**IMPACT OF FLOOD WARNING SYSTEM IN OUR SOCIETY**

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**(ST/CS/ND/20/235)**

**A SEMINAR REPRESENTED TO THE DEPARTMENT OF COMPUTER SCIENCE, SCHOOL OF SCIENCE AND TECHNOLOGY, FEDERAL POLYTECHNIC MUBI, ADAMAWA STATE, NIGERIA**

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**Abstract**

*Flood early warning systems play a major role in the disaster risk reduction paradigm as cost-effective methods to mitigate flood disaster damage. The connections and feedbacks between the hydrological and social spheres of early warning systems are increasingly being considered as key aspects for successful flood mitigation. The behavior of the public and first responders during flood situations, determined by their preparedness, is heavily influenced by many behavioral traits such as perceived benefits, risk awareness, or even denial. In this study we use the recency of flood experiences as a proxy for social preparedness to assess its impact on the efficiency of flood early warning systems through a simple stylized model and implemented this model using a simple mathematical description. The main findings, which are based on synthetic data, point to the importance of social preparedness for flood loss mitigation, especially in circumstances where the technical forecasting and warning capabilities are limited. Furthermore, we found that efforts to promote and preserve social preparedness may help to reduce disaster-induced losses by almost one half.*

**Keyword**: Flood Warning System, Monitoring, Telemetry, Disaster.

**Introduction**

The continuous and persistent increase in the occurrence of disasters poses a substantive danger to the achievement of both sustainable development and poverty reduction initiatives (United Nations Office for Disaster Risks Reduction [UNISDR], 2009). Among disaster events that have gained significant attention in recent times are those caused by floods. Flood hazard is a vicious threat, rather than a natural occurrence when humans interfere with flood plains. On the global scale, flood disaster is phenomenal. According to the United Nations Regional Coordinator in Dakar (October 2007) the worst flooding in 30 years that battered West Africa from July 2007 caused more than 210 death and affected more than 785,000 people (Arias et al., 2015).

The aftermaths of flood disasters are the large-scale destruction of infrastructure, displacement of people from their dwellings, the loss of human lives, outbreak of diseases, huge loss of investments among other things as the government and disaster management agencies tend to focus on disaster relief activities after disaster occurrences (Cools et al., 2016).

Dutta et al. (2015), stated that floods cannot be prevented but their devastating effects can be minimized if advance warning of the event is available. With the large increase in population and increasing urbanization (mainly driven by poverty), there are more people living in informal settlements, which are often on flood plains as this is the only undeveloped land available near cities. The people living in these settlements are those who are most at risk, not only due to their geographical location in the floodplain but also because they do not have the financial resources to recover from the damage caused by flooding. Early warning information can, therefore, allow the disaster managers to take steps which may significantly reduce the loss of life and damage to property.

While some areas are more prone to flooding than others, the establishment of flood warning systems near any major waterway or body of water provides critical information that can protect property and save lives. Of course, the most effective flood warning methods extend beyond the installation of gages and telemetry equipment, and employ qualified staff and carefully designed procedures to provide the earliest warning about whether a flood should be expected, when it will occur, and how severe it will be. This guide offers instruction to individuals, communities, and organizations interested in establishing and operating flood warning systems. When it comes to the installation and maintenance of gages, sensors, and other equipment, Fondriest Environmental can help you through every step of the process (Arias et al., 2015).

**Literature Review**

People or dwellers within disaster prone areas have a great responsibility during times of disasters in their vicinity which leads to the involvement in all to ensure the safety of people and the rescue of victims. Early warning system is one way to ensure people are informed prior to disasters occurrence to better manage various disasters including flooding. In his survey on the effectiveness of early warning systems for disaster management in Kinondoni municipality in Tanzania, it was revealed that though people may be affected with disasters like flooding, they are unwilling to move from their residence to other places without any genuine reasons such as pre-warning from significant authorities (Liu, Guo, Ye, Zhang, Zhao, & Song, 2018).

