*Original Research Article*

**Assessing the adequacy of existing risk management programs for the safety of old dams: The case of Mindu dam in Morogoro Municipality.**

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ABSTRACT

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| Governments were generally responsible for constructing and managing the world's largest dams, while private dams fell under the purview of individual owners. Incidents of technical failures in both government-operated and privately-owned dams have resulted in devastating fatalities and extensive harm to the environment and property. These occurrences have prompted significant apprehensions regarding the overall safety of dams worldwide. Although the structural and technical soundness of medium- to large-scale dams in Tanzania have been scrutinized, smaller private dams have been largely overlooked regarding existing and potential issues.  This study explores global literature to identify policy benchmarks for ensuring dam safety and adapts them for implementation in developing countries. Using a case study of Mindu-Morogoro, the study combines the World Bank's "essential" and "desirable" elements with generic models ranging from "minimum" to "best" practice to create innovative policy criteria. The case study includes an on-site dam survey, revealing micro-level deficiencies in both physical and managerial aspects. The findings indicate that the dam safety management policy in Mindu falls far below the minimal benchmark, highlighting the need to shift towards a "best practice" approach for enhanced security in Morogoro. It is essential to adhere to the minimum practice guidelines initially. To avert the risk of dam failure and subsequent flood disasters, other developing countries can draw insights from the policy analysis and design procedures. |

**Keywords:** *Policy Benchmarks, Dam Safety, Mindu-Morogoro, RUWA*

1. INTRODUCTION

Dam safety is a critical global concern as the world continues to rely on dams for various purposes such as water storage, irrigation, hydropower generation, and flood control (Materu *et al*., 2018; Pisaniello, 2011). Ensuring the integrity and safety of dams is paramount to prevent catastrophic failures that can lead to loss of lives, property damage, and environmental degradation. Dams play a crucial role in meeting the water and energy needs of many countries worldwide. According to the World Bank, there are over 57,000 large dams (height greater than 15 meters) across the globe, and countless smaller dams, serving a myriad of purposes(Adamo et al., 2020). A significant challenge in dam safety is the aging infrastructure. Many dams were constructed decades ago, and their structural integrity may be compromised over time (Thi *et al*., 2012; Tingey-Holyoak *et al*., 2011). The International Commission on Large Dams (ICOLD) estimates that over 60% of the world's large dams are more than 50 years old. Climate change and extreme weather events contribute to the increasing risk factors for dam safety, the frequency and intensity of storms, floods, and other natural disasters pose threats to the stability of dams, making it essential to reassess and reinforce existing safety measures. Dam failures and incidents have occurred globally, underscoring the urgency of prioritizing dam safety (Pisaniello, 2010). Historical events, such as that reported by Xu et al., 2008 have resulted in significant loss of life and highlighted the potential consequences of inadequate safety measures. Various countries and international organisations have established regulatory frameworks and safety standards for dams. However, the level of adherence and enforcement varies globally. The World Bank indicates that strengthening regulatory capacities is crucial for enhancing dam safety on a global scale (Brewer *et al*., 2005; Pisaniello *et al*., 2011).

In Africa, dam safety is a critical concern, given the continent's increasing reliance on dams for various purposes. However, the region faces several challenges related to dam safety, ranging from inadequate infrastructure and maintenance practices to the impact of climate change. A significant number of dams in Africa are aging and may not meet modern safety standards. The lack of proper maintenance and surveillance can lead to potential risks, threatening both human lives and the environment (Perera et al., 2021). According to the World Bank, a substantial percentage of dams in Africa are classified as having high or significant hazard potential, signifying the potential for severe consequences in case of failure. Climate change exacerbates these concerns, as extreme weather events, such as heavy rainfall and floods, become more frequent, inadequate funding and limited technical expertise contribute to the challenges in ensuring dam safety across the continent. Efforts are being made to address these issues, including capacity-building initiatives, collaboration with international organizations, and the development of regional guidelines for dam safety. However, the statistics underscore the urgent need for comprehensive strategies and investments to enhance dam safety in Africa and mitigate potential risks associated with aging infrastructure and the changing climate (Arslan et al, 2016).

