve irrigation water in times of stiff competition and in dry seasons. The implementation of desiltation and grassed water ways seemed to reduce soil erosion and therefore proving as reliable approach to reduce sedimentation in the river and the channels. This can contribute to water management in the scheme.

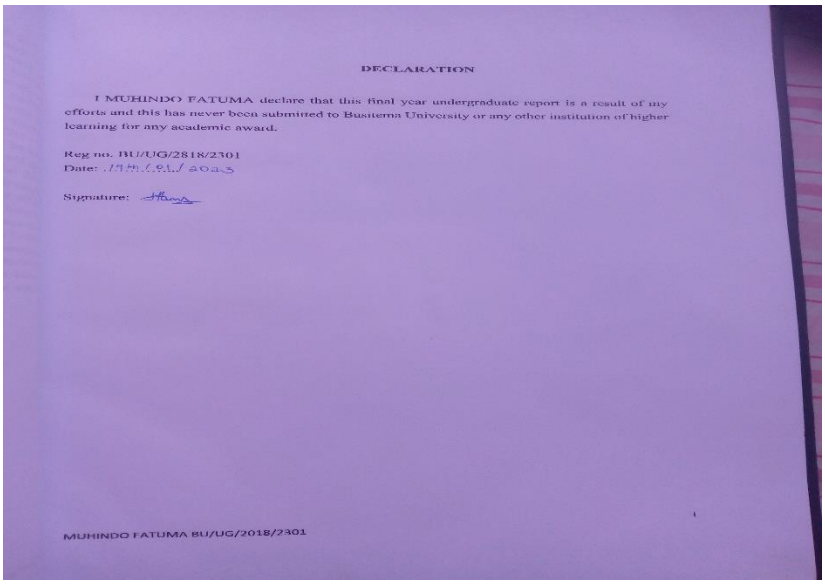
DECLARATION

I MUHINDO FATUMA declare that this final year undergraduate thesis is a result of my efforts and this has never been submitted to Busitema University or any other institution of higher learning for any academic award.

Reg no. BU/UG/2818/2301

Date: ……...

Signature:


DECLARATION

I MUHINDO FATUMA declare that this final year undergraduate report is a result of my efforts and this has never been submitted to Busitema University or any other institution of higher learning for any academic award.

Reg no. BU/UG/2818/2301
Date: 17/01/2023

Signature:

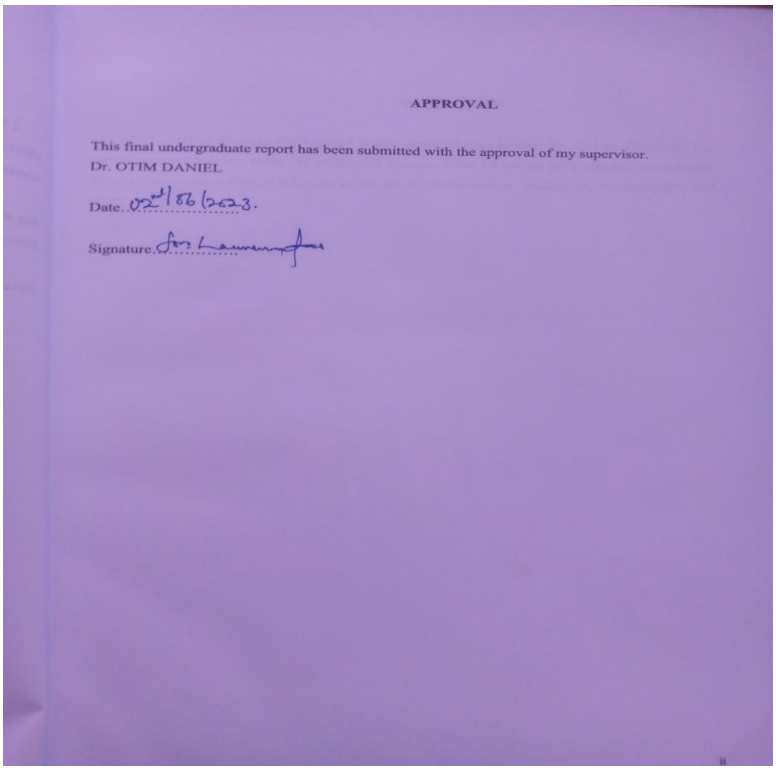
MUHINDO FATUMA BU/UG/2018/2301

APPROVAL

This final undergraduate thesis has been submitted with the approval of my supervisor.
Dr. OTIM DANIEL

Date…….

Signature…….


APPROVAL

This final undergraduate report has been submitted with the approval of my supervisor.
Dr. OTIM DANIEL

Date. 02/08/2023.

Signature.

DEDICATION

I dedicate this thesis to my beloved family especially my brother Mr. Bebwa Edhart for his cordial support that has made my journey to success. After all, we all have dreams, but to make dreams come into reality, it takes an awful lot of determination, dedication, self-discipline and effort.

