

The Impact of the Krueng Keureuto Dam and Reservoir on Flood Management in Aceh Utara Regency and Surrounding Areas: A Literature Review

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Abstract. *Flood disasters are a long-standing problem in North Aceh Regency and its surroundings, causing serious losses both material and non-material. To overcome this problem, the government has built the Krueng Keureuto Dam and Reservoir as part of its flood management strategy. However, the actual impact of this project on flood mitigation needs to be evaluated through a comprehensive literature review. This study aims to analyze the effectiveness of the construction of the Krueng Keureuto Dam and Reservoir on flood mitigation efforts in North Aceh Regency and its surroundings. From this literature review, it was identified that factors causing the ineffectiveness of the Krueng Keureuto Dam and Reservoir in flood prevention efforts in North Aceh Regency include non-routine sedimentation management, less stringent environmental protection, low participation and awareness of community behavior to prevent flooding and low inter-institutional coordination. This project has not fully met expectations in flood mitigation, but still has the potential to provide significant benefits if further elaborated. The author's recommendations for increasing the effectiveness of dams and reservoirs for flood mitigation include strengthening river sedimentation management, increasing environmental monitoring, community participation campaigns in reservoir maintenance and management, as well as expanding cooperation between the government and the private sector. Follow-up plans will involve regulatory updates, infrastructure improvements, as well as educational programs to increase public awareness about flood management.*

Keywords: *flood management, Krueng Keureuto Dam and reservoir, North Aceh*

1. Introduction

Currently, disasters have become a trending issue that is of concern to all parties, both locally and globally. The Tsunami disaster of 26 December 2004 with its devastating impact became the center of everyone's attention and opened our eyes to the importance of structural and non-structural disaster mitigation which aims to reduce the negative impact of a disaster event. The Tsunami Disaster was also very crucial for the birth of Law Number 24 of 2007 concerning disaster management, which in one of its articles mandates the establishment of a body that specifically deals with disaster management at the provincial and district/municipal level with the name Regional Disaster Management Agency (BPBD).

Based on data from the National Disaster Management Agency (BNPB), there were 2,724 natural disaster events in Indonesia during the period 1 January-1 September 2023. Flood disasters still dominate with 852 incidents, followed by extreme weather with a further 836 incidents, and 487 forest and land fires (karhutla), 442 landslides, 60 droughts, 24 tidal waves/abrasion, 21 earthquakes, and 2 volcanic eruptions, meanwhile, not a single tsunami event has occurred in Indonesia since the beginning of 2023 (DIBI, 2023). The flood disaster is also one of the disasters that continues to occur in North Aceh Regency. The problem of flooding in North Aceh Regency is a routine disaster that occurs

every year with a frequency of 3-5 times a year with the impact of losses reaching hundreds of billions and other immaterial losses. Since the formation of the North Aceh Regency Regional Disaster Management Agency (BPBD) in 2010 with Qanun Number 03 of 2010 concerning the Establishment and Organizational Structure of the North Aceh Regency BPBD, all efforts have been made to overcome flood disasters including prevention, mitigation, preparedness and warning systems. early, emergency response and rehabilitation and reconstruction, but until now flood disasters still continue to occur. Floods are natural events that occur when water overflows from rivers, lakes, seas, or other waterways and causes the water to overflow onto land that is not usually flooded. Flood disasters occur when the flood causes serious damage to property, infrastructure, and can endanger human lives. Flood disasters can be caused by excessive rain, melting snow, tidal waves, or a combination of these factors (Collins, M. 2015).

One of the national multi-year projects for structural flood mitigation in North Aceh Regency is the construction of the Krueng Keureuto Reservoir and Dam. This dam was built on the upstream side of the Keureuto River which is the parent of 6 (six) tributaries (Krueng Pirak, Krueng Ceku, Krueng Alueleuhop, Krueng Kreh, Krueng Peuto and Krueng Aluganto). The Krueng Dam River Basin covers an area of $\pm 235.61 \text{ km}^2$ with a main river length of 31.19km (North Aceh BPBD, 2023). The aim of building the Krueng Keureuto dam as stated in the North Aceh Medium Term Development Plan (RPJM) is as an effort to overcome flood disasters in North Aceh Regency and its surroundings, but to date these efforts have not produced the results as expected.

From the literature review, flood disaster management must be carried out comprehensively from upstream to downstream, therefore the construction of the Krueng Keureuto Reservoir and Dam is only one part of the puzzle that must be implemented in flood management efforts. According to the author, other efforts that must be made start from strict legislation for land clearing permits and taking firm action against forest destroyers, routine dredging of river sedimentation, cleaning all water drainage channels by reactivating the community to work together, educating the community not to throw away rubbish. to the river and reinvigorate the one man one tree reforestation program, and involve the business world to be actively involved in all disaster management activities, both pre, during and post disaster.

Based on the explanation above, the author is interested in conducting a literature review on the topic "The Impact of the Krueng Keureuto Dam and Reservoir on Flood Management in North Aceh Regency and its surroundings".