Tanzania has experienced a growing demand for water resources and energy, leading to an increased number of dams and reservoirs. However, the aging infrastructure and inadequate maintenance have raised concerns about the overall safety of these structures. To address these challenges, Tanzania has been working on improving its dam safety policies and practices. The government has implemented regulations and guidelines to ensure that dams adhere to international safety standards (Isomaki et al., 2012). Collaborative efforts with stakeholders, including local communities, engineers, and environmentalists, play a crucial role in monitoring and managing dam safety (Pisaniello, 2010). However, there are limited evidence to whether the current risk management programs are adequate to make Dams in Tanzania risk free.

This research aimed to evaluate the effectiveness and sufficiency of the current risk management programs, which are carried out in the old Mindu dam located in Morogoro municipality, Tanzania. The assessment covered a comprehensive examination of the existing strategies, policies, and practices in place to identify, mitigate, and manage various risks within the region's standards. Specifically, the study aimed to establish a dam safety policy benchmark for Tanzania, assess the rules and policies in place that control Tanzania's dam safety management and examine the variables that influence Mindu Dam Safety Issues.

2. material and methods

**2.1. Description of the study area**

This study was conducted at the Mindu dam, located in the Morogoro region's, Morogoro Municipality. Situated in the Ngerengere River Valley, the Mindu dam is roughly 3.8 kilometers southwest of Morogoro town (Kimambo et al., 2019). It is located at latitude 6.82°S and longitude 37.66°E (Figure 1). The area has a bimodal rainfall regime with short rains occurring between October and December (OND) and long rains from March to May (MAM) (Gobry *et al*., 2023). With an annual rainfall of between 800 and 1500 mm, the Uluguru Mountains receive the most precipitation in the basin. The dam primarily supplies Morogoro town with water (Kimambo *et al*., 2019). Its construction started in 1983 and was finished in 1985 with a dam design storage capacity of 20 Million m3(Stott, 1999)