There have been varying mechanisms that have been employed in different countries for early warning systems and various ways have been adopted to communicate risk and help people reduce risk and injury during a disaster within their locality. Arias et al. (2015) in their experiments in Malaysia on a miniaturized water flow and monitoring system which gives information about water level with the help of a sensor showed that, effective deployment of this early warning system will give enough information on water flow rate as well as water rise level which will help reduce casualties arising from flood disasters in the country. Proper communication procedures and the involvement of varying forms of communication channels to risk population was found to be an effective way if warning is given with at least ten days of lead time with action to reduce damage due to flood (Zahmatkesh et al., 2019).

## Usefulness of Early Warning Systems on Flood Disaster Management

There has been a pressing need for the implementation of early warning systems in order to mitigate the damages caused by these disasters over the years across the world. The World Meteorological organization in 2015 showed there is the need for impact-based forecasting and warnings to improve early warning that will yield better forecasting that predicted consequences of hazards for different groups in various sectors for better management. The negative impact of flood disasters has decreased drastically due to the presence of early warning systems which helped vulnerable populations to take actions before the damage could be caused (Cools et al., 2016).

## Challenges Associated with Early Warning Systems

Early warning systems implementation is found to be one of the most effective ways to reduce damage caused by disaster including loss of life, properties, farmlands and vegetative cover which is source of habitat for humans. In recent years, several countries (including China, Malaysia and European countries) have adopted the use of early warning signs for disaster management to improve on the living condition of citizens (Liu et al., 2018). There are however, certain challenges that are faced with early warning implementation as shown in various studies conducted in the areas where the early warning system for disaster management is implemented.

Another big challenge of early warning system is the changes caused by geological factors. Different geographical areas experience different hydraulic conditions which implies that, different warnings should be prepared for the different groups in the community based on their level of hydraulic experience or risk level (Liu et al., 2018).

The lack of technical skills, manpower, resources and the unwillingness for people to engage in volunteering activities for early warning and disaster management activities is a major problem faced by implementers of early warning system as posited by (Liu et al., 2018).

Another major challenge with early warning system is the tendency of the people to decrease their preparedness level after they have experienced the disaster according to Cools et al. (2016). Smith, Brown and Dugar (2017) showed that, there is a higher likelihood to have a high awareness or preparedness level after a few weeks following the experience of a disaster however, many people tend to fade their preparedness level away with time. Implementing warning system without the involvement of community may be ineffective because community members do not fully understand or know what actions to take if the warning in given (Smith et al., 2017).

**A Real-Time Solution**

An effective flood warning system should be based on the regular collection of local rainfall, stream level, and streamflow data. This can be done through routine monitoring, in which operating personnel make visits to stream gage and precipitation measuring sites, but a real-time monitoring system with telemetry can make data collection easier and, in many cases,, more cost-effective while allowing for the fastest possible response to a flood event. The NWS acknowledges that, even in areas where they provide flood warning coverage, a real-time, community-oriented flood warning system can reduce risks involved with flooding (Soille et al., 2016).

The NWS forecasts floods using complex mathematical models that predict how rivers and streams across the U.S. will respond to varying levels of rainfall and snowmelt. These models are based on records of stream stage and discharge, the calculations for which are outlined below. If you are interested in developing a responsive flood warning system without advanced forecasting capabilities, however, you can likely get by with a system based on Automated Local Evaluation in Real Time, or ALERT gages (Thorndahl, Einfalt, Willems, Nielsen, Molnar, 2017).

**Automated Flood Warning System**

Developing a flood warning system requires attention to three basic factors: Data collection via gaging, data processing, and the hardware and software required, and the dissemination of flood warning information. While automated flood warning systems are often surprisingly inexpensive to implement, the primary factor determining cost for any such system is the number of gage site locations. Additionally, the type of communications and telemetry capabilities at each site will contribute to costs (Thorndahl et al., 2017).

