

University of the Free State

Community-Based Early Warning Systems: The Jagersfontein Tailing Dam Disaster

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A mini-dissertation submitted in fulfilment of the requirements for the degree:

Master of Development Studies (MDS)

Faculty of Economic and Management Sciences

Centre for Development Support

Course Code: EDSA7900

Bloemfontein Campus

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2025

DECLARATION

I, **Xola Mavundla** declare that the master's degree mini dissertation that I herewith submit for the master's degree qualification Development Studies at the University of the Free State, is my independent work and that I have not previously submitted it for qualifications at another institution of higher education.

_____ _____

Xola Mavundla December 2025

ACKNOWLEDGEMENTS

The successful completion of this dissertation is a result of contributions by different individuals, whom I wish to acknowledge with gratitude:

- I would like to extend my appreciation to my supervisor, Prof. Lochner Marais, for his guidance, constructive feedback, patience, and support throughout the research process. His expertise and encouragement were instrumental in shaping this study.
- I am also grateful to the University of the Free State for providing the secondary data that informed this study.
- Lastly, I would like to express my heartfelt appreciation to my family and friends for their unwavering support, understanding, and encouragement throughout my academic journey. Their belief in me provided me with the strength and motivation needed to complete this dissertation.

ABSTRACT

The Jagersfontein tailings disaster, which occurred on 11 September 2022, highlighted critical weaknesses in early warning, risk communication, and institutional response. This study examined the available early warning signals prior to and during the Jagersfontein tailings disaster and how the community, the mine and institutions responded to the warnings.

The study utilised qualitative secondary data. The internal data was collected following the disaster at Jagersfontein and is available at the UFS. The study also utilised external sources, including academic journals, online reports, and memoranda written by the community of Jagersfontein, to explore the experiences and responses of residents during the catastrophic event.

The findings revealed gaps between policy intentions and community realities, particularly in relation to risk communication, preparedness, and response coordination. Furthermore, the lack of involvement of communities in risk assessment and preparedness measures resulted in residents being less prepared to respond to and recover from emergencies resulting from tailings facility failures.

The study concluded that integrating CBEWS into tailings management is important for improving disaster preparedness and reducing loss of lives and livelihoods and enhancing safety in mining towns.

Keywords: Tailings storage facility failures, Jagersfontein, Community-based early warning systems, Disaster risk reduction

LIST OF ABBREVIATIONS

CBEWS	Community-Based Early Warning System
DMA	Disaster Management Act
DMRE	Department of Mineral Resources and Energy
DWS	Department of Water and Sanitation
ICMM	International Council on Mining and Metals
IDP	Integrated Development Plan
MPRDA	Mineral and Petroleum Resources Development Act
NEMA	National Environmental Management Act
NWA	National Water Act
POPIA	Protection of Personal Information
SLP	Social Labour Plan
TSF	Tailings Storage Facility
UFS	University of the Free State

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CHAPTER 1:
INTRODUCTION

1.1 Introduction

Although the mining industry makes a significant economic contribution to surrounding communities, it has been associated with safety issues and social and environmental harm (Cronje, Reyneke, and Van Wyk, 2013). Limited transparency in disclosing safety information is also a concern (Cronje, Reyneke, and Van Wyk, 2013). This often results in disaster events that disrupt the functioning of the local communities. Strengthening risk disclosure can help vulnerable communities take action to mitigate and prepare for disasters (Owen et al., 2020). Historically, mines and governments saw communities as recipients of assistance during disasters, while the government and external agencies have assumed primary responsibility for disaster management (Enders, 2001).

This research examined the significance of engaging communities in disaster risk reduction. One of the key elements in disaster risk reduction is the implementation of a CBEWS, which empowers communities to prepare, respond to, and recover from disaster events effectively (Domingos and Nagamatsu, 2024). Communities are the first responders in disaster events and are also the first to suffer the adverse effects (Shakeri, Vizvari, and Nazerian, 2021); therefore, warning messages must be directed to at-risk communities, providing them with relevant information on hazards and disasters (Macherera and Chimbari, 2016). Such warning messages will allow at-risk communities to assess risk levels and make informed decisions to protect themselves, subsequently reducing the potential harm or loss resulting from disasters (IFRC, 2020).

1.2 Background of the Study

This study examined the tailings dam disaster that occurred on September 11, 2022, in Jagersfontein, a small mining town in the Free State Province (Marais et al., 2024). Jagersfontein is situated southwest of Bloemfontein, as illustrated in Figure 1.1 below.

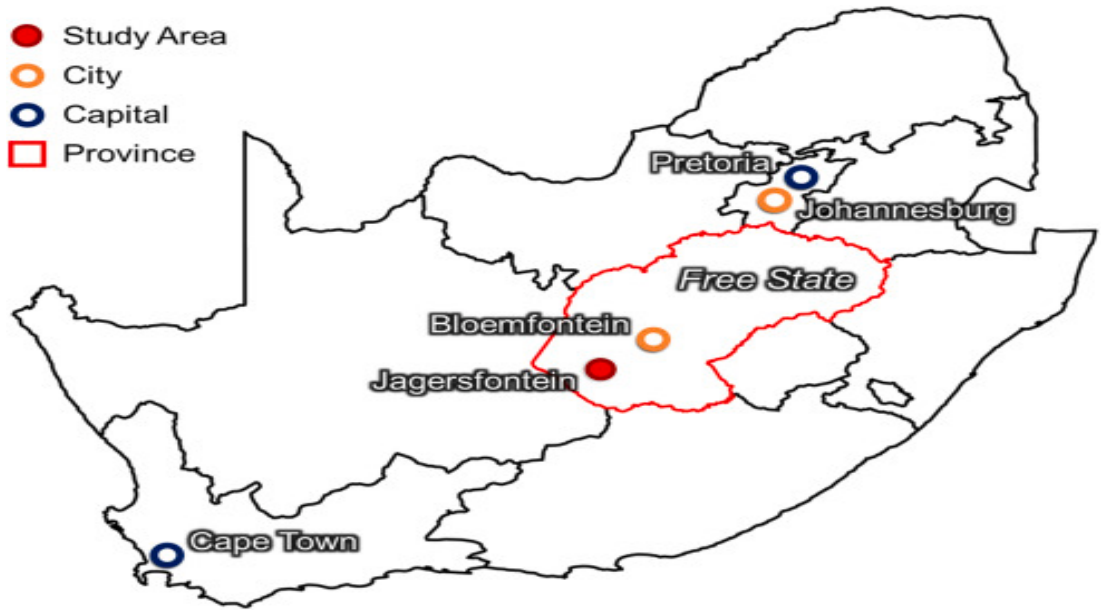


Figure 1.1: Map of Jagersfontein (Marais et al., 2024)

The town once played a role in the global diamond industry. In the event of the tailings dam disaster, the dam wall ruptured, releasing toxic mine waste into the settlements of Charlesville and Itumeleng, which are located downhill from the dam. Prior to the disaster, the mining company and the government had been warned by the community about the stability of the tailings dam; however, the mining company ignored and disregarded their concerns (Motsau, 2022). The Department of Water and Sanitation (DWS) was responsible for monitoring the dam. Before the dam rupture, the department issued several directives to the mining company for non-compliance (Motsau, 2022). However, the directives were lifted, and the mining company continued to pour waste into the dam.

The dam was built using tailings material, which is a practice known globally to be unstable. The failure of a tailings dam results in the loss of lives, injuries, destruction of property, infrastructure, and livelihoods, and has a significant impact on the environment (Hudson-Edwards et al., 2024). Therefore, such facilities require continuous monitoring, transparency, and open communication with local communities about the risks associated with them to ensure that both the mining company and the surrounding communities are prepared for emergencies related to the facility.

Despite warning management two days before the disaster that the overloaded dam was about to rupture, miners were instructed to remain silent and continue working (Motsau, 2022). On the day of the disaster, residents relied on informal communication

to warn each other about the dam failure; however, the majority of people did not know how to respond to the information. As a result, residents delayed evacuating their homes and ended up trapped in the mud (Motsau, 2022).