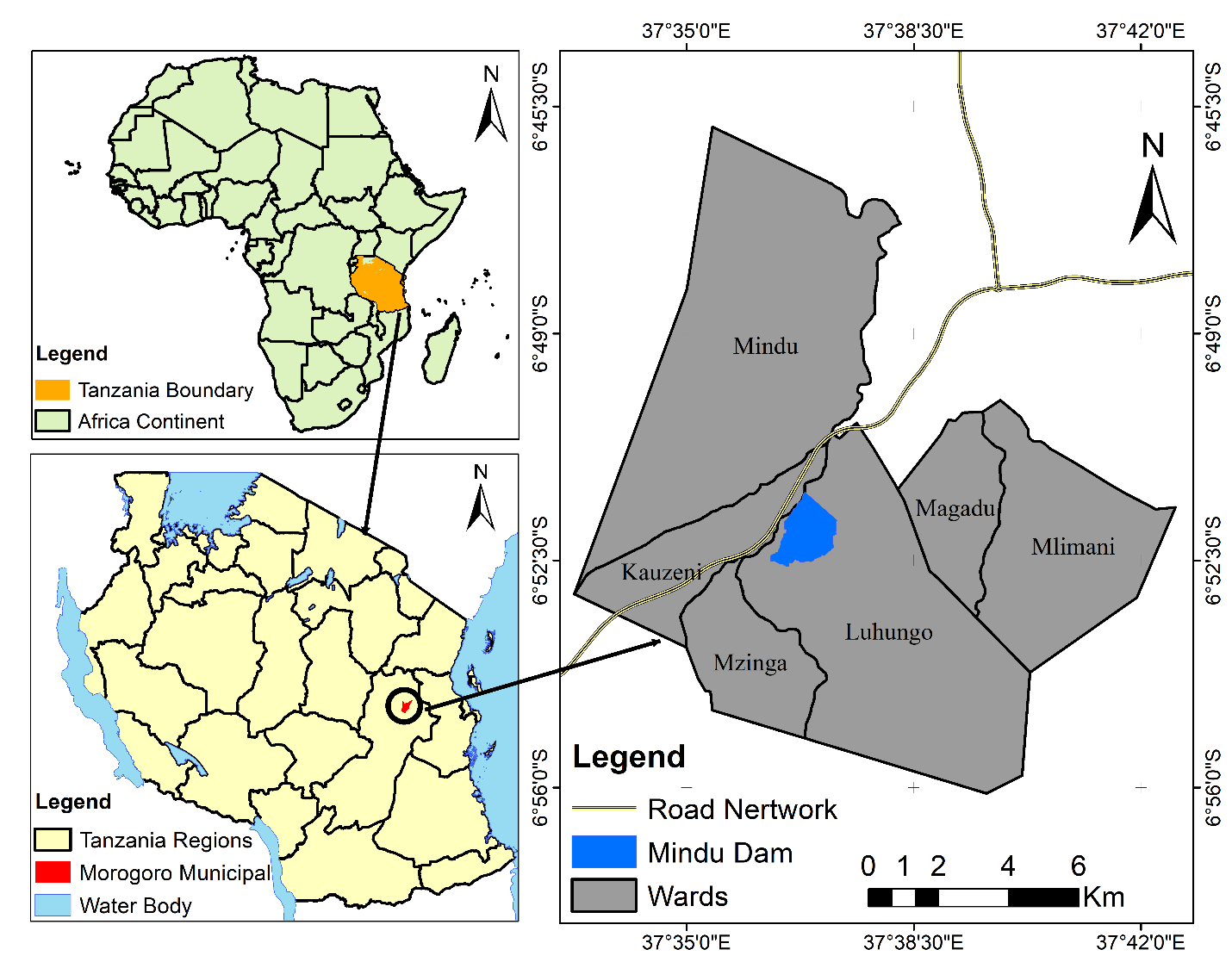


Figure 1. Study area showing the location of Mindu Dam

**2.2. Research Design**

The study adopted the cross-sectional research design whereby data were collected once from the six wards surrounding Mindu dam, namely Kauzeni, Mindu, Magadu, Mlimani, Luhungo, and Mzinga. The design allowed the collection of both quantitative and qualitative data within a short period by visiting the experts for more information based on the study subject. In addition, the design allows for cost, human and time effectiveness when it comes to data collection (Munshi & Ansari, 2021). Furthermore, the collected information is used in a variety of ways including to determine the association between variables as well as to approve and disapprove assumptions/hypotheses (Munshi & Ansari, 2021; Madhi *et al*., 2021).

**2.3. Data Collection**

This study was conducted in various phases as described below:

**Phase One:** To establish relevant benchmarks for comparing the sampled dams, a literature review was undertaken to explore global practices in benchmarking for dam safety.

**Phase Two:** Conducting ten on-site surveys as part of an embedded case study focusing on deliberately selected Mindu dam in Morogoro Municipality, Morogoro Region, Tanzania (Pisaniello *et a*l., 2013). Mindu dam was selected because it fulfilled the following two criteria: (1) being classified as "Significant" or "High" hazard based on an initial assessment of factors such as dam size, human habitation, and economic development in the downstream inundation area (Pisaniello & McKay, 2003; Tietenberg, 1998); and (2) qualifying as small dams(Salgado & Silva Carvalho, 2023). The on-site dam examination involved utilizing a dam inspection checklist sourced from the following periodicals: (1) "Your dam your responsibility: a guide to managing the safety of farm dams" released by the Department of Sustainability and Environment (DSE, 2007) in Victoria, (2) "Dam safety guidelines: inspection and maintenance of dams" published by the Water Management Branch of the Ministry of Environment, Lands and Parks, British Columbia (Cocklin *et al*., 2007; Donnelly *et al*., 2009) and (3) The global recommendations for the evaluation and examination of small earthen dams as outlined in the publications by Pisaniello, 2010a, b; Pisaniello and McCay, 2006.

**Phase Three:** The qualitative semi-structured interviews were conducted with representatives from thirty significant stakeholder groups. The in-person interviews took place between September 10 and October 21, 2023.

The study employed the mixed methods approach in data collection whereby quantitative and qualitative data were collected concurrently to get more information to help answer the research questions. Primary data were collected using a structured questionnaire; key informant interviews (KIIs) and focus group discussions (FGDs). The KIIs and the FGDs were guided by a checklist and an FGD guide respectively. A total of 10 key informants occupying different positions including engineers and policymakers were interviewed. Moreover, ten FGDs, each involving 20 participants, were conducted.

**2.4. Data analysis**

Data collected from literature review, observations (on site surveys), semi-structured interviews regarding different applied coping strategies in farmers’ fields and observable risk of mindu dam in morogoro , plus information collected from the household survey were analysed using descriptive statistics. Stata 14 and Excel were used to generate frequency tables, percentages, charts and graphs to summarize, present and interpret survey.