**ALERT Gages**

There are a wide variety of automated stream gages that can transmit stream level data via telemetry, but gages developed according to the NWS ALERT protocol are among the most common and will be the focus of this guide. However, it’s worth noting that many other gages designed to measure precipitation and water level operate under similar principles, and this guide may be applicable to certain aspects of other systems. ALERT systems have the advantage of operating under a common standard of communications criteria, so although a wide array of manufacturers develop and produce ALERT hardware and software, most of those products are cross-compatible. ALERT gages perform two primary tasks: sensing and communicating. An ALERT gage employs sensor to detect changes to a certain parameter, usually precipitation volume and/or water level. More advances gages may also be equipped with temperature and wind speed sensors. Some ALERT gages can also provide site-specific information, or information regarding the health of the unit (Smith et al., 2016).

**Data Processing**

The software used to collect and process data from ALERT gages will vary based on the user’s needs and preferences. Many ALERT gage manufacturers offer their own proprietary software to view data remotely, whether in a graphical or text format. The most useful ALERT processing software will permit multiple users to access the data simultaneously, and for multiple gages to be monitored at once (Smith et al., 2016).

**Information Dissemination**

Automated flood warning systems may utilize radio, cellular, or satellite telemetry to communicate with a host computer or network, but ALERT systems specifically operate using radio frequencies. Because of this, ALERT systems can suffer from some of the same issues as any other radio transmission device, including interference from electrical noise and atmospheric conditions. Interference may also occur if several ALERT systems operating in a close vicinity transmit simultaneously. Satellite and cellular telemetry tend to avoid these problems, but still require some consideration to site selection in order to maximize transmission quality. Automated flood warning systems of all sorts will also require a power supply. While gages installed near developed communities may be powered by connection with a commercial power grid, those located in remote areas generally rely on a combination of battery and solar power to run their telemetry devices (Wallemacq & House, 2018).

**Streamflow Measurements**

While streams and rivers may be monitored for many qualities and parameters that they share with lakes, ponds and basins, they possess one quality that sets them apart from other freshwater bodies: movement. Streamflow is a keystone parameter that impacts many other aspects of a river’s hydrology and water quality. Although these other aspects may be just as vital to a river’s health or just as applicable to your particular project they may be shared with other types of water bodies, and in many cases will be covered in other chapters. For this reason, this chapter will focus primarily on establishing streamflow through stage discharge measurement (Yu, Nakakita, Kim, Yamaguchi, 2018).

**Typical Flood Warning System**

As discussed above, there are a number of ways to configure an automated flood warning system, but the needs of one system can differ widely from another. The number of gage sites, their locations, and the instruments and sensors used at each will vary based on the nature of your application and the size of the intended coverage area. If your warning system is intended to service an entire community, the number of gages necessary will depend on the location of nearby water bodies in relation to property and infrastructure. If only a small portion of your community is exposed to a jutting stretch of river, for instance, one gage may be sufficient (Yu et al., 2018).

In a single-gage system, installing a station on a riverbank or standing structure, such as a pier or bridge support, will likely provide the best results. Gages can also be built into stilling wells or standpipes, making it easier to include other instruments, such as multi-parameter sondes equipped with an array of sensors, as well as data loggers and telemetry systems. While radio transmission is the standard telemetry option for ALERT-based systems, satellite and cellular options may be more beneficial to your application, depending on its size and location. Nearly all telemetry options will provide continuous real-time data to any computer or mobile device, ensuring that your system runs smoothly, and any control measures or emergency actions can be implemented immediately if parameter limits are exceeded (Yu et al., 2018).

**Tipping Bucket Rain Gauge**

Consisting of a funnel and a small container affixed to a tipping lever, rain gauges collect a set amount of precipitation before the container tips, dumping out any collected water and sending an electrical signal to a data transmitter (Liu et al., 2018).

