



**BUSITEMA  
UNIVERSITY**  
*Pursuing Excellence*

**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<sup>1</sup>**

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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.



30<sup>th</sup> May 2018

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**MR. MARTIN OKIRYA**  
**CO-SUPERVISOR**

## Dedication

This Final Year Project Report is a special dedication to Mwesigye Jimreeves, Emolu Nathan and Asimwe Democious – the 3 fallen Busitema University students to a drowning accident on March 25<sup>th</sup>, 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.

## Acknowledgement

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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I would also like to extend my special thanks to my parents; Maj. R.B. Mutabazi and Ms. F. Ninsiima and to my siblings for their endless love, support and tolerance for all my years of education.

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## Contents

Abstract.....	i
Declaration.....	ii
Approval.....	iii
Dedication.....	iv
Acknowledgement.....	v
List of Acronyms and Symbols.....	x
List of Figures.....	xi
List of Tables.....	xii
List of Equations.....	xiii
List of Appendices.....	xiv
1.0 INTRODUCTION.....	1
1.1 Preamble.....	1
1.2 Background.....	1
1.3 Problem Statement.....	2
1.4 Justification.....	3
1.5 Objectives of the Study.....	3
1.5.1 Main Objective.....	3
1.5.2 Specific Objectives.....	3
1.6 Scope of the Study.....	3
2.0 LITERATURE REVIEW.....	4
2.1 Preamble.....	4
2.2 Floods.....	4
2.3 A Review of River Nyamwamba Floods.....	4
2.3.1 Formation History of River Nyamwamba.....	5
2.3.2 Flow Hydrology and Sediment Transport.....	5
2.3.3 Flooding of the River.....	5
2.4 Types of Floods.....	6
2.4.1 Fluvial Flooding.....	6
2.4.2 Coastal and Lake Flooding.....	7
2.4.3 Pluvial Flooding.....	7
2.5 Effects of Floods.....	8

2.5.1 Positive Effects of Floods.....	8
2.5.2 Negative Effects of Floods .....	8
2.6 Mitigation of Floods .....	9
2.6.1 Structural Mitigation Measures.....	9
2.6.2 Non-Structural Mitigation Measures.....	11
2.7 Flood Warning Systems .....	12
2.7.1 Benefits of a Flood Warning System .....	12
2.7.2 Key Elements of a Flood Warning System .....	12
2.7.3 Basic Operation of a Flood Warning System.....	13
2.8 Application of Embedded Systems in Flood Warning.....	14
2.9 Instrumentation in Embedded Systems.....	14
2.9.1 Ultra-sonic Sensors .....	15
2.9.2 LCD Screens.....	15
2.9.3 GSM Modules.....	16
2.9.4 Buzzers .....	17
2.10 Reliability of Embedded Systems in the development of FWSs .....	17
2.10.1 Building an Adaptive and Resilient Sensory Input .....	17
2.10.2 Supporting Local Computation .....	18
3.0 METHODOLOGY.....	19
3.1 Preamble .....	19
3.2 Project Area.....	19
3.3 Specific Objective I – ‘Reviewing the Hydrological and Hydraulic Studies of River Nyamwamba’ .....	19
3.3.1 Materials, Equipment and Software in Field Research .....	19
3.3.2 Methods of Data Collection.....	19
3.3.3 Datasets used in Hydrological and Hydraulic modelling of the river.....	20
3.4 Steps used in reviewing the river data .....	20
3.4.1 Extraction of the Flood River Map.....	21
3.4.2 Computation of the Flood Map with the river flow data.....	24
3.4.3 Performance of the Flood Frequency Analysis .....	24
3.5 Specific Objective II – ‘Designing a Flood-Warning System using the River Data’.....	25
3.5.1 Design description.....	25
3.5.2 System Flowchart.....	27
3.6 Specific Objective III – ‘Construction and Testing of the Flood-Warning System prototype.’.....	28



3.6.1 Hardware Components used .....	28
3.6.2 Construction of the System.....	28
3.6.3 Testing of the System.....	29
3.7 Specific Objective IV – ‘Cost-Benefit Analysis of the Prototype in the Study Area.’ .....	29
3.7.1 Procedure of Analysis.....	29
3.7.2 Treatment of results .....	30
4.0 RESULTS, DISCUSSIONS AND PROTOTYPE DESIGN .....	31
4.1 Preamble .....	31
4.2 Specific Objective I – ‘Reviewing the hydrological and hydraulic studies of River Nyamwamba’ .....	31
4.2.1 Collection and Analysis of Hydrological data .....	31
4.2.2 Collection and Analysis of Hydraulic data .....	32
4.2.3 Selection of the Digital Elevation Model (DEM) .....	34
4.2.4 HEC-RAS Model Setup, Inputs and Results .....	34
4.2.5 RAS-GIS Import Process and Flood Delineation .....	37
4.2.6 Data Preparation for Flood Frequency Analysis .....	39
4.2.6 Gumbel Estimation of 10-Year and 100-Year Flood Events .....	41
4.2.7 Graphical Representation of the predicted 10-Year and 100-Year Nyamwamba Floods.....	43
4.3 Specific Objective 2 - ‘Designing a Flood-Warning system using the River data’ .....	44
4.3.1 Selection of Prototype Water levels from Actual River Stage values .....	44
4.3.2 Microcontroller Programming in ARDUINO.....	45
4.3.3 System Circuit diagram .....	45
4.4 Specific Objective 3 - ‘Construction and Testing of the flood-warning system Prototype’ .....	46
4.4.1 Selection of Components and Construction of the FWS Prototype .....	46
4.4.2 Testing of the System.....	48
4.5 Specific Objective 4 - ‘Cost-Benefit Analysis of the Prototype in the Study Area.’ .....	50
4.5.1 Profitability Index (P.I) method of Cost-Benefit analysis .....	50
4.5.2 Calculation of the Initial costs of Operation. ....	50
4.5.3 Estimation of Annual Outflow Costs .....	51
4.5.4 Estimation of Annual Inflow costs .....	51
4.5.5 Calculation of the NPV at 15 years.....	52
4.5.6 Cost-Benefit Analysis of the Prototype.....	54
5.0 CONCLUSION, CHALLENGES AND RECOMMENDATIONS.....	55
5.1 Preamble.....	55