The impact of the disaster resulted in two deaths, two missing persons and 164 houses destroyed (Motsau, 2022). Furthermore, the environment was damaged, livestock were killed, and the infrastructure and livelihoods were destroyed. The disaster exposed weaknesses in the regulation, monitoring and communication mechanisms required to ensure community safety in mining towns. Despite early warnings and visible structural instability, the mining company overlooked the concerns and continued to operate.

This study examined the extent to which early warning systems were present, understood and functioned before the Jagersfontein tailings dam disaster. Furthermore, the study assessed the gaps that contributed to the dam failure.

1.3 Problem Statement

There is currently limited data or information on the presence of CBEWS in mining towns. Disaster management in mining towns often employs a top-down approach, where mining companies, the government, and emergency management agencies view communities as primarily receivers of warnings and assistance during a disaster event. They show little interest in understanding community needs, capacities, and vulnerabilities. The mining company and municipalities do not involve the surrounding communities in risk assessment and preparedness measures. As a result, communities are less prepared to respond to and recover from emergencies resulting from tailings facility failures. Thus, the core of this study was this lack of disaster preparedness.

1.4 Aim and Objectives

This study examined the available early warning signals and responses from the community, government, and the mine in Jagersfontein. The objectives included the following:

- To analyse the existing early warnings before the Jagersfontein tailings failure.

- To assess the community, the mine and the government's response to these early warnings.
- To make policy recommendations in respect of tailing disasters and the role of early warning systems.

1.5 Significance of the Study

The findings will provide insight that can inform policymakers, guide mining companies in managing the risks associated with tailings storage facilities (TSFs), and prepare communities residing near these facilities.

Policymakers in this study included local authorities, municipalities and government departments. The study aimed to provide recommendations that enable policymakers and the mining industry to prioritise and implement early warning mechanisms to mitigate the impact of tailings disasters. The study also sought to educate communities residing in mining towns about the importance of participating in risk assessment and preparedness measures.

1.6 Delimitation of the Study

The study utilised secondary data available from the University of the Free State (UFS). The dataset consisted of interviews conducted, which focused on the impact of the tailings dam disaster on the community of Jagersfontein, as well as the complaints and warnings from residents about the overloaded tailings. The study also utilised external secondary data, including government reports, reference books, and literature review articles on early warning signals and community safety policies in mining towns, which are readily available on the internet (see Chapter 3).

1.7 Limitations

This study utilised secondary data to address its research objectives; therefore, a potential limitation of the secondary data analysis was whether the collected data were suitable for this study. The second limitation was access to various sources and perspectives, which could potentially result in conflicting or inconsistent data that might confuse or mislead the researcher.

1.8 Definitions and Key Terms

The following sections outline the key terms and definitions frequently used in the study.

1.8.1 Hazard

Hazards refer to the processes, phenomena or human activities that may cause loss of life, injury, or other health impacts, property damage, social and economic disruption or environmental degradation (United Nations, 2025). The hazard in the study encompassed the tailings dam that ruptured on September 11, 2022, resulting in fatalities, destroying houses and infrastructure, and impacting the environment.

1.8.2 Vulnerability

Vulnerability refers to the conditions determined by physical, social, and environmental factors or processes that increase the susceptibility of an individual, a community, assets, or systems to the impact of hazards (United Nations, 2025).

1.8.3 Risk assessment

Risk assessment refers to a process used to identify potential hazards, evaluate the likelihood and severity of harm they could cause and implement control measures to reduce or eliminate those risks (UNDRR, 2025a).

1.8.4 Disaster risk reduction

Disaster risk reduction aims to prevent new disasters and reduce existing ones. Disaster risk reduction is an integral part of social and economic development and is essential if development is to be sustainable for the future (UNDRR, 2023).

1.8.5 Early warning systems

Early warning systems refer to an integrated system designed to detect potential hazards and provide timely information to communities, individuals, government, businesses and others to take action and prepare for impending danger (United Nations, 2025). Such a system includes four interrelated key elements: disaster risk knowledge, hazard detection and monitoring, dissemination and communication of hazard information and preparedness at all levels to respond to warnings.

1.8.6 Community-Based Early Warning Systems (CBEWS)

CBEWS is a system developed, managed, and maintained by the community, allowing communities threatened by hazards to act in a timely and appropriate manner (IFRC, 2020). This helps reduce loss of life, injury, loss of livelihood, property damage, and environmental harm.

1.8.7 Tailings storage facilities (TSFs)

TSFs are engineered structures designed to contain waste material known as tailings, which are left over from mining processes. A TSF often grows over the life of the mine to accommodate increasing waste volumes. There are three types of TSF construction: upstream construction, downstream construction and centreline construction (Hudson-Edwards et al., 2024). The choice of design is based on factors such as location, climate conditions, geology, seismicity, construction materials and the nature of the tailings (Hudson-Edwards et al., 2024). The TSF in this study comprised the Jagersfontein tailings dam that stores mine waste generated from mining operations.

1.8.8 Regulatory framework

A regulatory framework is a system of rules, laws and guidelines designed to ensure compliance. These frameworks establish clear standards for industries and sectors, providing consistency and accountability. They protect consumers, the environment and public interests by enforcing safety and quality requirements.

1.8.9 Stakeholders

Stakeholders are groups, organisations, or persons that have an interest in or are affected by the decisions and activities of a business, project, or organisation. This study's stakeholders included the Jagersfontein Development Company, Kopanong Local Municipality, the DWS, the Department of Mineral Resources and Energy (DMRE), and emergency services responsible for responding to emergencies.

1.9 Sequence of Chapters

The study comprises five chapters. Chapter 1 introduced the background of the research topic. The chapter also included a problem statement, aims and objectives, the significance of the study, definitions, and key terms used throughout the study.

Chapter 2 focuses on literature and theoretical frameworks relevant to the research topic. The chapter discusses the early warning systems framework and mining laws and regulations that promote safety, environmental protection, and social responsibility. The chapter also focuses on TSFs and best international practices for managing them.

Chapter 3 presents the research design and the secondary data collection method suitable for the study. The chapter discusses the target population and the sampling techniques used. The chapter also focuses on ethical considerations and limitations of research design.

Chapter 4 presents and discusses the results from secondary data. The evidence for this chapter originated from secondary data obtained through thematic analysis of the data.

The final chapter presents a conclusion to the study. The chapter outlines the findings and recommendations based on the results. Lastly, the chapter makes a recommendation for further research on early warning systems.

CHAPTER 2:
LITERATURE REVIEW

2.1 Introduction

Globally, mining activities are conducted in over 100 countries, where mining companies extract minerals and metals to meet industry demands (Lumbroso et al., 2019). Most of these countries are classified as low and middle-income economies. Furthermore, mining companies contribute significantly to employment, providing direct employment to over 40 million people globally and indirectly supporting 200-500 million individuals (Kossoff et al., 2018). Despite the industry's economic benefits, mining companies have been associated with high risks and generate vast volumes of waste, often affecting communities located nearby (Bowers, 2024).

The industry generates billions of tons of discarded waste rock and approximately 13 billion tons per year of toxic wet slurry waste, known as tailings (Hudson-Edwards et al., 2024). These tailings are stored TSFs, which are the world's most significant engineered structures, holding large volumes of waste material (Larrauri, 2017). Some facilities exceed 500 metres of crest length with heights greater than 30 metres (Denyo, 2019).

These structures are the most common disposal system for mining waste and have been used for over a hundred years (Denyo, 2019). It is estimated that there are over 20,500 TSFs worldwide, comprising active, inactive, closed, and abandoned facilities (Hudson-Edwards et al., 2024). These facilities are intended to hold tailings permanently. To achieve this, mining companies must consider the site conditions when constructing TSFs, as well as the location conditions, including topography, seismic activity, rainfall, mineral characteristics, and proximity to the nearest communities (Denyo, 2019). This will ensure that the tailings are safely contained and that the environment and communities are shielded from risks associated with mine tailings (Denyo, 2019).

Although mining hazards differ from natural hazards, they both require early warning systems and preparedness measures. CBEWS have been widely implemented in communities vulnerable to and at risk of natural hazards and have proven effective in

strengthening community resilience by enabling local participation in risk assessment and preparedness (Domingos and Nagamatsu, 2024). Similarly, the Disaster Management Act 57 of 2002 (DMA) emphasises the importance of including the community in disaster risk reduction measures to mitigate the impact of hazards. However, there is currently a gap in the presence of CBEWS in mining towns. As a result, communities in mining towns often lack access to risk information associated with TSFs and early warning systems, leaving them vulnerable to hazards.

