BUSITEMA UNIVERSITY

FACULTY OF ENGINEERING

MASTER'S THESIS

IDENTIFICATION OF POTENTIAL IRRIGATION DEVELOPMENT SITES IN THE UPPER ASWA CATCHMENT, NORTHERN UGANDA

BY

OKETCHO YORONIMO

(B. AMI 2011, BU)

BU/GS14/MID/27

SUPERVISORS:

Dr. WILSON BABU MUSINGUZI
Eng. WILFRED R.ODOGOLA
Eng. MOHAMMEDD BADAZA

Master's Thesis Submitted to the Department of Agricultural Mechanization and Irrigation Engineering in Partial Fulfillment of the Requirements for the Award of the Degree of Master of Science in Irrigation and Drainage Engineering of

Busitema University

September 2018

ABSTRACT

Development of irrigation systems requires information on available water supply, terrain, soils, land use, climate and socio-economic factors. This research aimed at identification of potential irrigation infrastructure development sites within the upper Aswa catchment through determination of suitable water abstraction points, quantification of river flows available for irrigation and selection of optimum irrigation method for each of the sites. Suitability criteria for water abstraction points was the presence of surface water accumulation points at the outlet of sub-watersheds of the catchment, soil of moderate infiltration, presence of arable land as well as relatively gentle slopes. The DEM, land use, slope and the soil map of the catchment were obtained and processed. SWAT in QGIS 2.6 environment was used to burn the streams onto the already processed DEM and to divide the area into sub-basins. Twenty three sub-basins were delineated in which eleven sites evaluated were found to be highly suitable for irrigation infrastructure development on the basis of land, soil and slope factors. These sites are located along the three main river systems; Agago, Moroto/Aswal and Aswa II that drain the catchment.

Hydrological Assessment was done by constructing the flow duration curves for historical river discharges for the three main river systems within the study area. A high variability in the daily discharges was observed, depicting unstable flows. The 80% reliable flow for Agago was less than $1m^3/s$, Aswal (Moroto) was $0.1m^3/s$ and that of AswaII was slightly more than $5m^3/s$. Comparison of the longterm average monthly discharges with the monthly irrigation requirements of rice crop for small(<100ha), medium(100-500ha) and large scale(>500ha) irrigation development showed that there is need for off-farm storage infrastructure to cater for the Decemeber-March dry season corresponding to the lowest discharges and highest irrigation requirements of 9.5mm/day. For this period the storage requirement for the river systems in m^3 are 1436572, 2205610 and 1730241 for Agago, Moroto and Aswa II respectively as determined by subtracting the seasonal irrigation water need to the available discharge throughout the season allowing 25% environmental flow.

Optimum irrigation methods were determined using analytical-technical and technical-economic steps in which the acceptability indices for drip, sprinkler and surface irrigation methods against crop, field and human factors were compared at each of the sites to generate the VIMs of the different irrigation technologies. Across all the sites, surface irrigation method was the most adaptable with VIM ranging from 4 to 5.5. This was followed by sprinkler with VIM ranging from 3 to 4 and the least adaptable method was drip with VIM of 2 to 3.

In conclusion, whereas upper Aswa has expansive land area suitable for irrigation, the acreage that can actually be irrigated is limited to less than 1% due to low river flows during the dry season. Therefore, to increase the acreage under irrigation, it is necessary to consider conjunctive use of groundwater, construction of surface reservoirs alone can increase the irrigation command area by a very small margin.

DECLARATION

I, **OKETCHO Yoronimo,** declare that this research is my original work and has not been submitted for any award to any other Institution or University before. Any other author's work that was used in creating an establishment for the study reported in this thesis has been duly acknowledged.

Signed: .....

Date: 12/09/2018

Telephone Contact: +256-752454745/+256-392934088

Email: **oketchoyoronimo@gmail.com**

Physical Address: Busitema University, P. O. Box 236, Tororo

APPROVAL

The thesis is submitted with approval of the following supervisors:

Supervisors

DR. WILSON BABU MUSINGUZI,

Senior Lecturer,

Faculty of Engineering, Busitema University

Sign: ..... Date: 17/09/2018

ENG.WILFRED. R. ODOGOLA

Senior Lecturer,

Faculty of Engineering, Busitema University,

Sign: ..... Date: 12/09/2018

ENG. MOHAMMED BADAZA

Lecturer

Faculty of Engineering, Busitema University

Sign: ..... Date: 14/09/2018

ACKNOWLEDGEMENTS

I am so much grateful to Busitema University for the offer of scholarship to study this Master Degree under the ADB-HEST Merit based scholarship scheme without which it wouldn't have been possible for me to undertake this programme.

I further thank the Directorate of Graduate Studies, Research and Innovations (DGRI), the Academic Registrar's department, the Faculty of Engineering and the department of Agricultural Mechanization and Irrigation Engineering (AMI) for the sufficient arrangements made for the implementation of this programme.