3. results and discussion

**3.1. Establishment of a global dam safety policy benchmark**

The assessment of adequate policy required a benchmark, which would be used for comparison purposes for the Tanzania reservoir in Morogoro. This global analysis demonstrates how different countries have different management plans for managing dam safety. Nonetheless, it is possible to identify essential elements of some techniques. Common law, command and control procedures, management, reservoir registration and categorization, monitoring, bookkeeping, and reporting, rules and/or standards of behaviour, readiness and education for residents, punitive enforcement, and owner instruction and direction are some of these. According to an analysis of the aforementioned international evaluation criteria, there are three primary independent ways to give the public more comfort about dam safety:

**Approach 1:** Owner instruction, support, and direction. Supplying dam owners with informational documents and guidelines in the hopes that they will behave responsibly and according to common law requirements (Gunningham and Sinclair, 1999, 2002; Zivie-Cohce, 1997).

**Approach 2:** Using emergency action plans (EAPs) to organize the community. Making EAPs a requirement for all dam owners may be necessary under legislation (Pisaniello and McKay, 2007). To mandate the creation and upkeep of increasingly sophisticated plans for increasing hazard potential and to monitor the overall state of reservoir safety management, it is also necessary for the government to establish and maintain a reservoir registration (Pisaniello and McKay, 2007). Because downstream populations are informed of the dangers and hazards they face and are given the option to evacuate in the event of a dam failure, this law respects the principle of the "Community Right to Know" (Gunningham and Grabosky, 1998).

**Approach 3:** Command and Control - stringent oversight and regulation through the application of dam safety laws. Gunningham and Grabosky (1998) and Eisner (2004) discussed the establishment of legal requirements for reservoir owners to adhere to specific rules, de facto standards, codes, and regulations on dam safety management, as well as the provision of supervision to guarantee compliance and provide a degree of regulatory certainty. All of these studies (Bradlow *et al*., 2002; Tigey-Holyoak *et al*., 2011; Pisaniello *et al*., 2011; Pisaniello, 2010; Pisaniello and Burritt, 2010; Pisaniello and McKay, 2003) have a primary focus on ensuring newly built dams are appropriately conceived and constructed, while also promoting proper maintenance and collecting information on risk assessment of existing dams. These studies have led to the establishment of international dam safety benchmarks. It is advised to use three general models of dam safety management policy, which range from "minimum practice" to "best practice," to give the public greater confidence regarding dam safety (Pisaniello, 2010). These models are known as the global models.

The models consist of the following:

Minimum practice = approach 1 + approach 2 (i.e., the minimum level benchmark).

Average practice = approach 1 + approach 2 + some element(s) of 3.

Best practice = approach 1+ approach 2 + approach 3 (i.e., the best practice benchmark).

Together with the three global models, Bradlow *et al*. (2002) developed by the "World Bank frameworks," which are guidelines for dam safety regulations sponsored by the World Bank and also referred to as regulatory standards. As proposed by Gunningham and Grabosky (1998), a suitable regulatory mix that incorporates multiple mechanisms is meant to create a global standard or benchmark. This benchmark is essential for evaluating the effectiveness of on-farm water storage safety management in various legal contexts (Wagner & Schaltegger, 2003). In the event of a crisis, the public would be most assured and best practices would be established by a dam safety assurance policy that incorporates all three models. That being said, Gunningham and Sinclai (1999) suggest that it could theoretically be feasible to start and continue operations only using model 1's lowest benchmark. According to Pisaniello *et al*. (2011) and Pisaniello and McKay (2007), benchmark models are complementary to one another and can be used in concert to create thorough guidelines and crucial elements for establishing successful dam safety management policies in any jurisdiction. Table 1 integrates insights from the three international models and the World Bank frameworks to present key elements derived from international benchmarks. The international benchmarks mentioned earlier serve as the foundational standards for this paper's objective assessment of the suitability of the dam safety policy in Tanzania. The evaluation covers both central and local elements, including the overall policy enacted through laws and regulations, as well as practices and policy application on-site.