This chapter aimed to explore the potential of CBEWS to reduce the impact of disaster risk in mining towns. The first section of the literature explored key themes, including the definition of disaster and the framework of early warning systems. The section also outlines the principles and components of CBEWS, presenting case studies that illustrate the successful implementation of CBEWS.

The second section of the literature defined tailings and their different storage methods. The study examined case studies that illustrate the impact of the failure of these facilities, as well as best international practices and innovations that should be implemented to manage these facilities throughout their lifetime.

2.2 Disaster

Historically, the concept of disaster has been interpreted from various perspectives. For the focus of this section, the term ‘disaster’ was viewed from both dominant and alternative perspectives, thus analysing the relationship between the environment and society. The dominant perspective conceptualised disasters as external events originating from natural or technological hazards (Flint and Luloff, 2005). This perspective defines disaster as a sudden external event caused by nature, and the community is portrayed as the helpless victim (Flint and Luloff, 2005). The consequences of such events include loss of life, property damage, and disruption of daily activities. Recovery, according to this perspective, depends on external assistance from the government institutions and emergency services agencies (Flint and Luloff, 2005). Communities are regarded as recipients of assistance during a disaster rather than participants in managing disaster risk.

In contrast, the alternative perspective emphasises the social dimensions of disaster. Factors such as race, gender, poverty, and educational level have a negative impact

on the community's preparedness for disasters (Peek, Wachtendorf, and Meyer, 2021). This viewpoint gained popularity from 1947 to the 1970s, a period marked by an increase in disaster-related deaths in developing countries (Heijmans, 2009). Disasters were associated with the growing vulnerability of people to the physical environment. Vulnerable communities often reside near key resources, such as water, land, or employment opportunities, which increases their risk exposure (Seddiky, Giggins, and Gajendran, 2021).

This pattern was also evident in Jagersfontein, where the township settlements of Itumeleng and Charlesville were constructed downhill of the mine and its tailings facility (Motsau, 2022). The mining company and local government failed to meaningfully engage these communities regarding the potential risks associated with living near the tailings facility (Marais et al., 2024). The proximity of these vulnerable communities to the mining resources consequently placed them at risk, reflecting the alternative perspective that disasters emerge from the interaction between hazardous conditions and social vulnerability (Seddiky, Giggins, and Gajendran, 2021).

2.3 Early Warning Systems Framework

The United Nations' early warning system is a people-centred framework. The system, as depicted in the diagram below (Figure 2.1), comprises four elements: risk knowledge, monitoring and warning services, dissemination and communication, and response capability (United Nations, 2025). These elements are interdependent and rely on each other for a successful early warning system (United Nations, 2025). Therefore, the failure of one element affects the entire system.

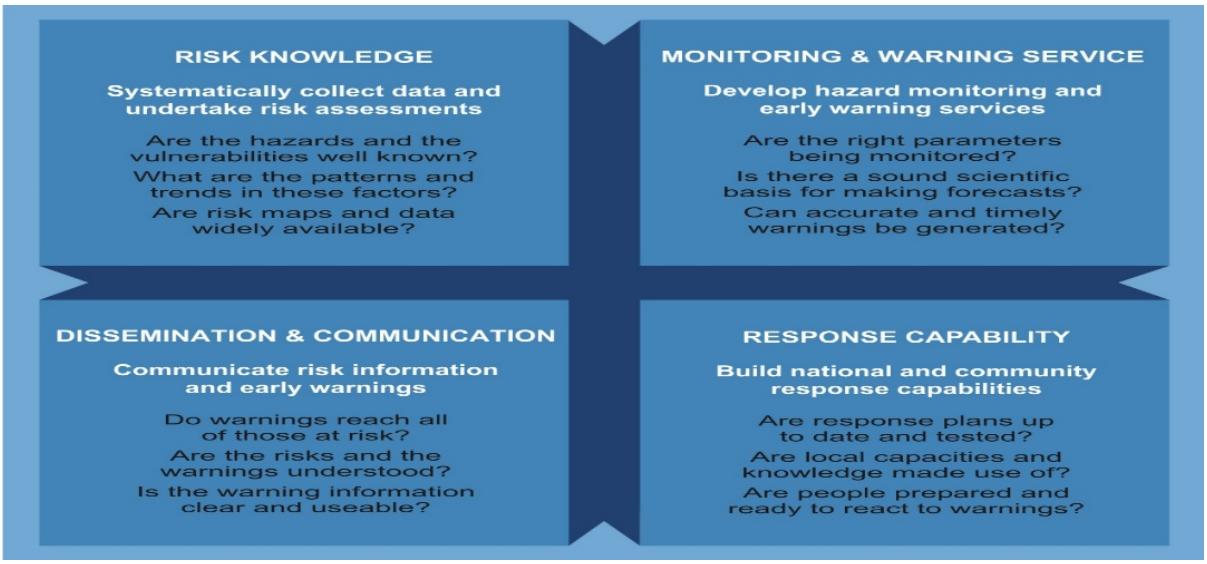


Figure 2.1: United Nations' Early Warning Framework (United Nations, 2025)

2.3.1 Risk knowledge

Disaster risk knowledge is based on a systematic collection of data and disaster risk assessment (UNDRR, 2024). Mining communities that are aware of the risks associated with hazards are empowered to mitigate and manage the challenges of impending disasters. Their capacities and available resources enable them to implement appropriate measures to prepare for and respond effectively to mine-related disasters (UNDRR, 2025b).

2.3.2 Monitoring and awareness

The monitoring and warning service focuses on hazard detection, monitoring, analysis, forecasting, and potential consequences (UNDRR, 2024). Establishing and implementing warning technologies and monitoring stations allows the mining town communities to detect imminent disasters. The early detection of disasters provides at-risk communities with sufficient time to notify other members and initiate evacuations effectively (United Nations, 2025).

2.3.3 Dissemination and communication

Warnings and messages produced by the government or communities must be communicated to individuals at risk (United Nations, 2025). The messages must be disseminated through various sources and channels, such as short text messages (SMS), sirens, megaphones, radios, telephones, television or flags (Domingos and

Nagamatsu, 2024). The information must always be clear, understandable, and accurate (UNISDR, 2015). Detailed information, such as location, scale, potential impact of the disaster, mitigation measures, response actions, evacuation routes, and shelter locations, should also be provided (United Nations, 2025).

2.3.4 Response capability

Response capability refers to the preparedness at all levels to respond to received warnings (UNDRR, 2024). This is achieved through collective disaster education programmes, contingency plans based on available resources and assigning roles and responsibilities to local leaders (Domingos and Nagamatsu, 2024). Continuous drills, education programmes and feedback can improve the response strategy.

Early warning systems exist at the global, national, and local levels, which are determined by the type and size of the disaster, as well as the capabilities of the various levels to address a catastrophe (Gonzales et al., 2013). Indigenous communities have their undocumented warnings that have existed for decades (Nyong, Adesina, and Elasha, 2007). These communities might resist the implementation of the system. However, this can be resolved by including indigenous knowledge in the early warning system (Mwaura, 2008), thereby ensuring the community's full support and ownership of the system. Disaster management agencies must empower local communities to share their knowledge and avoid intimidation by outsiders. Global warnings of imminent disasters are often communicated in scientific terminology and a foreign language, requiring governments to relay the message to the people (UNDRR, 2025b). The implementation of warnings requires political will; if the government is not convinced by the message, it will likely not reach the at-risk individuals (UNISDR, 2009).

2.4 Community-Based Early Warning System

Early warning systems are a crucial component of disaster risk reduction (Domingos and Nagamatsu, 2024). Community members are often the first responders in disaster events and are thus also among the first to suffer the adverse effects (Shakeri, Vizvari, and Nazerian, 2021). Therefore, warning messages should be directed to at-risk communities and provide them with relevant information on hazards (Macherera and Chimbari, 2016). This will enable the communities to assess risk levels and make

informed decisions to protect themselves, subsequently reducing the potential harm or loss resulting from disasters (IFRC, 2020).