Special thanks also go to Eng. Mohammed Badaza, Eng. Wilfred Odogola and Dr. Musinguzi Wilson Babu, my advisors, for their invaluable advice and guidance during this research.

I would also like to express my heartfelt gratitude to Horticulture Irrigation Project (HIP), for the gainful engagement and technical support and exposure offered to me as a research assistant during the course of this programme.

Last but not least, I thank all my colleagues; the workmates and the fellow graduate students for the support and guidance accorded to me during the pursuance of this programme.

DEDICATION

This thesis is dedicated to my dear wife Irene Gift; my parents and the entire family.

TABLE OF CONTENTS

List of figures

List of tables

LIST OF ACRONYMNS

AfDB	African Development Bank
Cumec	Cubic meters per second
DEM	Digital Elevation Model
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GIS	Geographic/Geospatial Information Systems
GoU	Government of Uganda
GWP	Global Water Partnership
HEST	Higher Education in Science and Technology
IDP	Internally Displaced Persons
IFAD	International fund for Agricultural development
ILO	International Labour Organization
IUCN	International union for Conservation of Nature
IWRM	Integrated Water Resources Management
NEH	National Endowment for the Humanities
NDP	National Development Plan
O&M	Operation and maintenance
PRA	Participatory Rural Appraisal
RFWH	Runoff Farming Water Harvesting
SDGs	Sustainable Development Goals
SDSS	Spatial decision Support System
SMCE	Spatial Multiple Criteria Evaluation
SRTM	Shuttle Rader Topography Mission
SWAT	Soil and Water Analysis Tool
UK	United Kingdom
NASA	National
UKAID	United Kingdom Agency for International Development
UN	United Nations
USAID	United States Agency for International Development
VIM	Value of Irrigation Method
WGS84	World Geodetic System 1984
WMZ	Water Management Zone
WRM	Water Resources Management

CHAPTER ONE: INTRODUCTION

1.1 Background

The United Nations Sustainable Development Goal (SDG) two aims at, by 2030, attaining sustainable food production systems and implementing resilient agricultural practices that increase production and productivity, help maintain ecosystems, strengthen capacity for adaptation to climate change, extreme weather and other disasters and that progressively improve land and soil quality. It further aims to increase investment, in rural infrastructure, agricultural research and extension services and technology development (UN 2030 agenda for sustainable development, 2015). Irrigation is thus a precursor to achieving this goal.

In Uganda, agriculture employs about 66% of the working population and contributes about 22% to total GDP, 71% of the working population is engaged in subsistence agriculture as their main occupation and 68% of households depend on it for their livelihoods (UBOS, 2014). Therefore, agriculture remains a fundamental part of Uganda's economy. Agriculture in Uganda, which is predominantly rain-fed, 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. 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 (Wanyama *et al.* 2016).

From 2003 to 2005, Uganda undertook a Water Resources Management (WRM) reform study with the objective "to establish an effective framework for Water Resources Management in Uganda to ensure that water resources are managed in an integrated and sustainable manner." The study led to preparation of a WRM reform strategy which recommended paradigm shift in WRM from centralized to Catchment/Basin. Consequently, Upper Nile, Victoria, Kyoga, and Albert WMZs were delineated. One of the priority issues highlighted by the Upper Nile WMZ stakeholders during the review study was the need to develop the irrigation potential and assuring of food security in the region (MWE, 2011). Despite previous efforts by the Government of Uganda to promote irrigation, less than 1% of agricultural households practice

REFERENCES

Abeyou Wale Worqlul, Amy S. Collick *et al* 2013: Realistic assessment of irrigation potential in the Lake Tana basin, Ethiopia; a conference paper, July 2013.

Aldo Benini, Patrice Chataigner et al, 2017: The use of expert judgment in humanitarian analysis: Theory, methods and applications.

Balasubramanian A.: Digital Elevation Model (DEM) in GIS; Technical Report · September 2017

Benini, A., P. Chataigner, N. Noumri, N. Parham, J. Sweeney and L. Tax (2017): The Use of Expert Judgment in Humanitarian Analysis – Theory, Methods, Applications. [August 2017]. Geneva, Assessment Capacities Project - ACAPS.

Bithell, S. L. and Smith, S. (2011:. The Method for Estimating Crop Irrigation Volumes for the Tindall Limestone Aquifer, Katherine, Water Allocation Plan. Northern Territory Government, Australia. Technical Bulletin No. 337.

Bojan Srdjevic, 2005: Valuation of irrigation methods by equal and weighted importance models and the analytic hierarchy process

Cornell University Press, New York, USA. Hudson, N.W. 1988. Conservation practices and runoff water disposal on steeplands. In: Conservation Farming on Steeplands, W.C. Moldenhauer, and N.W. Hudson (eds.). Soil and Water Conservation Society, Ankeny, Iowa, pp. 117-128.