AKNOWLEDGEMENT

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals. I would like to extend sincere thanks to all of them.
Firstly, I am highly indebted to Dr. Otim Daniel, Eng. Bwire Denis and miss. Nabunya Victo for their guidance and constant supervision as well as for providing necessary information regarding the project.
Great thanks and appreciations also go to my colleagues Nakanwagi Oliver, Musasizi Emmanuel, Ssebowa Tonny, Waisswa Emmanuel, Okodoi Moses and Kusemererwa Joseph in developing the project and people who have willingly supported me during the research period.

TABLE OF CONTENTS

LIST OF ACRONYMS

AWD	Alternate Wetting and Drying
DEM	Digital Elevation Model
DRS	Doho Rice Scheme
DWRM	Directorate of Water Resources Management
FAO	Food and Agricultural Organization
GIS	Geographical Information System
GSMaP	Global Satellite Mapping of Precipitation
HMS	Hydrological Modelling System
HRU	Hydrologic Response Unit
LULC	Land Use Land Cover

MWE	Ministry of Water and Environment
NDP	National Development Plan
NSE	Nash-Sutcliffe Efficiency
SCS-CN	Soil Conservation Service Curve Number
SDGs	Sustainable Development Goals
SRI	System of Rice Intensification
SWAT	Soil Water Assessment Tool
SWAT-CUP	SWAT Calibration and Uncertainty Procedures
TIN	Triangular Irregular Network
UNMA	Uganda National Meteorological Authority
USGS	US Geological Survey
UTM	Universal Transverse Mercator

LIST OF FIGURES

LIST OF TABLES

1 CHAPTER ONE

1.1 INTRODUCTION

1.2 Background of the Study

Globally, rice cultivation is the second most popular cereal crop and staple food for many people (Prodhan, 2020). Current projections show that rice continues to be the world's most important staple food in the coming decades. (OECD/FAO, 2021) The total annual world production of rice is approximately 903.4 Metric Tons with average productivity of 4 tons/ha (Srujana, 2017). China being the major producer of rice in the world with 212.1 Metric Tons followed by India with 172.6 Metric Tons (FAO, 2018), rice production has been extended to other continents including Africa. In sub-Sahara Africa, there is an increase in consumption of rice and continuous expansion of irrigated land has leading to increased demand for sustainable water management in paddy cultivation (Tsuchiya *et al.*, 2018). The need for "more rice with less water" is crucial for food security, and irrigation plays a greater role in meeting future food needs than it has in the past (Kumari, Kumari and Sharma, 2021).

In East Africa, Tanzania is the leading rice producer and accounts for 9% (2.6 million ton) of African rice production (30.8 million ton)(Materu *et al.*, 2021). However, due to a rising gap between production and consumption, many African countries are becoming increasingly dependent on rice imports (Materu *et al.*, 2021). At the same time, increasing irrigation withdrawals and spatial and temporal variability in rainfall and surface flows are causing water scarcity in many parts of East Africa (Katic, 2014). It has been reported that around 20% of irrigated areas in rice are estimated to suffer from 'physical water scarcity' by 2025 (Tuppad *et al.*, 2010). In addition, the impacts of climate change give rise to the scarcity of water, a condition in which the water demand grows beyond the available water supply because of its physical unavailability and an insufficient water management structure (Hoekstra et al, 2012). The situation is worsened for a country like Uganda whose major economy relies heavily on water.

According to (Dalipagic, 2014) Eastern region is the leading rice producer in Uganda and it produces approximately 3.6 metric Tons/ha. However, when compared with other countries, rice yields in Uganda, are remarkably low (Kajonphol T, 2018)**.** In Butaleja district, Doho rice scheme experienced reduced rice yields in the recent years because of increased land use changes in Manafwa catchment which cause floods in the downstream affecting the rice growing activities

6 REFERENCES

Bouman B.A.M, L. R. (2007). *Water management in irrigated rice: coping with water scarcity.* International Rice Research Institute.

Carrijo DR, L. M. (2017). Rice yields and water use under alternate wetting and drying irrigation: A meta-analysis. *Field Crops Rsearch*, 203: 173-180.

Chen, S., Jang, C., Chen, S., & Chen, K. (2013). Effect of N-fertilizer application on return flow water quality from a terraced paddy field in Northern Taiwan. *Paddy Water Environment*, 11 (1-4), 123-133,. doi:10.1007/s10333-011-0298-7.

Choi, S., Jeong, J., & Kim, M. (2017). Simulating the Effects of Agricultural Management on Water Quality Dynamics in Rice Paddies for Sustainable Rice Production—Model Development and Validation. *Water*, 2017, 9(11), 869. doi:10.3390/w9110869.

Dalipagic, I. a. (2014). *Agricultural value chain analysis in Northern Uganda: maize,rice, groundnuts, sunflower and sesame.* . Action Against Hunger. ACF- International.

