BUSITEMA UNIVERSITY
Pursuing Excellence

FACULTY OF ENGINEERING

DEPARTMENT OF MINING AND WATER RESOURCES ENGINEERING

FINAL YEAR PROJECT REPORT

DESIGN OF AN IRRIGATION STORAGE SYSTEM FOR BUSITEMA UNIVERSITY FARM

BY

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BU/UP/2014/609

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A final year project submitted to the department of water and mining engineering in partial fulfillment for the award of the bachelor degree of science in water resources engineering of Busitema University.

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ABSTRACT

Reservoirs are the one of the largest sources to store surface water. The escalating water crisis in the eastern part of Uganda during the dry seasons has made it very important to preserve available water and in turn to preserve the storage capacity of the reservoirs.

The goal of this project is to design a reservoir for Busitema University farm .This reservoir will allow Busitema University to have more flexibility with its irrigation scheduling.

Surveys were conducted with hand held GPS to obtain coordinates were used in the determination of the area of the Busitema farm.

The 50-year return-period design storm was determined with the aid of rainfall data for the catchment. The time of concentration was calculated, the critical rainfall intensity read off from the developed intensity-duration-frequency curves and the peak runoff calculated, using the rational method.

It was followed by determination of crop water requirement and this was achieved by using the Soil Water Analysis Tool (SWAT). This started with data collection from various sources i.e. from offices. Data collected included: - DEM, land use/land cover data, rainfall data and soil data.

Design of various components of the system was done using the given relevant formulas and equations .The storage reservoir was designed according to County and NRCS standards. A trapezoidal conveyance channel section was chosen and it was designed using detailed hydraulic calculations and manning's formula. The sizing and lining the conveyance channel will transform it into a sustainable, cost effective channel that can accommodate and convey the peak runoff from its catchment without overflowing.

Finally, the economic evaluation of the system was done using benefit cost ratio approach it was found to be feasible and thus should be invested in. Recommendations to ensure that all the project objectives are met are stated.

DECLARATION

I, Nuwemukama Immaculate, BU/UP/2014/609 declare that this final year project report with its organization and content is originally my work apart from citations.

Therefore, it has never been presented to any institution of higher education for any academic award.

Signature: .....

Date: ....30th...May...2018...

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I would also like to thank my family: my parents, Mr. and Mrs. Keingana Milton, my siblings and my uncles especially Mr. Tusiime Elly, for providing a constant encouragement and support, at many levels, and from a distance.

DEDICATION

I would like to dedicate this report to almighty God who gave me good health and time to work on my final year project because without him I was not going to make it. Then to my caring parents Mr. Keingana Milton and Mrs. Twongirwe Miriam, brothers and sisters for all their support in this period of training.

APPROVAL

This is to certify that I Nuwemukama Immaculate has done my final year project and this report contains only and only work that I was able to do under the close supervision and guidance.

We hereby approve the report for submission to the Board of Examiners and the Senate of Busitema University.

MAIN SUPERVISOR

NAME..... Karuma Chris .....

SIGNATURE.....

DATE..... 31/05/2018 .....

CO-SUPERVISOR

NAME.....

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LIST OF ACRONYOMS

GIS	Geographical Information System
DEM	Digital Elevation Model
NFA	National Forestry Authority
UBoS	Uganda Bureau of Statistics
HRU	Hydrological Response Units
SWAT	Soil Water Analysis Tool
SSF	Slow sand filter
LCCS	Land Cover Classification
ET	Evapotranspiration
CN	Curve Number
WCD	World Commission on Dams
NCRS	National Resources Conservation Services
SCS	Soil Conservation Service
NCRS	National Resources Conservation Services
SCS	Soil Conservation Service
CBA	Cost Benefit Analysis
HSG	Hydrologic Soil Group
Tc	Time of concentration
PMM	Penman–Monteith method

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study.