**3.2. An assessment of the rules and policies in place that control Tanzania's dam safety management**

In this section, we seek to lay the foundation for a comparative analysis of current laws and regulations against globally accepted standards (Table 4). The National Water Policy of 1991 was thoroughly revised after a protracted consultation process resulting in the new National Water Policy (NAWAPO), which was approved by the Cabinet in July 2002, marking the end of this process. It is thought that the NAWAPO addressed and fixed the flaws in the prior policy. In addition, it instituted the decentralization of water supply management, by Agenda 21 from the 1992 United Nations Environment Meeting in Rio de Janeiro. The "subsidiarity principle," which promotes managing water supplies at the most suitable local level, was highlighted in this agenda (Lein & Tagseth, 2009; Materu *et al*., 2018).

The current initiatives of the Ministry of Water and Irrigation as well as the projects of its sub-sector have not followed the traditional rational order of policy, strategy, and planning. These include the development of the National Strategy for Improvement of Urban Water Supply and Sewerage, the National Rural Water Supply and Sanitation Programme, and the evaluation of laws about water resources, urban water supply, rural water supply, and sewerage. Due to this deviation from the typical order, possible problems like duplications or omissions may arise. Addressing the requirements of small towns, defining "sanitation," explaining the differing roles of the Ministry of Water and Irrigation and the Ministry of Health, and establishing institutional and legal frameworks are a few particular challenges(Phiri et al., 2007; Thi et al., 2012).

The Morogoro Water Supply and Sanitation Authority (MORUWASA) and other organizations have passed laws that form the basis for the country's dam safety management systems. Circulars, Instructions, Directives, and Decisions from pertinent Ministries or Provincial People's Committees are examples of by-law documents that are also available. In particular, (1) the Law on Water Resources Management (also known as the LWRM, Water Utilization (Control and Regulation) Act No. 42 of 1974, as amended by Acts No. 10 of 1981 and No.17 of 1989, Water Laws (Miscellaneous Amendments) Act No.8 of 1997, and Water Laws (Miscellaneous Amendments) Act of 1999), (2) Water Supply Aspects are governed by Urban Water Act No. 7 of 1981, Water Laws (Miscellaneous Amendments) Act No. 8 of 1997 and Water Laws (Miscellaneous Amendments) Act of 1999 (Mwaka, 1999; Ramachandra & Kumar, 2004).

**3.2.1 Registration and classification of dams**

For dam registration it’s a Mandates of the local government such as municipal council or Responsible authority do the following:(i) keep a record of major dams (i.e., Tanzania's "prescribed" classification system) inside their jurisdictions; and (ii) assign subjective hazard ratings based on the state's three-tiered hazard rating system. For the government to monitor the density of potentially dangerous dams and, consequently, the severity of the dam safety issue

The Second Schedule of the International Commission on Large Dams (ICOLD) guideline specifies the criteria that must be followed when categorizing dams and tailings dams. The following levels of external risks are to be used for categorization: (a) very high-risk (b) high risk (c) low risk and (d) very low risk.

Table 1.Criteria for classifying dam

|  |  |  |  |
| --- | --- | --- | --- |
| Rating Category4 | Loss of life | Economic and social loss | Environmental and cultural loss |
| Very high  “A “ | There is a big chance that residents and the working, travelling, and/or recreational public will die in multiple ways.  Development often included towns, sizable business and industrial zones, major thoroughfares, railroads, and areas with high concentrations of recreational activity within inundation areas (the region that could be submerged in the event of a dam failure).  Over a hundred deaths are estimated. | Significant financial loss affecting public, commercial, and infrastructure assets both inside and outside the flooded area. | Significant loss or degradation of habitat for wildlife, rare and/or endangered species, distinctive landscapes, or sites with cultural significance. |
| High “B” | There is a chance that residents who work, travel, or engage in public recreation might forfeit several lives. Development in areas prone to flooding usually consists of roads and railroads, business and industrial zones, | Severe financial losses impact public, private, and infrastructure properties both inside and outside the flooded area.  . | Habitat loss or significant degradation for rare and/or endangered species, wildlife, unique landscapes, culturally significant locations, and important national or provincial fisheries (including water quality). |
| Low “C” | Reduced possibility of multiple fatalities; inundation area is usually undeveloped, aside from small roads, briefly inhabited areas, non-residential farms, and rural activities. If a larger development is present, there needs to be a trustworthy component of natural warning. | Minimal financial losses as a result of fewer public, private, and commercial activities. The estimates expenses whether direct or indirect are minimal under this category | The disappearance or serious degradation of habitats supporting rare and/or endangered species, distinctive landscapes, places of cultural significance, wildlife habitat, and regionally significant fisheries. |
| Very low  “D” | Very little chance of a catastrophe. An area that is flooded is usually underdeveloped. | Little financial losses that are normally contained on the property of the owners | There is not a noticeable decline in the number of fisheries inhabitants, wildlife. |

4 The classification of the rating category is established based on external risks that could occur downstream in the event of dam failure.

