



**BUSITEMA
UNIVERSITY**
Pursuing Excellence

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF WATER RESOURCES AND MINING ENGINEERING

**DEVELOPMENT OF A HYBRID FLOOD FORECASTING MODEL TO
INFORM INTERVENTION**

BY

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ABSTRACT

The Mpanga Catchment in Western Uganda is increasingly prone to flooding, driven by rapid land use/land cover (LULC) changes and the growing impacts of climate variability. This study assessed historical and projected flood risks by evaluating how LULC dynamics and climate change scenarios influence stream flow, flood hazard, vulnerability, and overall risk. Historical LULC data (1990–2020) were analyzed and projected to 2090 using QGIS-MOLUSCE with Artificial Neural Networks (ANN). Climate projections under RCP4.5 and RCP8.5 were generated using the Statistical Downscaling Model (SDSM), with precipitation and temperature projections serving as key inputs for hydrologic simulations in HEC-HMS. The model was calibrated and validated using observed data (1990–2020), producing strong performance metrics (NSE = 0.699 for calibration, NSE = 0.658 for validation). Rainfall-runoff modeling with the SCS-CN method revealed significant changes in discharge across return periods. The 50-year return period discharge increased from 538 m³/s (historical) to 41,292 m³/s (projected in 2090 under RCP4.5), while the 10,000-year discharge surged from 1,997 m³/s to over 1,090,801 m³/s under RCP8.5. These increases were strongly correlated with projected rises in rainfall intensity and temperature fluctuations. LULC transitions, particularly deforestation and urban expansion, were shown to amplify surface runoff and reduce infiltration, with cropland increasing by over 10% and forest cover declining by 7% between 1990 and 2020. Flood hazard maps created using HEC-RAS 6.4.1 showed flood depths increasing by up to 0.9 meters for the 50-year return period, and projected inundation areas for the 10,000-year return period reaching over 210 million ft² more than five times the historical extent. Vulnerability mapping through Analytical Hierarchy Process (AHP) revealed that proximity to rivers (weight = 0.40), LULC (0.23), and elevation (0.15) were the most critical factors contributing to flood susceptibility. Risk mapping demonstrated that the highest flood risk is projected for the year 2070, especially under the combined influence of LULC changes and high-emission climate scenarios (RCP8.5). This study provides robust, data-driven evidence that future flood risk in the Mpanga Catchment will intensify significantly under current land use and emission trajectories. The combined effects of deforestation, agricultural expansion, and climate change will not only elevate flood magnitudes but also expand hazard zones and deepen community vulnerability. Immediate action is needed to implement integrated flood risk management strategies that incorporate sustainable land use planning, ecosystem conservation, and climate adaptation to mitigate these looming threats.

DECLARATION

I **MUWANGUZI ELIJA** declare that the work in this final report is my original work and has not been presented to any higher institution of learning for any academic award.

NAME: MUWANGUZI ELIJA

SIGNATURE:

A handwritten signature in blue ink, appearing to be 'Muwanguzi Elija', is written on a light-colored, textured surface. The signature is fluid and cursive, with the first letter 'M' being particularly large and stylized.

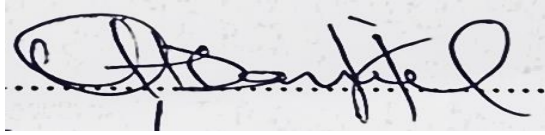
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APPROVAL

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LIST OF ACRONYMS

UNDRR- United Nations Disaster and Risk Reduction

KDDMC- Kabarole District Disaster Management Committee

MWE- Ministry of Water and Environment

NEMA- National Environmental Management Authority

HEC - RAS - Hydrological Engineering Centre's River Analysis System

DEM - Digital Elevation Model

MCDA - Multi Criteria Decision Analysis

AHP - Analytical Hierarchy Process

GIS - Geographic Information System.

DWRM - Directorate of Water Resources Management

UNMA - Uganda National Meteorological Authority

UBOS - The Uganda Bureau of Statistics

MAAIF - Minister of Agriculture, Animal Industry, and Fisheries

SME - Spatial Environmental Modelling

CRCCH - Cooperative Research Center for Catchment Hydrology

SCS-CN - Soil Conservation Service Curve Number

NASA - National Aeronautics and Space Administration

LULCC - Land use Land Cover Change

SDSM - Statistical Down Scaling Model

TOPSIS - Technique for Order Preference by Similarity to Ideal Solution

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