2. Method

Literature review is an analytical activity carried out on a special topic in a scientific field, in this case the author carried out an analysis of the impact of the Krueng Keureuto Dam and Reservoir on flood management in North Aceh Regency and its surroundings, using the traditional review method, namely the literature review process carried out using read and analyze literature on the same topic then draw conclusions. The steps in the literature review carried out by the author can be described as follows:

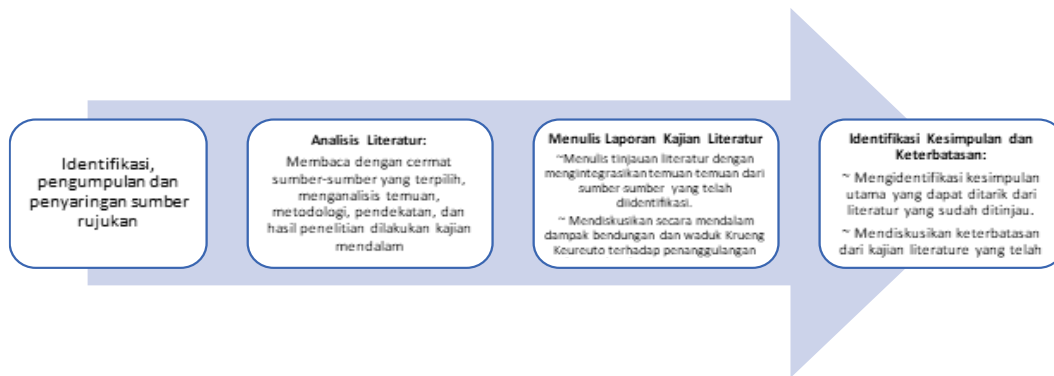


Figure 1. Flow of literature review

3. Results and Discussions

According to Thompson, E.R. (2021), several examples of dams and reservoirs in Indonesia and the world that have been successful in flood management efforts, namely:

- a. Katulampa Dam: Located in Bogor, West Java. This dam functions as a water retainer and flood control for the Jakarta area.
- b. Jatiluhur Reservoir: Located in Purwakarta, West Java. Apart from irrigation and hydropower, this reservoir also functions as flood prevention for downstream areas, including Jakarta.
- c. World
- d. Hoover Dam (United States): Located on the border of Nevada and Arizona. This dam not only produces electricity but also controls flooding on the Colorado River.
- e. Three Gorges Dam (China): One of the largest dams in the world located on the Yangtze River. This dam has a large capacity in controlling floods.
- f. Aswan Dam (Egypt): Located on the Nile River, this dam prevents the annual flooding of the Nile River and allows control of the water flow.
- g. From the example above, it can be concluded that the main purpose of building a dam and reservoir is to mitigate and control floods.

Lessons that can be learned from dams and reservoirs that have been successful in flood management efforts include:

- a. In-depth Planning: The success of a dam or reservoir often comes from careful planning, including analysis of the hydrology, geology, and ecology of the area.
- b. Routine Maintenance: Long-term success in controlling floods often depends on routine maintenance and inspections to ensure the structural integrity of the dam.
- c. Combination of Functions: The most successful dams and reservoirs usually have multiple functions, such as flood control, irrigation water supply, and electric power production.
- d. Community Participation: Involvement of local communities in the dam or reservoir planning and management process can increase project acceptance and success.
- e. Environmental Impact Assessment: Identifying and addressing the environmental impacts of dam and reservoir construction is crucial for the sustainability of local ecosystems.
- f. Adaptive Solutions: Using an adaptive approach where dam management and operations can be adjusted based on experience and data gained over time.

- g. Inter-regional or Inter-country Cooperation: In some cases, rivers cross national or regional boundaries. Inter-regional or inter-country cooperation can increase the success of flood control.
- h. Education and Training: Increasing public awareness and training professionals in the field of water resources management is critical to long-term success.
- i. Advanced Technology: Implementing the latest technology, such as real-time monitoring systems, can increase the efficiency and effectiveness of flood control.
- j. Mitigating Social Impacts: Addressing social impacts, such as community relocation or appropriate compensation, is crucial to gaining community support for the project.

Flood Management Strategy

According to Smith (2020), flood management strategies based on the latest technology and methods in dam design and construction as well as dam management and maintenance strategies are as follows:

- a. Adaptive Dam Design: Uses computational fluid dynamic technology to design dams that can adapt to changing water flows and weather conditions.
- b. Real-time Monitoring System: Implement sensors and cameras to monitor dam conditions, water flow, and weather conditions in real-time, enabling rapid response to emergency situations.
- c. Artificial Intelligence (AI)-based Flood Control Technology, which utilizes artificial intelligence to analyze data and make decisions about when and how much water should be released from reservoirs.
- d. Levee and Retaining Wall Construction: Using the latest technology in construction to create stronger, longer lasting levees and retaining walls.
- e. Evacuation Plans and Community Education: Using computer simulations to create effective evacuation plans and involving the community in training and simulations.
- f. Proactive Maintenance Strategy: Regularly carry out inspections and maintenance of the dam, and use technology to detect early damage.
- g. Complete Basin Approach: Assesses water flow and flood control by considering the entire watershed, not just part of the system.
- h. Revegetation and Ecosystem Restoration: Planting trees and vegetation in downstream areas to absorb more water and reduce surface runoff.