Critchley, W. and Siegert, K. 1991, A manual for the design and construction of water harvesting schemes for plant production, with contributions from: Chapman, C. and Finkel, M.

Demetre P. Argialas, John G. Lyon and Olin W. Mintzer, 1997: Quantitative Description and Classification of Drainage Patterns

Eduardo A Holzapfel and Jesús Chávez Morales, 2015: Procedure to Select an Optimum Irrigation Method.

FAO Soil and water conservation hand book; (http://www.fao.org/docrep/t0321e/t0321e10.htm) accessed on 10/07/2017

FAO. 1987. Soil and water conservation in semiarid areas. FAO, Rome, Italy. Soil Bulletin 57

Finkel, H.J. 1986. Semiarid Soil and Water Conservation CRC Press, Boca Raton, Florida, USA.

Global Water Partnership: http://www.gwp.org/the-challenge/what-is-iwrm/

Irrigation Reference Manual (Peace Corps, 1994, 485 p.)(accessible onhttp://www.nzdl.org/gsdlmod/

Lindsay, J. B., J. J. Rothwell, and H. Davies (2008), Mapping outlet points used for watershed delineation onto DEMderived stream networks, Water Resour. Res., 44, W08442, doi:10.1029/2007WR006507

Kassa Teka, Van Rompaey, A. and Poesen, J. 2010. Land Suitability Assessment for Different Irrigation Methods in Korir Watershed, Northern Ethiopia. Journal of the Drylands 3(2): 214-219

Kinthada et al., J Geol Geosci 2014. Land Use/Land Cover and NDVI Analysis for Monitoring the Health of Micro-watersheds of Sarada River Basin, Visakhapatnam District, India (accessed on: http://dx.doi.org/10.4172/2329-6755.1000146)

Lynne E Johnson, 2014. Geographic Information Systems in Water Resources Engineering.

MAIIF 2010. Uganda Strategic Investment Framework for Sustainable Land Management 2010 – 2020,

Malcewski, J. 1999; spatial multicriteria decision analysis. In spatial decision making and analysis. A geographical information sciences approach; Asgate publishing: undershot, UK, pp. 101-269.

Malczewski, J. (1999). GIS and multicriteria decision analysis. New York: Wiley.

Ministry of Water and Environment, 2011: 2010 National Water Resources Assessment report.

Ministry of Water and Environment Joint Sector Review Report, 2013.

Ministry of Water and Environment November 2011. National Irrigation Master Plan for Uganda (2010-2035).

Mwebembezi L.2013: catchment based Integrated Water Resources Management in Uganda

Namara, R. E., et al. (2010). "Typology of irrigation systems in Ghana." International Water Management Institute, Colombo, Sri Lanka.

National Development Plan II 2014, Uganda Vision 2040.

Negash Wagesho 2014 Arba Minch University, Institute of Water. GIS-based Irrigation suitability analysis: A case study of Abaya-chamo basin, southern rift valley of Ethiopia. accessed Technology on *https://www.researchgate.net/publication/268365890*

New Partnership for Africa's Development (NEPAD)government of the republic of Uganda, support to NEPAD–CAADP implementation, TCP/UGA/2910 (I), (NEPAD Ref. 04/03 E)

Oweis, T., *Hachum*, A. and *Kijne*, J. (*1999*) Water Harvesting and Supplemental Irrigation for Improved Water Use Efficiency in the Dry Areas.

Speirs et al; 2013: Soil phosphorus tests II: A comparison of soil test–crop response relationships for different soil tests and wheat

SWIM Paper 7.Nasr, M., 1999. 'Assessing Desertification and Water harvesting in the Middle East and North Africa: Policy Implications' ZEF discussion Paper on Development Policy, University of Bonn.

Tallaksen, L M and van Lanen, A J (2004). Hydrological drought: processes and estimation methods for streamflow and groundwater, Developments in Water Science 48. Elsevier BV.

Uganda national bureau of Statistics. Statistical abstracts October 2015.

UNESCO World Water Assessment Program, 2006. Uganda National Water Development Report 2005 (UN-WATER/WWAP/2006/9).

United Nations 2015:The 2030 agenda for sustainable development, accessed from *http://www.un.org/sustainabledevelopment/development-agenda/*

Wanyama, Ssegane *etal*, 2016, Irrigation Development in Uganda: Constraints, Lessons Learned, and Future Perspectives. Accessed on *www.asceelibrary.org* on 5th February 2017.

World Meteorological Organization, 2008: Manual on Low flow estimation and prediction, Operational Hydrology report No.50

Y. Mao et al, 2014. Automated drainage network extraction model

Yunxiang L., Baolin S; 2011: GIS Techniques for Watershed Delineation of SWAT Model in Plain Polders.