Keureuto Dam Operation for Flood Control System

Variadi Variadi1*, Iqbal Khairul2, and Mufti Fajarullah1, Adriman Ramzi3
1Association of Sumatera Water Region I, Ministry of Public Work and Housing, Indonesia
2Civil Engineering Departemen, Universitas Syiah Kuala, Indonesia
3Electrical Engineering Departemen, Universitas Syiah Kuala, Indonesia

Abstract. Floods are one of the most destructive natural disasters. Dams are engineered structures built across rivers and streams to control water flow, primarily for purposes like water supply, hydroelectric power generation, and flood control. In the modern era, technological advancements and an enhanced understanding of hydrology have transformed dam operations within flood warning systems. Early warning systems for floods are founded on the principle of forecasting and alerting communities and authorities about imminent flood events. Keureuto Dam has multi-purpose benefits including to reduce flooding. The planned system includes sensors that record hydrological data (ARR and AWLR), equipment that receives the data recorded as well as a transmitter network from the sensors to the data center. in the Keureuto watershed, three AWLRs are planned to be installed upstream of the dam, one at the dam, seven AWLRs downstream of the dam. data from upstream is sent using a radio network, while from upstream it uses a cellular network. with a data center located at the dam.

1. Background

Floods are one of the most destructive natural disasters, causing loss of life, extensive property damage, and disruption of communities. As a result, flood warning systems have become essential tools for mitigating these disasters. Within these systems, the operation of dams plays a pivotal role in managing water levels and minimizing flood risks [1].

Dams are engineered structures built across rivers and streams to control water flow, primarily for purposes like water supply, hydroelectric power generation, and flood control. In the context of flood warning systems, dam operations are crucial for several reasons [2].

The operation of dams within the context of flood warning systems relies on a set of fundamental principles. These principles are designed to balance the objectives of flood control, water resource management, and infrastructure safety [3].

* Corresponding author: khairuliqbal@usk.ac.id

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In the modern era, technological advancements and an enhanced understanding of hydrology have transformed dam operations within flood warning systems. These innovations have significantly improved the precision and effectiveness of managing water resources and flood control [4]. This innovation of Flood Early Warning System including remote sensing and monitoring [5], [6], computer modelling [7]–[9], integration with flood warning system [4], [10], [11] public awareness initiative [12], [13] and climate change adaptation [1], [4], [10], [14].

The construction of the Keureuto Dam has multi-purpose benefits, because its existence is very necessary in North Aceh as a reservoir to reduce flooding which always occurs in the rainy season. This dam also functions to provide raw water and irrigation water supply as well as for hydropower, so it can increase economy in North Aceh Regency [15] [16].

2. Flood and Early Warning System

Early warning systems for floods are founded on the principle of forecasting and alerting communities and authorities about imminent flood events. These systems encompass a complex network of technologies, data sources, and communication channels that work together to provide timely and accurate information. The primary components of flood early warning systems include:

- **Meteorological and Hydrological Monitoring:** Real-time monitoring of weather conditions, river levels, rainfall, and soil moisture is fundamental. Data from weather stations, river gauges, and remote sensing satellites are crucial for predicting and tracking flood events.
- **Hydrological Models:** Advanced hydrological models simulate the behavior of rivers and watersheds, enabling forecasters to predict how rainfall and runoff will affect water levels. These models help in generating flood forecasts.
- **Communication Infrastructure:** Efficient communication is vital for transmitting warnings to at-risk communities and authorities. This can include everything from sirens and public address systems to mobile apps and text messages.
- **Community Engagement:** Public education and community involvement are essential aspects of flood early warning systems. Ensuring that people understand the risks and know how to respond to warnings is critical for saving lives.

The early warning system mainly consists of four elements: (1) Risk Knowledge, (2) Monitoring and Warning Services, (2) Dissemination and (4) Communication and Response Capabilities, as in the following diagram:
3. Hydrology

This hydrological study was carried out to identify river basins along Krueng Keureuto from upstream to downstream. This initial identification needs to be carried out as a basis for consideration in determining the prospective location for the AWLR (Automatic Water Level Recorder) Keureuto Dam.

