**INTRODUCTION**

**Background**

According to the World Health Organization (WHO), floods are the most frequent type of natural disaster and occur when an overflow of water submerges land that is usually dry. A flood is essentially the accumulation of water over normally dry land. There are 3 common types of floods, namely flash floods, coastal floods and river floods. Flash floods are caused by rapid and excessive rainfall that raises water heights quickly, and rivers, streams, channels or roads may be overtaken. River floods, on the other hand, are caused when consistent rain or snow melt forces a river to exceed capacity whereas coastal floods are caused by storm surges associated with tropical cyclones and tsunami.

Often, the inappropriate ways in which waterways are managed, coupled with the alterations that are made to land play a significant a role in flooding. Increasingly, flooding factors are also linked to climate change. Floods can cause widespread devastation, resulting in loss of life and damages to personal property and critical public health infrastructure. Between 1998-2017, floods affected more than 2 billion people worldwide. People who live in floodplains or non-resistant buildings are mostly affected by floods. Furthermore, areas which lack warning systems and awareness of flooding hazard, are most vulnerable to floods.

**Flooding Situation in Kampala**

In Africa, the city of Kampala in Uganda with a current population of 3.5 million people, is one of the urban areas that face frequent flash flooding events in each rain season. This is mainly due to unregulated urban development in the flood prone areas, climate change, and poor management of drainage system and solid waste ([Douglas et al., 2008;](#_bookmark117) [Sliuzas, 2012](#_bookmark149)). These flooding events have caused significant damage to infrastructure, loss of life, environmental destruction and disruption to economic activities.

Flooding in Kampala is significant due to several reasons:

* Public Safety: The recurrent floods pose a direct risk to human life, particularly in informal settlements.
* Economic Disruption: Floods damage roads, homes, and businesses, leading to significant economic losses.
* Health Risks: Floodwaters often carry pollutants and lead to outbreaks of waterborne diseases like cholera.
* Urban Planning Challenges: The lack of an effective drainage system and uncontrolled urbanization exacerbate the flood risk.

**Existing Flood Control Methods and Limitations**

Currently, the following approaches are employed to address the flooding problem in Kampala:

* Manual Observation and Data Collection: Local meteorological departments and disaster management authorities rely on rainfall data collected from weather stations. However, this method is limited by its lack of real-time data, accuracy, and coverage.
* Community-Based Early Warning: Local communities in flood-prone areas sometimes use traditional knowledge to predict flooding based on weather patterns. While useful, this approach is informal, lacks scientific precision, and is not always reliable.
* Drainage Improvement Projects: Kampala Capital City Authority (KCCA) has implemented drainage improvement projects to reduce the likelihood of flooding. However, these measures address only long-term infrastructural issues and do not provide early warnings.
* Satellite Imagery and Remote Sensing: Some projects use satellite data and Geographic Information Systems (GIS) to map flood-prone areas. While promising, these systems are expensive and rely heavily on data processing, which may delay warnings.

Due to the ineffectiveness of the above-mentioned methods, there is a pressing need for a robust Flood Early Warning System (FEWS) that can predict, monitor, and respond to potential flood events in real-time, providing timely information to vulnerable communities and authorities. The implementation of an effective FEWS will also play a pivotal role in safeguarding the city's population, infrastructure, and economy.

**Contribution to Engineering**

The design of a Flood Early Warning System (FEWS) for Kampala would significantly contribute to the field of engineering by combining multiple disciplines such as hydrological modeling and data analysis. The system would utilize open-source data to integrate real-time rainfall and water level monitoring with predictive models, using machine learning algorithms to predict flood events.

This approach would advance the field in the following ways:

* Improved Infrastructure Planning: Engineers could design more flood-resilient infrastructure based on predictive flood data.
* Innovative Use of Technology: Leveraging IoT sensors and machine learning would demonstrate how modern technologies can enhance traditional civil engineering solutions.
* Data-Driven Decision-Making: Real-time data will allow city authorities to make informed decisions and allocate resources effectively during flood emergencies.
* Timely Alerts: Communities can be warned of impending floods, allowing residents to evacuate to safer areas, reducing casualties.
* Minimized Property Damage: Businesses, homes, and public infrastructure can be better protected by allowing sufficient time to implement flood defenses or move assets to safer locations.
* Mitigate Health Risks: Early warnings would help in managing the risk of waterborne diseases by preventing exposure to contaminated water.

<https://www.who.int/health-topics/floods#tab=tab_1>

<https://www.nrdc.org/stories/flooding-and-climate-change-everything-you-need-know#facts>

<https://essay.utwente.nl/84728/1/mhonda.pdf>

<https://www.weforum.org/agenda/2024/07/early-warning-systems-parametric-insurance-climate-resilience-africa/>