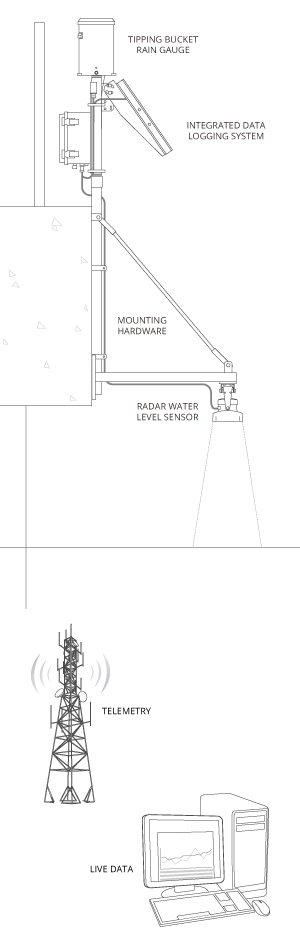


Figure 1: Tipping Bucket Rain Gauge

**Integrated Data Logging System**

An integrated data logging system is a real-time monitoring station that houses the data logger, telemetry module, and power/charging supply. Since it is generally cost-prohibitive to run AC power to the monitoring location, integrated solar panels are used to continuously charge the 12VDC battery for autonomous operation (Yu et al., 2018).

**Radar Water Level Sensor**

Water level sensors using radar technology provide a non-contact alternative to other level gauging methods such as submersible pressure transducers, allowing for monitoring in hard to reach locations (Yu et al., 2018).

**Telemetry**

Telemetry provides access to data in real time. ALERT transmits wireless communications via radio frequencies, but cellular and satellite-based options are also available.

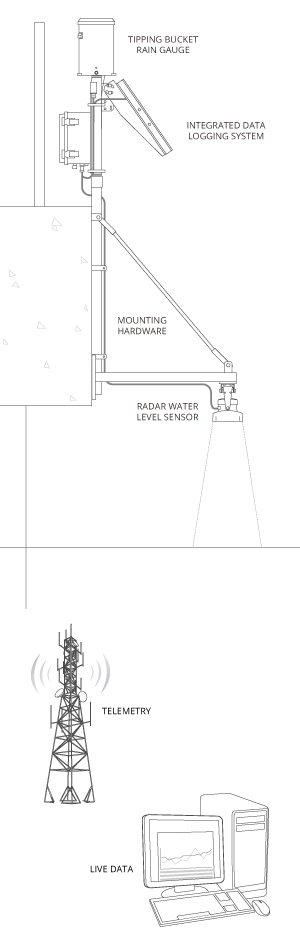


Figure 2: Telemetry

**Conclusion**

Flood warning Systems are recognized as crucial tool to estimate the flood disaster risks and to mitigate the impacts of floods. As their core functions include data acquisition, processing, visualization, and transmission, they are expected to collect necessary data from various platforms such as ground, satellite, and NWP models and integrate them to produce superior products with lesser biases, use hydrological/hydrodynamic models to covert those data into useful risk-related products such as water levels and inundation distributions, and transfer these products to end-users through various communication channels. At the same time, all the above limitations effectively reflect the gaps of our current knowledge on Flood warning Systems, which may not be addressed at once, but could form an agenda for action in this specific domain for the future.

**Recommendations**

To improve the global knowledge on Flood warning Systems status and progress, the following recommendations are put forward.

1. The paper recommends that an Investments made into development of all components of Flood Early Warning Systems need to be better coordinated globally and better reported. Standard ways of reporting on Flood Early Warning Systems investments as well as on the benefits, including avoided losses, of Flood Early Warning Systems need to be developed.
2. Also, recommends that an enhanced community support to Flood Early Warning Systems needs to be ensured by including social awareness programs, regular post-disaster feedback surveys from target communities and provision of community-tailored response and evacuation plans.

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