A community in CBEWS is a social network exposed to physical or social vulnerabilities (IFRC, 2020). A top-down and bottom-up approach characterises the system. The top-down approach is a hazard-centred early warning system that focuses on collecting, analysing, and interpreting data (Domingos and Nagamatsu, 2024). Data is collected from monitoring tools, such as satellites, meteorological agencies, and sensor networks, and then transformed into warning messages for decision-makers (Domingos and Nagamatsu, 2024).

The bottom-down approach is the final stage where early warning messages are generated by monitoring systems and disseminated to at-risk communities. (Domingos and Nagamatsu, 2024). The warning messages are transmitted through mobile phones, sirens, local networks and community leaders (Glantz, 2009). The at-risk communities must understand the system and provide feedback to participants who developed and issued the warning (Glantz, 2009). The two approaches rely on each other to create a collaborative and feedback-driven system.

The CBEWS approach is considered the most effective method for disaster risk reduction at the community level. It requires the involvement of the at-risk community in the multi-hazard identification process. The formulation and establishment of the system must be done within the confines of the social structures of the communities (McLeroy et al., 2003). CBEWS facilitates communication channels between communities, local government and other stakeholders involved in disaster management (UNISDR, 2009). It encourages the participation of at-risk communities, especially children, youth, women, persons with disabilities, Indigenous groups and immigrants, in formulating and implementing early warning systems (UNISDR, 2015). This creates ownership of the system and enhances sustainability. The system is cost-effective because it leverages local knowledge and available resources, making it particularly suitable for developing countries that face financial constraints in disaster risk reduction (Domingos and Nagamatsu, 2024).

2.5 Case Studies Demonstrating Effective CBEWS

The CBEWS approach has been widely implemented to reduce disaster risk at the community level, particularly in areas prone to natural hazards (Domingos and Nagamatsu, 2024). This section presents case studies of countries that have successfully implemented CBEWS.

2.5.1 Bangladesh

The government of Bangladesh, in collaboration with the communities of coastal areas and the International Federation of the Red Cross, established and implemented the Bangladesh Cyclone Preparedness Programme (IFRC, 2018). The programme educated communities in coastal areas about the importance of early warning messages and the importance of evacuation during emergencies. As a result, more than half a million people were evacuated to places of safety before Cyclone Mora in 2017 (IFRC, 2018). This case study demonstrates how a collaborative and people-centred EWS reduced disaster risk and enhanced the community's resilience.

2.5.2 Mozambique

Mozambique is a country prone to cyclones, and for the first time in history, people in Mozambique were prepared for Cyclone Freddy. The day before the hurricane struck on February 24, 2023, radio stations, car-mounted megaphones and authorities across the country were urging people to relocate to shelters on higher ground (UNDRR, 2023). When the cyclone landed, most of the population had already relocated to safe areas with food and water supplies (UNDRR, 2023). This significantly reduced the impact of the disaster on people's lives. This case study illustrates how timely warnings, effective communication channels, and organised evacuation planning can minimise the loss of life during a climate-related event.

2.5.3 Somalia

Somalia is a country that experiences various weather-related disasters, mainly due to the effects of climate change. Thus, Action for Women and Children Concern, a non-governmental, grassroots Somali organisation, collaborated with various organisations and agencies to implement a project aimed at raising awareness about climate change (UNOPS, 2021). The organisation also collaborated with the local government and

radio and media sites to develop an early warning system for climate-related events (UNOPS, 2021). This case study demonstrates how community-based organisations, when supported by government and the media, can strengthen early warning capacity by improving information sharing, enhancing local knowledge and promoting proactive disaster preparedness.

2.5.4 Nepal

Nepal is a country prone to natural disasters, and the 2015 Gurkha earthquake had a widespread impact across the country (UNDRR, 2024). To strengthen disaster preparedness in communities, scientists from various universities collaborated with the Government of Nepal to implement an early warning system that provides timely messages to protect people living in landslide-prone areas (UNDRR, 2024). The system offers accurate alerts days and weeks in advance, allowing people sufficient time to prepare or evacuate (UNDRR, 2024). This case study illustrates that collaborative action can facilitate the development of advanced early warning technologies that reduce the impact of risk in hazard-prone areas.

2.6 Tailings

2.6.1 Background

Mining produces economic and non-economic products generated from the mineral processing plants. Economic products are sought-after materials, such as copper, gold, uranium, and bauxite (Denyo, 2019). Non-economic products are waste materials left over after mineral processing, called tailings (Schoenberger, 2016). Tailings are crushed rocks composed of particulate matter, process water, and chemicals (Denyo, 2019). Tailings can contain sulphide material that can cause acid drainage, as well as other processing chemicals and fluids that are often toxic, radioactive, and corrosive (Schoenberger, 2016).

Tailings are stored by directly depositing mine waste into water bodies, such as rivers, lakes, or the sea (Hudson-Edwards et al., 2024). However, this storage method is often associated with severe environmental damage. As a result, most countries have strict regulations that restrict mining companies from pursuing this type of strategy (Hudson-Edwards et al., 2024). Some mining companies backfill tailings into pits left over from underground mining. Mining companies do not favour this storage method because it

increases the costs associated with further processing of tailings that are placed back underground (Hudson-Edwards et al., 2024). Alternatively, tailings can also be deposited in TSFs made of natural or mined-out pits or an on-surface impoundment with a dam (Hudson-Edwards et al., 2024). This type of storage method is the most commonly used by mining companies.

2.6.2 Tailing storage facilities

TSFs or dams are the most commonly used storage method favoured by large-scale mining operations. They are considered cost-effective because they are constructed using local soil, coarse rock, and tailings (Adamo et al., 2021). The dams have a large storage capacity and a flexible design that scales with the facility's increasing capacity (Edwards, 2019). The direction in which the dam crest raises is either upstream, centreline, or downstream; these sequential raises are illustrated in the diagram below (Figure 2.2). Upstream construction is the most cost-effective but the least stable, as it relies on the stability of the tailings as the foundation for dam construction (Davies, Martin, and Lighthall, 2000). This construction method has been involved in most failures worldwide (Chambers and Higman, 2011).

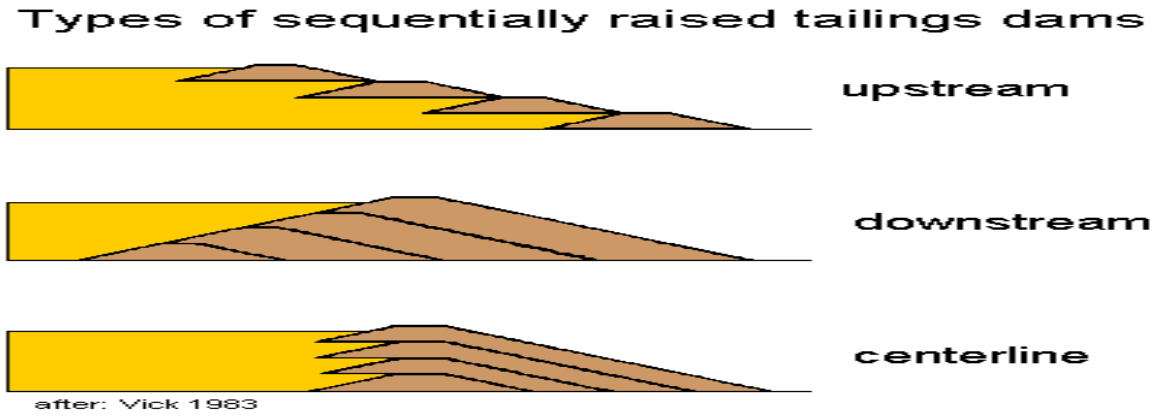


Figure 2.2: Sequentially Raised Tailings Dam (WISE Uranium Project, 2023)

The 2021 information disclosure by multiple global mining companies revealed that upstream tailings dams were the standard type of TSF in the 20th century; however, there was a shift to downstream tailings between 2010 and 2020 (Hudson-Edwards et al., 2024). The shift was prompted by concerns about the frequent failures of upstream dam construction (Hudson-Edwards et al., 2024). The information disclosure also revealed that active upstream dams had the highest incidence of stability concerns, irrespective of whether the dams were constructed in developing or

developed countries (Hudson-Edwards et al., 2024). Thus, countries such as Brazil, Ecuador, Chile, and Peru, which experience high rainfall and seismic activity, have banned the upstream construction of tailings dams due to concerns over stability (Hudson-Edwards et al., 2024).