5.2 Conclusion.....	55
5.3 Challenges .....	55
5.4 Recommendations .....	56
Works Cited.....	57
APPENDIX .....	59

## 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

## List of Figures

FIGURE 1.1 - The Catchment Area of River Nyamwamba as an extract from the map of Uganda .....	2
FIGURE 2.1 - Boulders and Cobblers in the aftermath of the 2013 Nyamwamba Flood.....	5
FIGURE 2.2 - Flood damage to Infrastructure [showing a Highway washout].....	9
FIGURE 2.3 - Illustration of a Flood Levee.....	10
FIGURE 2.4 - Key Elements of a Flood-Warning System .....	13
FIGURE 2.5 - An ATMEGA Microcontroller used in Embedded Systems’ designs .....	14
FIGURE 2.6 -An LCD screen used to display microcontroller output data .....	15
FIGURE 2.7 - A GSM module used to send electronic output messages .....	16
FIGURE 2.8 - A buzzer used to make a sound output / alarm at Flood Level .....	17
FIGURE 3.1 - Steps in reviewing Hydrological and Hydraulic River data .....	21
FIGURE 3.2 - The Process of extracting a Flood River Map.....	21
FIGURE 3.3 – A Flow Chart for the Flood Plain Delineation Process in ArcGIS and HEC-RAS Programs.....	23
FIGURE 3.4 - The Flood Frequency Analysis Procedure in the HEC-SSP Program.....	25
FIGURE 3.5 - System Block diagram of the FWS Components.....	26
FIGURE 3.6 - System Flow Chart of the working FWS.....	27
FIGURE 4.1 - A Cumulative Mass Curve for Kasese Rainfall data.....	32
FIGURE 4.2 - A HEC-RAS representation of River Nyamwamba Geometric data .....	34
FIGURE 4.3 - An X-Y-Z Perspective plot showing the 3D view of River Nyamwamba.....	35
FIGURE 4.4 - A Cross Section across the upstream banks of River Nyamwamba.....	35
FIGURE 4.5 - The Profile Plot of River Nyamwamba .....	36
FIGURE 4.6 - A general Plot showing the velocities of Flow along the river.....	36
FIGURE 4.7 - The Rating curve of water Flow along the River .....	37
FIGURE 4.8 - The Bonding Polygon for the modelled area along River Nyamwamba in ArcGIS .....	37
FIGURE 4.9 - River Nyamwamba Geometric data laid on the TIN .....	38
FIGURE 4.10 - Delineated flood plains along River Nyamwamba.....	38
FIGURE 4.11 - A Graph of Annual Peak Flows of River Nyamwamba against Days of Peak Flows .....	39
FIGURE 4.12 – Graphical Flood Frequency Analysis of River Nyamwamba [100-Year Flood] .....	43
FIGURE 4.13 - The System Circuit diagram .....	46

## List of Tables

TABLE 2.1 - Differences between Urban Flooding and Riverine Flooding .....	8
TABLE 3.1 - Hydrological and Spatial Datasets sources .....	20
TABLE 3.2 - HEC-RAS Model inputs and outputs .....	22
TABLE 3.3 - Output units and modes of the FWS design .....	26
TABLE 3.4 - Precaution notices and output units at different Threshold levels .....	26
Table 4.1 - Annual Precipitation Totals [in mm] of Kasese District, 1985-2016 .....	31
TABLE 4.2 - Annual Peak Discharges of River Nyamwamba .....	33
TABLE 4.3 - An analysis of the River Nyamwamba Flow discharge data .....	40
TABLE 4.4 - Computation of model Threshold levels to Actual river stages.....	44
TABLE 4.5 - Initial Costs of installation of the FWS prototype .....	50
TABLE 4.6 - Annual costs of operation of the FWS .....	51
TABLE 4.7 - Destruction extent of Property in the 2013 Nyamwamba Flood .....	52
TABLE 4.8 – Computation of Total Annual Operation Expenses throughout the FWS design life .....	53

## List of Equations

EQUATION 2.1 - Design Risk of a Flooding Event.....	4
EQUATION 2.2 - Return Period of a Flooding Event .....	4
EQUATION 2.1 - Benefit of a FWS .....	12
EQUATION 3.1 - Computation of Prototype water levels.....	28
EQUATION 3.2 - Profitability Index of a Project.....	29
EQUATION 3.3 - Net Present Value of an Implemented Project at time, t.....	30
EQUATION 4.1 - Estimation of River discharges from another reference river.....	33
EQUATION 4.2 - Computation ratio of River Nyamwamba to River Mobuku Flow discharges.....	33
EQUATION 4.3 - Estimation of the Peak Discharge at return period, T.....	41
EQUATION 4.4 - Integration variable of the return period, T.....	41
EQUATION 4.5 - Gumbel constant, q of the Standard Deviation.....	41
EQUATION 4.6 - Gumbel constant, w of the Mean .....	41

## List of Appendices

APPENDIX A-1 - Monthly Rainfall Data of Kasese District, 1985-2016 .....	59
APPENDIX A-2 - System Coding in the ARDUINO Programming language .....	60
APPENDIX A-3 - Pictorial of the Prototype Testing process.....	63

## 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<sup>2</sup> 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 escalated 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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