FAO. (2018). Retrieved from http://faostat.fao.org/

FAO. (2020). Retrieved June 22, 2022, from http://www.fao.org/3/T7202E/t7202e00.htm#dataContent

FAOSTAT. (2019). *Food Agricultural Organization. FAOSTAT Crops.* Retrieved July 10 , 2022, from http://www.fao.org/faostat/en/?#d

Farmer, B. H. (1986). *"Perspectives on the 'Green Revolution'in South Asia". Modern Asian Studies.* doi:10.1017/s0026749x00013627

GRiSP. (2013). Global Rice SCience Partnership. Los Banos: International Rice Research Institute.

Hou H, S. X. (2012). Seasonal variations of CH4 and N2O Emmsisions in response to water management of paddy of paddy fields located in Southeast China. . *Chemosphere*, 89: 884-892.

Huang, C., Li, N., Zhang, Z., Liu, Y., Chen, X., Wang, F., & Chen, Q. (2020). What Is the Consensus from Multiple Conclusions of Future Crop Yield Changes Affected by Climate Change in China? *International Journal of Environmental and Resources and Public Health*, 17, 9241.

IFPRI. (2020). *Projections.* Washington D. C.

Kajonphol T, S. N. (2018). Correlation and multiple regression model for economic traits of local rice (Oryza sativa L.) in upland rice system. *Applied Mechanics and Materials.*, 879:71-77. doi:0.4028/www.scientific.net/AMM.879.17

Lin L, Z. B. (2012). Evaluating yield response of paddy rice to irrigation and soil management with application of the AquaCrop Model. *Transactions of the ASABE*, 55: 839-848.

Liyantono, Kato, T., Kuroda, H., & Yoshida, K. (2013). GIS analysis of conjunctive water resource use in Nganjuk district, east Java, Indonesia. . *Paddy Water Environ.* , 11 (1-4), 193-205. doi:10.1007/s10333-011-0304-0

MAAIF. (2010). *MAAIF (Ministry of Agriculture, Animal, Industry and Fisheries), (2010). Agriculture Sector Development Strategy and Investment Plan: 2010/11 – 2014/15.*

Materu, S. S. (2018). Water Use and Rice Productivity for Irrigation Management Alternatives in Tanzania. *water*, 10, 1018.

Materu, S., Sanjay, S., Sishodia, R., Tarimo, A., & Tumbo, D. (2018). Water Use and Rice Productivity for Irrigation Management Alternatives in Tanzania. *water* , 10, 1018.

MWE. (2012). *Proposed institutional arrangements and regulatory framework for sustainable management of irrigation schemes implemented under FIEFOC project. Final report.* Kampala.: Ministry of Water and Environment (MWE).

NPA. (2020). *National Development Plan (NDP) 2010/11-2014/15. The National Planning Authority (NPA), P O Box 21434, Kampala.* Kampala. Retrieved from wwww.npa.ug.

OECD/FAO. (2021). *OECD-FAO Agricultural Outlook OECD Agriculture statistics (database).* Retrieved from http://dx.doi.org/10.1787/agr-outl-data-en

Otsuka, K. a. (2009). "Technology Policies for a Green Revolution and Agricultural Transformation in Africa." . *Journal of African Economies, forthcoming*.

Pérez-Escamilla, R. (2017). Food security and the 2015–2030 sustainable development goals: From human to planetary health: Perspectives and opinions. *Current developments in Nutrition*, 1(7), e000513.

Prodhan, Z. &. (2020). Rice Aroma: ANatural Gift Comes with Price and the Way Forward. *Rice Science*, 27(2), 86-100.

Rahman S.M, K. K.-S. (2013). Early growth stage water management effects on the fate of inorganic N, growth and yield in rice. *Soil SCience and Plant Nutrition*, 59: 921-932.

Srujana, G. S. (2017). Studies on Genetic Variability, Heritability and Genetic advance for yield and quality components in rice (Oryza sativa L.). *Journal of pharmacognosy and phytochemistry*, 6(4), 564-566.

Trust, K. (2012). *Development of Inclusive Markets in Agriculture and Trade (DIMAT): The Nature and Markets of Rice Value Chains in Uganda.*

Trust., K. (2012). *Development of Inclusive Markets in Agriculture and Trade (DIMAT): TheNature and Markets of Rice Value Chains in Uganda.*

World_Bank. (2008). World Development Report 2008:. *Agriculture for Development.*

Xie, X., & Cui, Y. (2014). Development and test of SWAT for modeling hydrological processes in irrigation districts with paddy rice. *Journal of Hydrology*, 396 (1-2), 61-71. doi:10.1016/j.jhydrol.2010.10.032.

Yang J, Z. Q. (2017). Moderate wetting and drying increases rice yield and reduces water use, grain arsenic level and emission. *The Crop Journals*, 151-158.