2.6.3 Failures

There are at least 3500 tailings dams worldwide. However, their construction and care are a new concept to mining companies and society (Chambers and Higman, 2011). These facilities require strict monitoring by the mining company, even after the mine has permanently closed (Lumbroso et al., 2019). For the past 30 years, there have been two to five major tailings dam failures per year (Davies, Martin, and Lighthall, 2000). Failures usually involve a combination of human and physical factors.

Human factors involve errors in the facility's location, construction, design, and maintenance (Edwards, 2019). This is due to the rush for natural resources, which often involves not adhering to engineering standards in the global mining industry (Azam and Li, 2010). Failures that occurred due to human factors increased from 10% from 1910 to 1999 to 30% from 2000 to 2009 (Azam and Li, 2010). Other contributing human factors include company management culture and the industry regulatory context within which these facilities operate (Hudson-Edwards et al., 2024). Examples include the normalisation of a mining company deviating from adequate engineering standards, the challenge of safety concerns reaching management and remuneration incentives that favour short-term production over safety (Hudson-Edwards et al., 2024).

The physical factors contributing to failure include extreme weather events (resulting from climate change), earthquakes, foundation and slope failures caused by structural weaknesses, and water seepage or poor drainage (Edwards, 2019). The intense rainfall conditions due to climate change increased from 25% before 2000 to 40% after 2000, especially at mine sites located in coastal areas (Azam and Li, 2010). The physical factors can often account for what happened, and the human factors can help explain why it happened (Hudson-Edwards et al., 2024).

2.6.4 Failure impacts

Since 1915, an estimated 257 TSF failures have occurred, releasing 250 million cubic metres of tailings (Hudson-Edwards et al., 2024). The most apparent impacts of TSF failure are loss of lives, injury, and destruction of property and livelihood. The failures have killed an estimated 2650 people and affected 317,000 individuals through loss of livelihood, displacement, risk to health and property damage (Hudson-Edwards et al., 2024). Exposure to metals and metalloids can pose a health hazard to the population. These contaminants can enter the human body through skin contact, inhalation of contaminated dust and accidental ingestion of contaminated water and food (Hudson-Edwards et al., 2024). The impact of contaminants depends on the volume and dispersal of contamination, as well as the success and speed of remediation (Hudson-Edwards et al., 2024). It has been proven that women in developing countries are the most affected by TSF failures, as they are generally responsible for collecting water where there is no potable water supply (Lumbroso et al., 2019). The frequent use of contaminated water by women for cooking and cleaning has a significant impact on their health (Lumbroso et al., 2019).

TSF failures have contributed to environmental damage by diverting river channels, flooding floodplains, and impacting coastal areas (Hudson-Edwards et al., 2024). The poisoning of these areas has rendered them unusable, costly, or challenging to reclaim (Adamo et al., 2021). The accumulation of contaminated waste has poisoned plants, contributing to the loss of animals and human life (Adamo et al., 2021). Acid mine drainage in old and abandoned tailings dams has contributed to environmental damage (Lumbroso et al., 2019). This is because the tailings dams were not designed, constructed, or operated with awareness of the environmental impact of acid mine drainage. Furthermore, no provisions were made to minimise the generation of acid leachate from entering groundwater or surface water (Lumbroso et al., 2019).

TSF failures can also compromise a population's physical and mental health through the stress of displacement, loss of livelihood, loved ones and loss of cultural identity (Hudson-Edwards et al., 2024). Additionally, a contaminated environment can affect the area's ecological tourism (Hudson-Edwards et al., 2024). This can reduce the number of tourists in the area, negatively impacting the local economy and the community's livelihood. Moreover, these failures have financial implications, including

litigation for the mine company through criminal and civil proceedings, fines and penalties, and reputational damage (Hudson-Edwards et al., 2024).

The impact of tailings dam failures on the environment and communities can be attributed to poor land-use planning, an ineffective understanding of risk, inadequate risk communication, and the absence of early warning systems (Edwards, 2019). The three most serious TSF failures documented globally are the Mount Polley failure in Canada (2014), the Fundão failure in Brazil (2015), and the Brumadinho failure in Brazil (2019). These three catastrophic failures resulted in fatalities, loss of livelihoods, property damage, and environmental harm.

2.6.5 Failure case studies

2.6.5.1 *Mount Polley Failure in Canada*

In August 2014, Canada experienced its largest mining disaster when the Mount Polley Mine, owned by Imperial Metals, had a tailings dam failure, releasing 24.4 million cubic metres of toxic waste and sludge into nearby rivers, lakes, and streams (Timperley, 2014).

The failure caused widespread environmental damage. The breach severely contaminated the Fraser River, which spans 1375 kilometres across the province of British Columbia, with many First Nations residing along the river system (Shandro et al., 2017). The residents considered the river essential for salmon fishing and other traditional activities. The harvesting and hunting practices were nutritionally critical and economically beneficial for the First Nations (Shandro et al., 2017), as they enabled them to feed their families without relying on expensive, less nutritious, store-bought food.

There were early warnings of the imminent tailings failure, but Imperial Metals ignored the warnings. In 2009, an environmental consultant assessed the mine for Imperial Metals and the local First Nations groups (Sheppard, 2014). The assessment revealed that the pond levels exceeded the authorised levels of five years ago (Sheppard, 2014). In 2012, Imperial Metals failed to report the excess height of wastewater, resulting in the pond overflowing and releasing an estimated 150 cubic metres of wastewater over 13 hours (Sheppard, 2014). In April 2014, prior to the failure, the mine experienced high flows due to the spring melt, which blocked the pump system and resulted in

overflowing wastewater (Timperley, 2014). Later in the same year, the Ministry of Environment gave Imperial Metals five warnings for exceeding the permitted heights of wastewater within its tailings pond (Timperley, 2014). Furthermore, a report commissioned by two First Nations groups and funded by Imperial Metals stated that the mine had not developed a detailed monitoring or emergency contingency plan (Sheppard, 2014).

Following the tailings breach at Mount Polley, a local state of emergency was declared, and a temporary ban was imposed on using water from the area (Timperley, 2014). The failure left residents concerned about the long-term effects of the contaminated water on their health, commercial fishing activities, and their financial stability and future job prospects.

2.6.5.2 *Fundão and Brumadinho Failures in Brazil*

The Vale S.A. and BHP Billiton are two of the world's largest mining companies based in Brazil. The mining companies are committed to sustainable development and responsible tailings management (Owen et al., 2020). However, they have destroyed lives and the livelihoods of thousands of local communities in two of the worst environmental disasters in Brazil's history (Owen et al., 2020).

The Fundão Dam, controlled by Samarco, a subsidiary of Vale S.A. and BHP Billiton, housed mine waste equivalent to 16,000 Olympic-sized swimming pools (Bowers, 2024). On November 5, 2015, the dam wall broke, releasing 43 million cubic metres (80 % of the total contained volume) of tailings down the Deco River Valley, killing 19 people, destroying villages and bleeding out into the Atlantic Ocean (Bowers, 2024). The TSF failure negatively impacted 5,000 streams, 16 hectares of permanent conservation area along the Doce River Basin, and 1,200 hectares of riverbanks (Larrauri, 2017). Thousands of people were left without access to clean water, subsequently affecting their livelihoods (Torres, 2015). A total of 218 buildings were destroyed, including public buildings, churches, farms, and residences (do Carmo et al., 2017). Furthermore, 21.1 kilometres of rural roads, 12 bridges and a small hydroelectric plant in Bicas were destroyed (do Carmo et al., 2017).

The dam has experienced problems and challenges since it started operations. It presented challenges with its drainage systems and showed signs of erosion (Phillips, 2018). In 2014, a consultant warned the Samarco Company that static liquefaction

could be present; however, mining activities continued, resulting in an increase in the dam's height (Phillips, 2018). When the dam broke, there was no warning siren for the residents; instead, they warned each other by telephone calls (Phillips, 2018). Furthermore, although the dam was equipped with devices that measured the liquid pressure and water level, several of these were either not functioning or had been relocated to another dam (Phillips, 2018).