**3.3. The Variables Influencing Mindu Dam Safety Issues**

Given the Natural factors i.e. flooding, erosion, structural i.e. Spillway capacity and other human factors such as vandalism associated with dam safety, this study explores the factors contributing to the identification of safety issues with dams in Morogoro. According to feedback from and household interviews of various stakeholders, a significant number of dam failures occur during extreme weather events, notably floods and heavy rainfall, often coinciding with each other (refer to Table 4. The majority of respondents expressed the belief that floods and heavy rains were prominent contributors to dam failures. Additionally, landslides were identified as another factor leading to dam failures, particularly in areas with mountainous terrain, such as the Uluguru Mountains. The age of dams was highlighted as a crucial determinant of their stability, with dams constructed over 40 years ago being more susceptible to failures. These insights were gleaned from both the questionnaires and interviews conducted as part of the study. The compromised safety resulted from inadequate design and construction, posing a threat to the inherent safety of these dams.

Stakeholders have conveyed the viewpoint that the main reason behind the present inadequate level of dam safety and instances of dam failures predominantly stems from subjective (human) factors. These key stakeholders emphasize that human factors are deemed as equally, if not more, significant than natural disasters and the age of dams in the context of ensuring dam safety (refer to Table 5).

The frequently cited factor contributing to dam safety issues is the lack of a risk-based assessment for dam safety.

Table 2 Common problems facing the Mindu dam in Morogoro.

|  |  |  |
| --- | --- | --- |
| **Frequency(Key Participants)** | **Percentile (%)** | **Principal issues relating to dam safety** |
| 25 | 83.3 | Significant erosion is evident on both the upstream and downstream faces. |
| 26 | 86.7 | The top has been affected by traffic, resulting in an uneven summit with depressions. |
| 30 | 100 | The outlet is aged, damaged, and cracked. |
| 18 | 60 | Landslide occurrences in downstream |
| 30 | 100 | Vegetation on both the upstream and downstream sides of the dam. |
| 30 | 100 | The spillway is obstructed and insufficiently sized. |

**N.B:** Due to the proximity of numerous residences downstream and adjacent to the dam, the dam carries a significant risk rating.

Several common problems facing the Mindu dam were identified from a field survey conducted through this study using 30 respondents from the field. 100% of all households interviewed agreed that the aging of the outlet of the dam, dense vegetation cover upstream and downstream of the dam and insufficient capacity and damage to the spillway are the leading problems facing the dam. Another leading problem facing Mindu dam is that it was observed with 86.7% agreement from household interviews that the dam top has been affected by human activities such as settlement which is attracted by the passage of trunk road it was also observed that the surrounding area of the dam has a lot of pit holes and depression caused by human activities encroachment. Not only that but also erosion was observed upstream and downstream of the dam and 83.3% percentage of the respondents agreed that this is the problem facing the dam and 60% of the respondents identified that the landside occurrences downstream are another problem facing the dam.

Table 3. Expertise Opinions on the Dam Conditions.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sn** | **Issue** | **No of Expert** | **Percentile (%)** |
| 1 | Visible Holes/Cracks | 8 | 80 |
| 2 | Sign for erosion occurrences | 10 | 100 |
| 3 | water seepage | 7 | 70 |
| 4 | outlet pipe damage | 8 | 80 |
| 5 | vegetation blockage | 10 | 100 |
| 6 | animal damage | 8 | 80 |
| 7 | Flood occurrence | 10 | 100 |
| 8 | Compliance with the dam safety procedures | 5 | 50 |
|  |  |  |  |

A comprehensive assessment of key issues affecting dam safety, through expertise from the responsible authority in managing the Mindu dam (MORUWASA) was conducted to highlight several critical factors affecting the safety of the dam like erosion, vegetation blockage, and flood occurrence. From the findings, it was observed that erosion, vegetation blockage and flood occurrence are the key factors affecting the dam.

