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FACULTY OF ENGINEERING.

DEPARTMENT OF AGRICULTURAL MECHANIZATION AND IRRIGATION ENGINEERING.

FINAL YEAR UNDERGRADUATE THESIS

A PREDICTIVE IRRIGATION SCHEDULING MODEL BASED ON ENVIRONMENTAL AND CROP DATA

Case Study: Nakivale Refugee Settlement Camp, Isingiro District, Southwestern Uganda

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A final Year Undergraduate Thesis Submitted to the Department of Agricultural Mechanization and Irrigation Engineering as the Requirements for Partial Fulfillment for the Award of Bachelor of Agricultural Mechanization and Irrigation Engineering, Busitema University.

SUBMISSION DATE……………………………………………………….

ABSTRACT

The increasing water scarcity globally is a serious challenge to irrigation development. Irrigation water management requires designing optimal irrigation systems for effective water use which is quite challenging due to limited technical skills and in-situ meteorological data, especially in developing world, for estimation of crop water need. Several approaches and models exist on estimation of crop water needs including CROPWAT, soil water balance model.

This study developed a comparative predictive irrigation scheduling models based on environmental and crop data that accurately respond to fluctuations in critical parameters to enhance water use efficiency and crop productivity for given crop, the case of Nakivale Refugee Camp, Uganda. Before developing the model, re-analyzed climatic data was obtained from NASA for period of 20 years ranging from 1997-2021for Nakivale Refugee Camp. Although, the spatial variability of environmental parameters is usually dramatic, whose time series data are rowdy, non-linear, and non-stationary, and hard to predict accurately. Based on the effect of several environmental and crop parameters on irrigation schedule, 5 critical parameters were identified for the model construction thus precipitation, mean temperature, relative humidity, crop coefficient and wind speed. The autoregressive integrated moving average (ARIMA) and Extreme gradient boosting (Xgboost) machine learning (ML) algorithms in python, were employed to construct irrigation schedule by splitting the data into 90% training from 1997-2012 and 10% test data from 2020 to 2021. The accuracy and effectiveness of models was evaluated based on Root mean square error (RMSE), mean absolute error (MAE) and coefficient of R-squared (R^2).

The results show that ARIMA can predict irrigation water requirement (IWR) with MAE of 0.4580 although Xgboost gave the best predictions with MAE of 0.08085. The Xgboost algorithm with inbuilt application programming interface (Api) predicted future climate parameters, crop coefficients and IWR for 5 days based on the input crop planting date. Model Validation using k-fold cross-validation analysis gave the best MAE, RMSE, MSE, R2 and NSE values of 0.08085, 0.29062, 0.08446, 0.94814 and 0.97432 respectively. This study verified the application of ARIMA and Xgboost models with Xgboost as the best ML algorithm for prediction of irrigation schedule and future IWR at local level. This can help irrigation practitioners and farmers to reduce time, enhance effective water applications and management for improved yields.

DECLARATION

I ATIM CAROLINE, registration number BU/UP/2019/3321 declare that this Thesis is a result of my research work and has never been submitted to any institution of higher learning for any academic award

I stand to account for all this information contained in this report and to regret any queries that may arise out of it if there is any.

ATIM CAROLINE

Signature ....

Date 2nd/10/2023...

APPROVAL

This final year Undergraduate Thesis has been submitted to the department of agricultural mechanization and irrigation engineering for examination with approval from the following supervisors.

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List of abbreviations/Acronyms

UN – United Nations

UBOS – Uganda Bureau of Statistics

GDP – Gross Domestic Product

MAAIF – Ministry of Agriculture Animal Industry and Fisheries

MWE – Ministry of Water and Environment

NGOs – Non – government Organizations

SDGs – Sustainable Development Goals

ARIMA – Autoregressive Moving Average

FAO – Food and Agriculture Organization

BIC – Bayesian Information Criterion

AIC – Akaike Information Criterion

1.0. CHAPTER ONE

1.1BACKGROUND

Globally, irrigation has attained increasing importance due to of the growing demand for food arising from a rapid population growth. The current global population stands at 7.2 billion people, with a growth rate of around 1.14% and is projected to increase to about 9.7 billion by 2050 (United Nations 2019). Additionally, Africa's, population stands at 1.1 billion people projected to increase to 2.1 billion by 2050 (Bongaarts 2009). Uganda's, population is estimated at 42.3million people, with an average annual growth rate of 3% (UN 2022). Correspondingly, pressures on Earth's natural resources including the arable land are rising in tandem with the growing human population. The agricultural sector in Uganda contributes to 24.6% of the gross domestic product (GDP), supporting livelihood for over 72% of the economically active population, with most of the raw materials to the Agro-based industrial sector (UBOS 2015). Agriculture in Uganda, is predominantly rain-fed, and is increasingly adversely affected by the climate change and variability manifested in erratic rain patterns, prolonged dry spells, and floods. As a result, farm-level productivity is far below the attainable potential for most crops (Fermont and Benson 2011). Under these conditions, irrigation is critical in aiding farmers against climate change and plays an integral role in transitions from subsistence to commercial farming by ensuring year-round production and farm employment (Machethe et al. 2004; Ngigi 2009; Van Averbeke et al. 2011; Kadigi et al. 2012; Haile and Asfaw 2015; Megersa and Abdullahi 2015). The national policy framework for the development of irrigated agriculture is anchored on poverty alleviation and economic growth (GOU 2010). The drafted National Irrigation Master Plan (NIMP) for 2010–2035 (MWE 2011) identifies drivers of irrigation development in Uganda, which include (1) Vision 2050, which calls for "a transformed Uganda society from a peasant to a modern and prosperous country within the demand for agricultural products is constantly growing due to population growth and changing dietary preferences. However, water and energy are components for irrigation agriculture, and water resource is becoming scarce in the next 30 years"; (2) climate change and variability; (3) new markets; and (4) an increasing number of major international investors looking to establish commercial agricultural assets in the region. Despite previous efforts by the Government of Uganda (GoU) to promote irrigation, less than 1% of agricultural households practice irrigation in Uganda (UBOS 2010; MAAIF 2011). The area equipped for irrigation is less than 3% of the total potential irrigable area in Uganda estimated at 567,000 ha (MWE 2011).

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