The mine owners had underestimated the extent of damage caused by the dam's rupture. The Fundão tailings failure can be regarded as one of the most significant technological disasters ever recorded, due to the volume of tailings released and the resulting environmental damage. Consequently, 21 company executives were charged with qualified murder, and there was a halt in mining operations (Larrauri, 2017). Moreover, the mine faced high financial and reputational costs.

In January 2019, after Vale S.A. vowed never to be associated with such a catastrophic event again, a second Vale's B-I dam collapsed in Brumadinho, killing an estimated 270 people and sending 9.7 million cubic metres of waste into the Paraopeba River (Earthworks, 2025). At the time of the dam rupture, around 600 people were gathered at the mine's canteen and administrative area (Phillips, 2019). Among the victims were miners, tourists, and local communities. The mine waste and contaminated water affected 26 municipalities, as well as the local fauna and flora (Pacheco et al., 2022), leaving a significant environmental and social impact.

A report commissioned in 2020 found that Vale was aware of the instability of its B-I dam as far back as 2003 but ignored the concerns (Earthworks, 2025). Studies conducted after the failure identified that the dam collapse was due to structural instability caused by liquefaction, citing inadequate drainage of the reservoir and a dam not designed to contain liquefied material (Boadle and Slattery, 2020). Moreover, recommendations were made to the mining company to develop a contingency plan and community escape drills, but none were in place when the dam wall broke (Timson, 2019). Instead, the community heard the sound of the dam rupture, the screams of people they loved and warnings from strangers (Timson, 2019). Thousands lost their homes and livelihoods in the Mount Polley, Fundão and Brumadinho dam failures. Both dams were built using the upstream storage method.

Based on the case studies, it is evident that tailings management poses a significant global challenge to safety and sustainability, requiring improvements in policy, reporting standards, and the creation of well-established disaster risk reduction strategies.

2.7 Disclosure

There has been a global call from society, governments, international agencies, and the media for the mining industry to disclose the interactions between tailings facilities, communities, and the environment (Kemp et al., 2024). This call follows a series of failures in which the local community and workers had limited prior knowledge about the risk of TSF failures (Kemp et al., 2024). TSF failures disrupt the functioning of local communities, resulting in loss of life, livelihoods, and damage to property and the environment. Therefore, these failures should be viewed as disasters because the affected community often cannot recover on its own means (Owen et al., 2020). The failures tend to be large in scale and have long-term impact on the community and the environment (Hudson-Edwards et al., 2024).

Mining companies often withhold tailings-related information from local communities, as this provides companies with a proprietary advantage over local populations in developing and operating hazardous tailings facilities (Owen et al., 2020). The local population is largely unaware of the likelihood and consequences of tailings dam failure; however, they are the first to respond in the event of failure and also the first to suffer the adverse effects (Shakeri, Vizvari, and Nazerian, 2021).

Therefore, mining companies should provide warning messages and relevant information on hazards to the at-risk communities (Macherera and Chimbari, 2016). This will enable the communities to assess risk levels and make informed decisions to protect themselves. Moreover, establishing and implementing warning technologies and monitoring stations will enable the mining companies and communities to detect imminent failures (Domingos and Nagamatsu, 2024). As a result, it will provide sufficient time for the mine companies to notify the at-risk communities and initiate evacuation efforts (United Nations, 2025). This will thus reduce the potential harm or loss from TSF failure (IFRC, 2020).

The mining industry's hesitancy to disclose is based on the theory that disclosure of information causes panic and fear. Furthermore, the industry's specialists believe that the information will be too complex for the community to comprehend (Kemp et al., 2024). However, the mining industry needs to acknowledge that how it communicates determines panic, not the act of disclosing (Owen et al., 2020). The industry must implement effective means to communicate important risk-related information to the community in a clear and meaningful manner, despite its complexity. By disclosing information through education programmes and contingency plans, the mining companies can help the community respond to TSF failures (Domingos and Nagamatsu, 2024). Furthermore, involving the at-risk communities in the planning, implementation and management of risk reduction efforts through the utilisation of local knowledge and their experience will strengthen the relationship between them and the mining industry, promote awareness and understanding of risk, leading to better decision-making at all levels (Domingos and Nagamatsu, 2024).

2.8 Best Practices and Innovations

2.8.1 Background

In 2016, the International Council of Mining and Metals (ICMM) led a review report for its member companies on tailings standards (Owen et al., 2020). The report stated that mining companies have poorly implemented standards for managing tailings dams. This led the ICMM to release a statement committing its members to continuous improvement in tailings dam design, construction, and operations within a robust government framework (Owen et al., 2020). However, the ICMM statement failed to focus on social considerations or the requirement for public disclosure of information about tailings risks to local communities and the environment.

Following the Brumadinho disaster, the demand for mining companies to disclose information about the risks associated with their tailings facilities increased significantly. In 2019, various organisations, including the Church of England Pensions Board and the Swedish Council for the AP funds, supported by the UN-backed Principles for Responsible Investment, wrote to 683 listed mining companies, requesting that they provide public disclosure of the tailings facilities under their control (Owen et al., 2020). In response to the pressure from global organisations, agencies and the public, the members of the ICMM participated in a multi-stakeholder process.

They drafted a new global standard, the Global Industry Standard for Tailings Management (GISTM), which was launched in 2020 (Owen et al., 2020). The new standard required mining companies to disclose information about the setting, design, operation, management and closure of their tailings facilities (Owen et al., 2020). The information needs to be public so that local communities can engage meaningfully in discussions about public safety.

2.9 The Global Industry Standard for Tailings Management

The GISTM provides a framework for managing tailings facilities, emphasising zero harm to communities and the environment, and zero tolerance for human fatalities (Logan and Williams, 2021). It outlines the implementation of best practices for the facility's entire life cycle (planning, design, construction, operation, closure and post-closure) with consideration for social, environmental, governance and technical issues (Global Tailings Review, 2020). The ICMM released the Tailings Management Good Practice Guide in 2021, focusing on implementing the technical issues identified in the standard (Logan and Williams, 2021).

The standard outlines six topic areas, divided into 15 principles from which 77 requirements are derived. The six topic areas and their requirements for mine companies are summarised as follows (Global Tailings Review, 2020):

- **Topic 1: Affected Communities.** Mine companies must respect the rights of project-affected communities by obtaining and maintaining informed consent.
- **Topic 2: Integrated Knowledge Base.** Mine companies must develop and maintain an interdisciplinary knowledge base that encompasses social, environmental, local, and economic aspects. Furthermore, they must maintain an updated breach analysis of the facility, which will also help identify communities at risk.
- **Topic 3: Design, construction, operation, and monitoring of the tailings facility.** Mine companies must utilise all elements of knowledge to enhance the facility's resilience to climate change. They must also regularly update the assessment of climate change's social, environmental, local and economic impacts.

- **Topic 4: Management and Governance.** Mining companies must develop policies and systems to ensure the safe management of their facilities. This includes the appointment of an accountable executive, an independent board and experienced employees.
- **Topic 5: Emergency Response and Long-Term Recovery.** Mine companies must use best practices to prepare for emergency preparedness and response.
- **Topic 6: Public Disclosure and Access to Information.** Mine companies must practise transparency by making tailings-related information available to the public.

It is evident that this standard for tailings management adopts a holistic approach, aiming to ensure that communities and the environment affected by mining activities are factored into operational planning from the outset (UNEP, 2025). The Global Management Institute, based in South Africa, could oversee the implementation and conformance with the GISTM. The institute calls on all mining companies to become signatories, thereby committing to implementing the standard (UNEP, 2025). This will help mining companies strengthen relationships with regulators and affected communities, enhance investor confidence and provide access to preferred insurance coverage (UNEP, 2025).

South Africa is the leading country in terms of tailings management regulations and standards (Dladla and Ramsamy, 2022). The country's standards either meet or exceed the requirements of the GISTM in most areas. Therefore, it is expected that a tailings dam fully compliant with the country's regulations and standards should conform effortlessly to most of the GISTM requirements (Dladla and Ramsamy, 2022). Mining companies must endeavour to protect the safety of employees and the communities by diligently monitoring the conditions in and around the tailings facility (UNEP, 2025). Proactive measures taken by mining companies to comply with the standard's requirements can mitigate risks and enhance TSF safety. The standard encourages monitoring early signs of instability to ensure that preventative action can be taken and communities can be protected.