Table 4.Physical elements that are thought to be causing the present dam safety issues

|  |  |  |
| --- | --- | --- |
| Element | No.of key participants(n=30) | Percentile (%) |
| Flooding occurrences | 26 | 86.7 |
| Intense rainfall | 28 | 93.3 |
| Dam impairment | 30 | 100.0 |
| Landslide incidents | 20 | 66.7 |

From the field interview of the experience of the respondents, it was observed that dam impairment downstream 100% agreed is the major causing present dam issues today due to poor maintenance and repairing of the downstream infrastructure, while 93.3% of dam safety issues are caused by high rainfall occurrence due to climate change, 86.7% of the damage were noticed to be caused by flooding caused by the occurrences of high rainfall in upstream along the mount Uluguru. Soil and landslide occurrence along the upstream was agreed by 66.7% of the respondents to another cause of dam damage.

|  |  |  |
| --- | --- | --- |
| Element | No.of key participants(n=30) | Percentile (%) |
| insufficient, risk-based assessment of dam safety | 25 | 83.3 |
| Local management of dam safety is deficient | 30 | 100.0 |
| Absence of centrally located dam governance | 20 | 66.7 |
| Lack of accountability | 24 | 80.0 |
| The value of life is deemed low | 18 | 18.0 |

Table 5.Examined human elements contributing to the current challenges in dam safety

All 30 participants unanimously agreed that the local management of dam safety is deficient. This represents 100% agreement among participants, showing a unanimous concern about the competence and effectiveness of local management in ensuring dam safety by the concerned authority. 83.3% of the participants believe that the current methods used to evaluate the safety risks of dams are inadequate. While 66.7% of the participants see the lack of a central authority as a significant issue in managing dam safety effectively. In addition, 18% agreement among participants, suggests that a minority perceives a disregard for human life in dam safety considerations.

Table6. Key stakeholders’ shared concerns about the Mindu dam

|  |  |  |
| --- | --- | --- |
| Problems associated with the dam | No.of key participants (n=30) | **Percentile (%)** |
| Water seepage | 15 | 50.0 |
| Soil Erosion | 28 | 93.3 |
| Breaking | 20 | 66.7 |
| Incapacity due to sedimentation and/or losses | 30 | 100.0 |
| blocked exit | 15 | 50.0 |
| An improperly constructed spillway | 20 | 66.7 |
| Unlawful activity (sabotage or vandalism) | 19 | 63.3 |
| Excessing growing of vegetation/ trees | 29 | 96.7 |
| A sinkhole | 20 | 66.7 |
| Land/Soil slides | 30 | 100.0 |

100% of all stakeholders agree that sedimentation and material losses reduce the dam's capacity to hold water, affecting its efficiency and longevity. (93.3%) of the household are worried about soil erosion around the dam area. 93.3% of the respondents agreed that Erosion can undermine the dam’s foundation, leading to structural instability.50% of the households interviewed are concerned about water seeping through the dam, which can weaken the structure and lead to potential failures.66.7% of the participants are concerned about the dam breaking. This reflects fears of catastrophic failure resulting in flooding and extensive damage downstream.

4. Conclusion

Dam safety policies and practices, both at the local and national levels, show that currently Mindu dam safety does not meet the minimum and best standards. While achieving the minimum practice benchmark is a fundamental anticipation for all countries irrespective of their socio-economic development, reaching the best practice benchmark may be considered an ambitious goal for developing nations such as Tanzania.

To establish a suitable management policy for the safety of Mindu dam, the government can effectively adopt globally recognized guidelines as benchmarks. The focus on the Mindu-Morogoro case study reveals significant deficiencies in dam safety management that require immediate policy intervention. The Morogoro Water Supply and Sanitation Authority (MORUWASA) should implement various initiatives based on the study findings to address the situation of the Mindu dam such as mandatory regular inspections and maintenance, training and capacity-building programs for dam operators and local communities to enhance their understanding of dam safety protocols and procedures, implementing a monitoring system to track the condition and performance of dams over time for the early detection of potential issues and ensuring timely interventions, incorporate advanced technologies like sensors for real-time monitoring to aid in the early detection of potential failures and enhancing the physical infrastructure by reinforcing dam structures, upgrading spillways, and improving drainage systems.

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