From the theoretical explanation above, and according to Henderson, W.T. (2016) which was analyzed by the author when connected to the question why currently the Krueng Keureuto Dam and Reservoir have not had an impact in accordance with community expectations in flood management efforts in North Aceh Regency? The author can explain as follows:

- a. Elements that are in accordance with the literature review include elements: in-depth planning, community participation at the planning stage, environmental impact assessment and adaptive solutions offered according to community needs in flood management efforts in North Aceh Regency and its surroundings.
- b. Elements that are not discussed in this literature review are: Inter-regional and inter-country cooperation (the Krueng Keureuto Dam and Reservoir are local).
- c. The elements that are the source of problems for questions in this literature review that require discussion and discussion are presented in the following Table 1.

Table 1. Results of literature study on the success of dams and reservoirs in flood mitigation in Aceh

No	Elements of Study	Literature Research	Kr. Dam & Reservoir Facts Keuretoe
1.	Routine maintenance	Dams and reservoirs require regular maintenance and inspection and require structural integrity	Operational costs for maintaining and dredging sedimentation in reservoirs and river basins are still shared responsibility between the central government and the provincial and district governments. So that reservoirs and watersheds are shallow and the water discharge that can be accommodated during the rainy season decreases and flooding occurs again and again.
2.	Combination of reservoir functions	The success of dams and reservoirs must have the dual function of flood control, irrigation, recreation and electricity generation	The aim of building dams and reservoirs, namely to prevent flooding, has not been successful, this is because it is a multi-year project, construction has not been completed, downstream from the reservoir there are still 2 rivers that meet and pass through populated areas so that river water is not accommodated in the reservoir. The North Aceh region also receives floods from the neighboring district, namely Bener Meriah, and the reservoir can only reduce 33% of the number of flood events due to high rainfall, while the remaining 67% needs to be considered and discussed further regarding other efforts.
3.	Education and Training	Increase public awareness of the importance of protecting and maintaining reservoirs and river flows to prevent flooding. Socialization of emergency response plans in case of flooding	Community awareness of protecting reservoirs and cleaning the environment by working together, especially blocked waterways, has greatly decreased, with many families living in watershed areas even throwing rubbish into rivers. Socialization and simulation of flood emergency response plans are not continuously carried out so that internalization of this behavior does not occur

4. Conclusions

From various sources that have reviewed the literature, the author can conclude that the Impact of the Krueng Keureuto Dam and Reservoir on Flood Management in North Aceh Regency: A Literature Study" is as follows:

- a. Dams and reservoirs are critical infrastructure that not only function as water storage, but also as a means of flood control.
- b. There are different types of dams, each with certain characteristics, advantages, and disadvantages.
- c. Through efficient working mechanisms, dams and reservoirs can regulate water flow, store water, and release excess water as needed.
- d. The construction of dams and reservoirs has positive impacts, such as providing water sources, irrigation and flood control, but also brings negative impacts and challenges, including environmental problems and community resettlement.
- e. Several dams and reservoirs in Indonesia and the world have succeeded in showing their important role in flood management.
- f. Lessons from the case studies demonstrate the importance of good design, maintenance, and management in the construction and operation of dams and reservoirs.
- g. The latest technology and methods in the design and construction of dams and reservoirs can increase the efficiency and effectiveness of flood control.

5. Recommendation

Based on the literature review analysis that has been carried out, several factors that may influence the non-maximal function of the Krueng Keureuto dam and reservoir in flood management efforts in North Aceh and its surroundings along with the recommendations offered are:

- a. Increased Infrastructure Investment: Findings show that effective construction of dams and reservoirs can play an important role in flood management. Therefore, the North Aceh District government should increase investment in this infrastructure to reduce the risk of flooding in the future.
- b. Integration of Local Knowledge: Given the variations in geographic and hydrological conditions in North Aceh District, it is very important to integrate local knowledge in the design and management of dams and reservoirs.
- c. Resettlement Policies: Given the possible negative impacts of dam construction, such as resettlement, urban planning and settlement policies should take this aspect seriously to minimize disruption to local communities.
- d. Education and Training: Based on findings regarding the importance of dam maintenance and management, there is a need for regular training for technical personnel and local communities on effective management and maintenance methods.
- e. Inter-Agency Collaboration: The effectiveness of dams and reservoirs in flood management is not just the responsibility of one entity. This requires coordination between various government agencies, NGOs, and the private sector.
- f. Adoption of Technology: Using the latest technology in the design, construction and maintenance of dams and reservoirs can improve the effectiveness and long-term sustainability of this infrastructure.
- g. Periodic Evaluation: Considering climate change and the variability of natural conditions, it is necessary to carry out periodic evaluations of the performance of dams and reservoirs, as well as adapting policies and practices in the field in accordance with the evaluation findings.

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