FACULTY OF ENGINEERING

DEPARTMENT OF MINING AND WATER RESOURCES ENGINEERING

DESIGN AND CONSTRUCTION OF A FLOOD-WARNING SYSTEM PROTOTYPE BASED ON EMBEDDED SYSTEMS FOR RIVER NYAMWAMBA, KASESE DISTRICT[1]

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[1] *This Final Year Project Report is presented as a Partial Fulfillment for the Award of a Bachelor of Science Degree in Water Resources Engineering of Busitema University.*

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Abstract

This Final Year Project report contains all the details of a study on the design and construction of a Flood Warning System (FWS) for River Nyamwamba of Kasese district – a river that has been prone to floods of a greater magnitude than other rivers in the Tropical region of Africa. The idea was developed on a principle that floods are a meteorological event that develops over time, and thus a need for sufficient time for people to evacuate, and to protect their lives and property.

However, the range of existing FWSs have a tangle of conflicting requirements in terms of cost and reliability, and have challenges from factors as diverse as technological and social. The complexity of these systems and need for autonomy while remaining maintainable and accessible by nontechnical personnel is a bottle-neck that is often unsolved in developing countries. Built on Computer Embedded Systems, this study is about a cheaper and reliable FWS for a country like Uganda.

The study began with modelling the flow of River Nyamwamba with different datasets (i.e. DEM, Topography sheets, river map, imageries, flow data, stage data, land use maps and rainfall data) that were collected from field work and various offices. The datasets were conditioned and processed in a GIS environment using the ArcGIS software. The result was further exported to the HEC-RAS program to perform a steady flow simulation of the river. The RAS mapper export from HEC-RAS was then re-imported back into ArcMap to delineate a flood plain that was overlaid to a Google Earth image to visualize and determine the high risk areas along the river. The high risk areas provided reliable river flow parameters that were used as input values for the design of the FWS.

The FWS was built on a technology of Computer Embedded Systems that employs Arduino-programmed microcontrollers to control all input and output values regarding the modelled river. An ultrasonic sensor was used to monitor water levels at three threshold points (i.e. Level 1 for normal flow, Level 2 for an intermediate flow, and Level 3 for a peak flood level). From this, the river stage was displayed onto an LCD screen at all times, an electronic SMS was sent to operators at intermediate flow, while an Alarm was sounded at Flood level.

Key Words: Geographical Information Systems, Flood Frequency Analysis, Flood Mapping, Modelling, Flood Warning Systems, Embedded Systems, Simulation, Design, and Construction.

Declaration

I, Tumwijukye Shaban, an undergraduate student of a Bachelor of Science in Water Resources Engineering solemnly declare that this research report on the 'Design and Construction of a Flood Warning System Prototype for River Nyamwamba, Kasese district' is my original work that has been done and prepared by myself. It has not been previously or concurrently submitted for the award of any academic degree, diploma or certificate of Busitema University or any other university. The materials borrowed from other sources and included herein have been properly cited and acknowledged. All information in this document has been obtained and presented in accordance with academic rules and ethical standards of the Busitema University Senate.

Signature **Date**

…… ……

TUMWIJUKYE SHABAN

Approval

This is to confirm that this Final Year Project report on the 'Design and Construction of a Flood Warning System Prototype for River Nyamwamba, Kasese district' has been written and presented by TUMWIJUKYE SHABAN, a B.SC (Water Resources Engineering) student under our supervision.

Signature and Date.

…… 30th May 2018

MR. DAVID KIMERA

MAIN SUPERVISOR

Signature and Date.

……..

MR. MARTIN OKIRYA

CO-SUPERVISOR

Dedication

This Final Year Project Report is a special dedication to Mwesigye Jimreeves, Emolu Nathan and Asiimwe Democious – the 3 fallen Busitema University students to a drowning accident on March 25th, 2017 at Sangalo Sand Beach, Busia on the shores of Lake Victoria. They were dear friends, enthusiastic brothers and ambitious students of Engineering that we shall always miss. May their souls rest in eternal peace.

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This work has been carried out at the Department of Water Resources and Mining Engineering of the Faculty of Engineering, Busitema University. My great thanks go to Allah, the Almighty for helping me complete this Final Year Research Project. It was only by His grace and blessing that I could finish my report.

I sincerely extend my thanks to my supervisors; Mr. Kimera David and Mr. Okirya Martin for their insightful and comprehensive guidance while undertaking the study. It was a great privilege to work under their guidance and professional supervision.

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Contents

List of Acronyms and Symbols

AutoCAD – Automatic Computer Aided Design [Software]

DC – Direct Current

DEM – Digital Elevation Model

DREF – Disaster Relief Emergency Fund

DWRM – Directorate of Water Resources Management

FWS – Flood Warning System

GIS- Geographical Information Systems

GSM - Global System for Mobile Communication

HEC-RAS – Hydrologic Engineering Center-River Analysis System [Software]

HEC-SSP – Hydrologic Engineering Center – Statistical Software Package [Software]

HTML – Hypertext Markup Language

IDE – Integrated Development Environment

KML – Kilembe Mines Limited

LAN – Local Area Network

LCD – Liquid Crystal Display

MWE - Ministry of Water and Environment

NEMA - National Environment Management Authority

NPV – Net Present Value

NWS – National Weather Service

P.I – Profitability Index

SIM – Subscriber Identity Module

SMS – Short Messages

S.F - Scale Factor

THMCL - Tibet Hima Mining Company Limited

TIN – Triangular Irregular Network

UMD - Uganda Meteorological Department

URCS- Uganda Red Cross Society

USACE - United States Army Corps for Engineers

WSDF-SW - Water and Sanitation Development Facility, South Western Branch

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1.0 INTRODUCTION

1.1 Preamble

This chapter gives a background knowledge of floods, considering a case study of River Nyamwamba of Kasese District. The Problem statement, justification, objectives of the research and the scope of the study are also discussed here.

1.2 Background

Uganda's water resources exhibit both seasonal and spatial variability – implying that some areas have too much water, while others are water stressed (Okello, 2016). Additionally, this is worsened by climate change patterns that lead to extreme weather conditions of floods and drought. According to (UMD, 2014), floods are a leading weather-related disaster in the country, with cases like the February 2010 floods and mudslides that affected 300,000 people in Bugisu and Teso sub-regions. Additionally, in May 2013, River Nyamwamba in Kasese burst its banks to a heavy flood that led to death of 8 people, displacement of 9,663 others and a destruction of 700 acres of food crops – contributing to people's vulnerability in terms of food insecurity (URCS, 2014).

The flooding of River Nyamwamba is attributed to heavy rains in the months of April, May, September and October. A study by (DWRM, 2015) explains that these rains in the 72.4 km^2 Nyamwamba catchment area lead to a high deposition rate in the river and an additional sediment transport capacity in terms of boulders, cobbles and silt of over 1,000,000 tons per year. These depositions have affected the river's hydrological carriage capacity to high volumes of flow during heavy rains and rapid snowmelts from the Rwenzori Mountains.

Currently, the floods are also escaladed by the rapid population growth with marginal land for developmental use in Kasese district leading to encroachment of the river through poor environmental and agricultural practices. According to (Rwakakamba, 2009), these practices have exposed people to geological and seismic related hazards through infrastructural development in gazetted river banks and flood areas. They create river bank failures that are easily washed away when the river swells with increase in its hydraulic flow.

The Ministry of Water and Environment of the Government of Uganda proposed an action plan for river Nyamwamba floods, with clear immediate and long term management strategies

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