3.1. Watershed identifications

The Keureuto River has a length of 51.38 km and a watershed area of 792 km². The geometric condition of the Krueng Keureuto River downstream is a low-lying area which has a relatively small storage capacity compared to the discharge that flows. In this river there are sharp turns and there is also meandering [16].
Fig. 2. Keureuto Catchment Area

The downstream Krueng CA-25 (Alur Tingkeup), CA-26 (Krueng Kreh), and CA-27 (Krueng Pirak) appear to have an area of more than 50 km$^2$, which suggests that they make a sizable contribution to river runoff. This location has the potential to be used as an AWLR location in the upstream sections of the river that require serious attention, specifically CA-3 (Lingga Channel), CA-8, and CA-11, as well as in the downstream portions.

From Figure 2, we get an initial picture that CA-1 to CA-13 are in the upstream of the Keureuto River, while the rest (CA-14 to CA_32) are downstream. The catchment area parameters above are only applied to large tributaries that have the potential for flooding, as explained at the beginning.

3.2. Design Rainfall

In general, Figure 3 shows the location of the Rain Station regarding the area of the water catchment area on the Keureto River, where the rain stations include Malikusaleh Climatology Station (North), Cot Girek 2 Rain Station (East) and Takengon Rain Station (South). It can be concluded that the rain post data used covers the sub-basin area of the main river.

Fig. 3. Existing Rainfall Station

Using rainfall data from these three stations, the following design rainfall is obtained in table 1:

<table>
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<tr>
<th>No</th>
<th>Return Period (T)</th>
<th>Probability</th>
<th>Design Rainfall (mm)</th>
</tr>
</thead>
</table>

Table 1. Keureuto Dam Design Rainfall
Meanwhile, the design discharge data using the rational method for the Keureuto watershed is as follows.

### Table 2. Keureuto Dam Design Flood

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<th>NO</th>
<th>ID</th>
<th>CA (km²)</th>
<th>Length (km)</th>
<th>Q₁₀₀ (m³/s)</th>
<th>Q₂ (m³/s)</th>
<th>Q₅ (m³/s)</th>
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*Source: Analysis*
3.3. Flood Disaster Map

Map of flood-prone areas specifically for North Aceh Regency, see Figure 4. It can be seen that there are many areas prone to flooding in the downstream area of the Keureuto Dam, where there are 3 (three) large tributaries.

![Fig. 4. Flood Disaster Prone Map](image)

4. Keureuto Flood Early Warning System

4.1. AWLR

To form an early warning system for flooding on the Keureuto River through the Keureuto Dam, three AWLRs are needed upstream of the dam. The proposed position has taken into account:

1. There is adequate road access to reach the location to facilitate the operation and maintenance of the station,
2. River conditions are relatively straight so that turbulence does not occur which will interfere with measurements.

The proposed AWLR position is as in the following figure.
Fig. 5. Proposed AWLR Position

So that the AWLR station upstream of the dam can provide The benefits of being a flood early warning system (Flood Early Warning System, FEWS) require building your own radio communication network (private radio network). It is estimated that 3 relay model repeaters (store-and-forward) are needed to be able to transmit measurement information for the 3 upstream AWLRs to the control room (DCO) at Keureuto Dam.

Based on the layout of the rivers in the upstream and downstream areas of the Keureuto Dam as well as the results of the AWLR locations upstream and downstream of the Dam, the measurement scheme for the Keureuto Dam flood early warning system (FEWS) is as shown in the following figure.

Fig. 6. The Measurement Scheme for The Keureuto Dam Flood Early Warning System (FEWS)

4.2. System Configuration

The Keureuto Dam flood early warning system (FEWS) requires 2 different communication media, namely using radio for the upstream area and cellular/GPRS for the downstream area of the dam. Overall the proposed system configuration is as shown below:
For the AWLR area upstream of the dam, rainfall and water level measurement data are sent via radio data relay using the store-and-forward method, to the telemetry computer server in the Keureuto Dam Control Room (DCO). For AWLR areas downstream of the dam, rainfall and water level measurement data are sent to the dam control room via the internet via cellular network.

**Conclusion**

The Keureuto Dam Flood Early Warning System, which consists of 11 AWLRs in the upstream, dam and downstream areas up to Kuala Keureuto on the coast, is needed as a support system for the Keureuto Dam’s function as flood control, especially in the downstream area, including Lhoksukon City and its surroundings.

**Reference**

1. P. Perera, Duminda; Seidou, Ousmane; Agnihotri, Jetal; Rasmy, Mohamed; Smakhtin, Vladimir; Mehmood, Hamid; Coulibaly, “Flood Early Warning Systems: A Review Of Benefits,” (2019).