A sufficient, safe drinking water supply is essential to life but most people in world are not having access to the basic necessity. Also water is needed in the world for agriculture since it takes a large portion of the people's economy in the world(Land, 2017). The government and organizations are promoting technologies that will help their people to access the water since most people in the world are poor and rainwater is one of these technologies. Sophisticated RWH systems are being used in industrial countries to reduce the water bills thus meeting the needs of remote communities in arid regions. Also hillsides were cleared of vegetation and smoothed in order to provide as much run off as possible and the water was then channeled in contour ditches to agricultural fields.(Rupp, 2007)

In Uganda there is a drip project whose goal is to ensure that rainwater is harvested cheaply and effectively as a means of relieving food shortages. This project is mostly carried out in dry areas to assist the farmers by building a low cost rainwater harvesting system based on the ready-made collection system of the grass roof of their huts. ('Harvesting in', 2005)

In eastern Uganda, water is harvested from rivers, wells, lakes, swamps, artificial dams or reservoirs and directly from the rooftops when the rain falls. Water is harvested for different reasons like for irrigation, drinking, industrialization, and other domestic uses like washing clothes as shown in the diagrams below(Ahmed, 2008).

Figure 1: How water is harvested in eastern Uganda

Figure 2: A reservoir

Busia District belongs to the area regarded as having highly reliable conditions for agricultural production hence, an important national Agricultural base and food basket.

References

Ahmed, S. (2008) 'Rainwater Harvesting', *Practical Action Technical Brief*, 44(871954), p. 12 pp.

Ankidawa, B. A. and Tope, A. A. (2017) 'Design of Slow Sand Filter Technology for Rural Water Treatment in Girei , Adamawa State , North Eastern Nigeria', 3(3), pp. 1–7. doi: 10.9734/AJEE/2017/34395.

Atanabe, F. W. *et al.* (2012) 'Estimating the Volume of Surface Runoff from in Situ Measured Soil Sorptivity', 98(1983), pp. 95–98.

Bengtsson, L. and Sept, R. L. (2004) 'Figure 1', pp. 1–18.

Bharali, B. (2015) 'Estimation of Reservoir Storage Capacity by using Residual Mass Curve', 2(10), pp. 15–18.

Bryant, R. B. (2010) 'Filtering mediums for treating stormwater runoff: Lessons from ditch drained agriculture'.

Carr, M. K. V (2014) 'The water relations and irrigation requirements of banana (Musa SPP .) T H E WAT E R R E L AT I O N S A N D I R R I G AT I O N R E QU I R E M E N T S O F BA NA NA (M U S A S P P .)', (July 2009). doi: 10.1017/S001447970900787X.

'Collection and Conveyance Systems' (2007).

Crop water requirements Crop water requirements (no date).

Desta, H. and Lemma, B. (2017) 'Journal of Hydrology: Regional Studies SWAT based hydrological assessment and characterization of Lake', *Journal of Hydrology: Regional Studies*. Elsevier, 13(August), pp. 122–137. doi: 10.1016/j.ejrh.2017.08.002.

Engineering, C. (no date) 'Flow in open channels', pp. 1–61.

Engineering, W. R. (no date) 'Cve 471 water resources engineering'.

'Harvesting in' (2005), 44(871954).

Hydraulics, O. C. (no date) 'CIVE2400 Fluid Mechanics Section 2 : Open Channel Hydraulics', pp. 1–39.

'Irrigation Storage Reservoir' (no date), p. 436.

'IrrigationWaterConveyance' (no date).

Land, H. (2017) 'Quantification of soil erosion and transport processes in the in the Myjava', 19(September 2015), p. 7073.

Lhomme, J. P. *et al.* (2015) 'Estimation of crop water requirements : extending the one-step approach to dual crop coefficients', (2), pp. 3287–3299. doi: 10.5194/hess-19-3287-2015.

'Part 650 Engineering Field Handbook Chapter 1 Surveying' (no date).

'Proposed Methods for Analyzing Feasibility , Costs , and Benefits of Water Storage Projects in Oregon Senate Bill 839 Economic Subgroup Report Table of Contents' (2014).

Requirements, C. (2012) 'Swat tutorial', (1), pp. 1–15.

Rupp, G. (2007) 'Rainwater Harvesting Systems for Communities in'.

Silva, C. L. and Oliveira, C. A. S. (1999) 'Runoff measurement and prediction for a watershed under natural vegetation in central Brazil', *Revista Brasileira de Ciência do Solo*, 23(1), pp. 695–701. doi: 10.1590/S0100-06831999000300024.

Size, R. (2005) 'WATER STORAGE RESERVOIRS', i, pp. 4–7.

Standard, I. (1990) 'GENERAL REQUIREMENTS FOR SLOW SAND FILTERS', 101(October).

Tarboton, D. G. (2003) 'R AINFALL -R UNOFF P ROCESSES'.

Tomac, J. (2014) 'No Title'.