BUSITEMA UNIVERSITY
Pursuing Excellence

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 and Irrigation Engineering

Final Year Undergraduate Thesis

Climate Suitability Analysis of Alternate Wetting and Drying Irrigation for Expansion of Rice Cultivation in Uganda

Case Study: Eastern Uganda

BY

BAGAMBA EDSON
BU/UG/2019/0134
+256774764269/+256759444363
bagambaedson@gmail.com

Supervisors: Mr. Bwire Denis.

Madam. Nabunya Victo.

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ABSTRACT

Rice cultivation plays a significant role in contributing to food security in Uganda. Paddy cultivation is carried out using traditional continuous flooding practice that requires a lot of water, contributes to greenhouse gas emissions, posing a threat to the future of paddy production due to climatic changes causing droughts and water scarcity. Promotion of sustainable water management practices such as alternate wetting and drying (AWD) irrigation is required. This study investigated the suitability of AWD irrigation as a climate-smart water management technique to improve on water management in paddy rice fields in Uganda.

Relevant climate data, including temperature, precipitation, evapotranspiration, and soil moisture, were used to analyze the current and future climate suitability of the technique in paddy rice fields. The data was prepared in QGIS 3.28.1, and the files were imported into Maxent for habitat modeling, to enhance accurate predictions of rice crop distribution under different climate scenarios. For suitability analysis, Ecological Niche Modeling (ENM) technique in conjunction with maximum entropy model (Maxent) were used to assess the ecological niche of paddy rice, potential benefits and viability of AWD practice for Eastern region, considering factors such as water availability, soil characteristics, and climate conditions.

The results show that 5 major environmental predictors: organic carbon stock (OCS), volume fraction of coarse fragments (CRFVOL), available water (AW), exchangeable potassium (EXK) and topographical wetness index (TWI) and precipitation of the warmest quarter (BIO18) were the most influential predictors in evaluation of AWD. The findings from Maxent model for potential suitability distribution of irrigated rice in Eastern Uganda indicates high-performing metrics with area under the operating characteristic curve(AUC) and percentage correctly classified(PCC) on training data with> 92% and > 90%, respectively. The percolate rates ranging from 1- 5mm/day was found unsuitable for AWD in wet season with rainfall amount greater than 20mm/day and suitable in dry season under all percolates rates. The AWD was found more suitable with increasing percolation rates and region has 70.4% of sand clay loam texture soils class favoring paddy cultivation due to its high percolation rates.

The study is a guide into suitability analysis of AWD and provide insights of the potential benefits and limitations of adopting AWD irrigation in Uganda, as a foundation for pilot implementation, and scaling up of the practice in paddy rice fields. Therefore, this is a supportive tool to the decision

ad policy makers, irrigation engineers and government for development of sustainable water management strategy that enhance reduced water consumption, mitigation of greenhouse gas emissions and expansion of paddy rice production for food security in Uganda.

DECLARATION

I BAGAMBA EDSON, REG No. BU/UG/2019/0134, declare to the best of my knowledge that this Research thesis is as result of my research efforts.

Student's signature..

Date…12th/10/2023…

APPROVAL

This research thesis has been submitted to the department of Agricultural mechanization and irrigation Engineering of Busitema University with approval of the following University Supervisors.

Mr. BWIRE DENIS

Signature.… ………….

Date…………27th/3/2024…………….

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LIST OF ACRONYMS

AWD	ALTERNATE WETTING AND DRYING
DEM	DIGITAL ELEVATION MODEL
MCDA	MULTI CRITERIA DECISION ANALYSIS
MAXENT	MAXIMUM ENTROPY
FAO	FOOD AND AGRICULTURAL ORGANISATION
GIS	GEOGRAPHIC INFORMATION SYSTEM
MAAIF	MINISTRY OF AGRICULTURE ANIMAL INDUSTRY AND FISHERIES
NARO	NATIONAL AGRICULTURAL RESEARCH ORGANIZATION
CF	CONTINUOUS FLOODING
TWI	TOPOGRAPHICAL WETNESS INDEX
AUC	AREA UNDER THE OPERATING CHARACTERISTIC CURVE
PCC	PERCENTAGE CORRECTLY CLASSIFIED

CHAPTER ONE: INTRODUCTION

Rice accounts for 29% of total grain crop output worldwide. (Xu and colleagues, 2003) and rice production has been carried out for over 10,000 years (Kenmore, 2003), longer than any other crop. The global rice cultivation area is estimated to be 150,000,000 ha, with annual production averaging 500 million metric tons (Tsuboi, 2004). The FAO predicted a record rice harvest up to 2.3 % amounting to 666 million tons in 2008, although rice prices could remain high in the short term, in the same year as crops are only reaped by the end of the year. According to the FAO's rice price index, 'rice prices rose steeply by around 76% between December 2007 and April 2008'. For prices to fall, favorable weather conditions must prevail in the imminent months and governments relax rice export constraints.

Rice is also gaining popularity in Africa. The annual rice consumption in Africa is around 16 metric tons, while production is around 14 metric tons, resulting in 2 million metric tons deficit. Rice is currently grown in more than 75% of African countries, with a total population of close to 800 million people. Rice is a staple food for people in Africa: Cape Verde, Comoros, Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Egypt, Reunion, Senegal, and Sierra Leone. It is also a popular food in Côte d'Ivoire, Mali, Mauritania, Niger, Nigeria, and Tanzania (Somado et al., 2008).

Rice production in Uganda started in 1942 mainly to feed the World War II soldiers, however, due to a number of constraints, production remained minimal until 1974 when farmers appealed to the then government for assistance (UNRDS., 2009). In response, the government identified the Doho swamps and constructed the Doho Rice Irrigation Scheme (DRS) with the help of Chinese experts. Today rice is grown mainly by small-scale farmers almost throughout the country, but also by large-scale farmers in a few places (Bwire et al., 2023). Total annual production is estimated at 165,000metric tones. Total rice consumption is estimated at 225,000metric tones (MAAIF., 2009). The population growth rate is 3.2% thus the demand for rice is expected to rise. Uganda adopted NERICA 1, 4, and 10 varieties in addition to the old lowland varieties. Since the introduction of upland rice in 2002, rice farming has grown from 4,000 farmers to over 35,000. From the earlier releases of three upland rice varieties in Uganda in 2002 courtesy of the Rock feller support farmers were able to reap $9 million (14.9 billion) in 2005. In the process, the country has seen rice imports drop between 2005 and 2008. This trend of events

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