Mine companies must engage with the government, first responders, local authorities and other relevant stakeholders to ensure the effective implementation of the emergency preparedness and response plan (Infrastructure News, 2025). Moreover, mining companies must collaborate with local governments to provide disaster

management services and offer training to facilitate expected GISTM compliance (Infrastructure News, 2025). Furthermore, the standard encourages mine companies to engage with communities in emergency preparedness and risk assessment to enhance overall risk management (UNEP, 2025). This will enhance the community's knowledge and response in the event of a TSF failure, thereby reducing the loss of life and improving safety.

Mining companies must build constructive relationships with environmental groups to address social and environmental concerns. This relationship will help strengthen the company's social license to operate (Infrastructure News, 2025). The GISTM is strong on engagement and encourages the development of a collaborative emergency preparedness and response plan (Infrastructure News, 2025). This involves understanding the environment and collaborating with individuals affected by the project. This foundation is a gradual and ongoing process that can be strengthened with time and consistent transparency.

Despite the positive intentions of the standard, it has drawn criticism from stakeholders, academia, civil society, and industry experts. Although the industry promotes the GISTM to address the challenges of TSF facilities, the standard might fail to drive the anticipated change (Hudson-Edwards et al., 2024). This is because the standard is voluntary in nature; it is not a legally binding framework, and therefore compliance depends on companies' willingness to adopt and implement it, particularly those affiliated with the ICMM (Hudson-Edwards et al., 2024). This can limit the standard's global enforcement, especially in countries with weak regulatory frameworks (Hudson-Edwards et al., 2024). Without frameworks that enforce compliance, the standard is being implemented inconsistently across the industry.

Secondly, the GISTM places responsibility on mining companies to assess and manage risks internally. This approach facilitates a system of corporate self-regulation, raising concerns about accountability and transparency, especially in the context of weak regulatory oversight (Hudson-Edwards et al., 2024). The absence of a global body to monitor compliance reduces the credibility of reported compliance. Furthermore, critics argue that the requirements of the standards can make implementation expensive, especially for small- to medium-scale mining companies. This can lead to only well-resourced companies fully complying with the standard. Lastly, the standard does not sufficiently integrate tailings management with broader

environmental, social and governance goals (Hudson-Edwards et al., 2024). Tailings facilities are vulnerable to climate-induced events such as extreme rainfall and seismic activity. However, the standard does not guide the integration of climate change adaptation into facility planning and design (Hudson-Edwards et al., 2024).

2.10 Conclusion

Tailings management is a significant global safety and sustainability challenge that requires improvements in policy, reporting standards and well-established disaster risk reduction strategies. To effectively manage tailings facilities, mining companies must integrate early warning systems to monitor and address potential risks. A functioning early warning system ensures that communities receive timely, clear and actionable alerts during imminent disaster events. Therefore, mining companies must include at-risk communities in the risk assessment, mapping, preparedness and communication process. This will reduce the potential harm or loss of lives and livelihoods that a disaster event could cause. Moreover, mining companies must establish and implement warning technologies and monitoring stations in their TSFs to allow for the detection of imminent failures.

CHAPTER 3:
RESEARCH METHODS

3.1 Introduction

Research is a process driven by the research question, which defines the scope and purpose of the investigation (Cohen, Manion, and Morrison, 2018). The researcher must plan and decide on the research method that would suit the investigation (Pace, 2021). This involves deciding on participant recruitment and the assessment process while considering the timeframe and available resources (Pace, 2021). This research employed a case study design and a qualitative approach, utilising secondary data.

3.2 Research Design

A case study is a research approach to understanding real-life phenomena (Coombs, 2022). The case study method is ideal when the researcher is interested in “how”, “why”, and “what” questions (Gray, 2014). It investigates individuals, groups or events to gain a detailed understanding of the case subject and generate new theories and insight, thereby providing a deeper understanding of the issue (Coombs, 2022). A case study was suitable for this study because it allowed for the exploration and investigation of complex real-life issues (Zainal, 2007).

A single-case design was suitable for this study, as it involved the Jagersfontein community, which was affected by the tailing dam disaster due to not receiving an early warning alert of the imminent catastrophe. As a result, the disaster claimed lives, injured people, killed livestock, damaged the environment, and destroyed houses and infrastructure (Motsau, 2022).

A case study design enables multiple forms of data collection, capturing the population’s perception and reaction to a specific situation (Schoch, 2020). Insight into the details and complexities of the Jagersfontein tailing dam disaster was gained to obtain a better understanding of elements, such as early warning awareness and response. The case study method helped examine the background and environment of the study area (Coombs, 2022).

3.3 Qualitative Research Approach and Design

This study applied a qualitative approach. This approach captures the richness of social phenomena that are too complex to reduce to statistical analysis (Lim, 2024). The methodology provides tools necessary to understand the nuances of human experiences, behaviours and interactions (Lim, 2024). The qualitative approach relies on inductive reasoning, and the outcomes generate hypotheses (Lim, 2024). The researcher studies the phenomena in their natural settings in an attempt to effectively interpret people's realities and find solutions that are culturally sensitive and socially relevant (Bazen, Barg, and Takeshita, 2021). Therefore, in a qualitative paradigm, the researcher becomes the primary data collection instrument (Teherani et al., 2015).

This study utilised secondary qualitative data collected approximately nine months after the disaster through sixty semi-structured interviews. This helped gain deeper insight into the lived experiences and perspectives of the individuals in Jagersfontein before the tailings dam disaster.

An in-depth understanding of phenomena helped develop culturally sensitive and socially relevant theories relating to early warning systems (Islam and Aldaihani, 2022). Developing such theories helped policymakers and disaster management agencies address the challenges faced by communities in mining towns related to tailings dams. The approach ensures that the knowledge generated applies to the complexities and needs of the world by grounding research in the experiences and perspectives of individuals (Lim, 2024).

3.4 Data Collection Method

The study used secondary data. Secondary data refers to the use of data gathered by other researchers (Chivaka, 2018). Secondary data were suitable for the study because internal and external data relating to the Jagersfontein tailings dam disaster were collected and available. The internal secondary data collected was available from the UFS and managed by CDS following the disaster at Jagersfontein. Interviews were conducted with disaster victims, first responders (including community first responders) and government and mining officials. The dataset available at the UFS focused on the impact of the tailings dam disaster on the Jagersfontein community, as well as the complaints and warnings from residents regarding the overloaded tailings. Therefore,

the dataset provided insight into the timelines of community complaints and early warnings about the dam's structural damage. This research study received ethical clearance from the University of the Free State to conduct the study (see Appendix A).

External secondary data, such as government reports, reference books, and literature review articles on early warning signals and community safety policies in mining towns, were readily available on the internet and also consulted in this study. Experts in disaster management wrote literature reviews, discussing and listing all relevant publications from which the information was derived (Udu, Chukwuemeka, and Oti, 2018).

Using existing data in this study reduced the time and financial resources needed for data collection (Johnston, 2014). Moreover, the utilisation of existing quality data from different sources and perspectives on the Jagersfontein tailings disaster provided access to larger datasets with greater breadth and contained substantial depth (Chivaka, 2018). Furthermore, accessing the existing data accelerated the pace of this research because the most time-consuming step, data collection and measurement development, was eliminated (Johnston, 2014). This ensured that the research study was completed and that findings were provided on time, allowing for the development and contribution of new knowledge to occur promptly (Johnston, 2014).

A limitation of using secondary data was determining whether the data collected for primary research purposes were suitable for this research study (Salkind, 2007). To overcome this limitation, this study evaluated the methodology of the original studies by examining the sample size and sampling techniques, as well as the data collection methods and data analysis performed (Salkind, 2007). This approach assessed whether the data were collected in a manner compatible with the current research aims and objectives, thereby narrowing the search and avoiding irrelevant data.

3.5 Target Population

This study utilised secondary data; therefore, the study was constrained by the original data collection methods. This section outlines the target population and sampling techniques used in the study. The term 'population' in secondary data analysis refers to all members from whom the original data were collected, and the conclusion was made (Kabir, 2016). For this study, the population included the following:

3.5.1 Affected communities

The affected communities resided in the two areas of Jagersfontein known as Itumeleng and Charlesville. These areas are located downhill from the mine tailings dam; therefore, these residents were the most affected by the tailings dam disaster (Motsau, 2022).

3.5.2 Local authorities and government departments

The local authorities comprise Kopanong Local Municipality, which is responsible for establishing and implementing disaster management plans and early warning systems (Disaster Management Act 2002). Government departments are responsible for overseeing the tailings dam and ensuring community safety.

3.5.3 The mining company

The mining company in Jagersfontein is mandated to protect the local community, the environment and the mineworkers from the negative impact of mining activities (National Environmental Management Act 97 of 1998 [NEMA]).

3.6 Sampling Techniques for Secondary Data

Secondary data sampling involves selecting cases, people or data records from a larger population or dataset for analysis (Kabir, 2016). Since this study did not collect primary data, it selected existing datasets, reports, or cases that have been studied. This was achieved by using several sampling techniques, which are discussed next.

3.6.1 Purposive/judgement sampling

Purposive sampling involves selecting relevant and essential data that fit the research goals and objectives (Rahman, 2023). The chosen samples provide the researcher with an in-depth understanding of the phenomena (Subedi, 2021). Publicly accessible academic studies, media reports and datasets that discuss disaster preparedness and early warning systems were purposefully selected. Moreover, the study selected available media reports and interviews that provided rich information and testimonies on community early warning signals prior to the Jagersfontein disaster.

3.6.2 Saturation and sample size

Saturation is defined as the point at which the researcher has reached satisfactory data collection (Mthuli, Ruffin, and Singh, 2021). Data saturation was addressed by evaluating the relevance and quality of the secondary dataset in relation to the research topic. When the dataset provided the same information without adding new insights, it indicated saturation (Mthuli, Ruffin, and Singh, 2021).

Thematic saturation was achieved when new themes or explanations no longer provided new insight. The keywords that helped frame the study and structure the analysis were early warning signals, community monitoring, local knowledge, tailings dam failure, and disaster risk reduction. If the datasets lack richness and depth, additional sources, such as reports, government documents, and academic literature, were utilised. The approach helped fill potential gaps.

3.7 Secondary Data Analysis

The process of secondary data analysis is illustrated below (Figure 3.1).

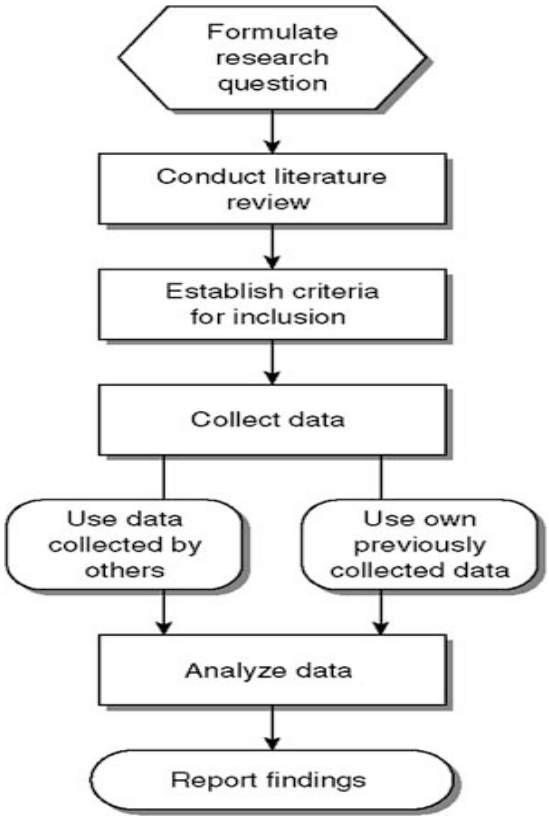


Figure 3.1: Steps in Qualitative Secondary Data Analysis (Salkind, 2007)

3.7.1 Formulate the research questions/objectives

The study objectives were as follows:

- To analyse the existing early warnings before the Jagersfontein tailings failure.
- To assess the community, mine and government response to these early warnings.
- To make policy recommendations in respect of tailing disasters and the role of early warning systems.

3.7.2 Conduct literature review

The literature review focused on the elements of disaster risk reduction and the key principles and challenges of CBEWS, particularly in relation to the Jagersfontein tailings dam disaster. The review encompassed laws and regulations governing mining activities and community safety.

3.7.3 Establish criteria for inclusion

This study employed several criteria to determine the appropriate match between the dataset and the research, ensuring the quality of both the primary study and the dataset. These criteria are outlined below.

- Determine who collected the primary data

The credentials of the sources or authors of secondary data or information were determined by scrutinising the educational background, past research work and experience in the current study field (Johnston, 2014).

- Determine the type of information collected

Determining the purpose of the original research study that produced the data was essential (Johnston, 2014). This influenced factors such as the target population, the sample selected, the wording of survey questions, and the study's context (Johnston, 2014). Furthermore, knowledge of the purpose of data collection helped determine the quality of secondary data, including the potential level of bias (Udu, Chukwuemeka, and Oti, 2018).

- Determine the date of publication

The date when the data were collected was considered because survey data typically takes time to be released and made available for use by other researchers (Johnston, 2014). This research study selected data collected in 2022 on the Jagersfontein tailing disaster. The data collected at that time was the most current in relation to the topic.

- Determine the methodology employed in obtaining the data

It is essential to understand the primary methods employed and the associated issues related to survey methods and instruments (Udu, Chukwuemeka, and Oti, 2018). This was important because the study had to determine the validity of the original measurement tool. Furthermore, this study examined how issues such as sampling, missing responses and bias were addressed in the primary research.

- Determine the management of the primary data

Collecting secondary documentation detailing the processes and protocols followed by the primary researchers was important (Johnston, 2014), including questionnaires, coding material and all publications relating to the research study.

- Determine the consistency of information obtained from one source with information available from other sources

This study employed multiple sources to increase confidence in the findings. The use of multiple sources either arrived at the same conclusion or did not provide the study with an option for contrast (Udu, Chukwuemeka, and Oti, 2018).

3.7.4 Collect data

The study collected secondary data to outline the challenges of CBEWS concerning tailings dam disasters and provided available techniques to address the problem (Chivaka, 2018). This yielded more accurate data than that collected through primary research (Udu, Chukwuemeka, and Oti, 2018). Secondary data were suitable for the study because internal and external data relating to the Jagersfontein tailings dam disaster were collected and available.

3.7.4.1 *Use data collected by others*

This study utilised secondary data collected by other researchers. The study utilised existing internal data from the UFS's database, including surveys and scholarly

journals, concerning the Jagersfontein tailings dam disaster. The scholarly journals featured articles of original research or experimentation written by experts in the field of Social Sciences, which have undergone peer review (Udu, Chukwuemeka, and Oti, 2018). External secondary data, including government reports, reference books, and literature review articles on early warning signals and community safety policies in mining towns, were collected and utilised.

3.7.5 Analyse data

This study applied thematic analysis. This was achieved by gathering all the collected data and assessing it for relevance to the research objectives (Hecker and Kalpokas, 2025). Irrelevant data was removed, and the relevant data was organised into manageable formats for analysis (Hecker and Kalpokas, 2025). The secondary data in this study were coded. Coding involves labelling segments of data with short keywords, ideas or phrases that summarise the content (Johnston, 2014). Data was coded into keywords, ideas or phrases relating to early warning systems, disaster preparedness, tailing disasters, policies on community safety and community participation.

Once the data were prepared, the researcher conducted the iterative process of coding the data and identifying themes (Hecker and Kalpokas, 2025). This was achieved by reading the data multiple times, refining and grouping codes into potential themes (Johnston, 2014). The aim was to condense the data into a set of themes that captured the essence of the data in relation to the research objective. Similar codes were merged into broader themes, such as a lack of community awareness, mine community safety, and policy gaps.

Moreover, similar case studies on tailings dam disasters were compared globally and nationally. This provided insight into how local policies and the government can be adjusted based on the lessons learned and best practices.

3.7.6 Report findings

The identified themes were interpreted in relation to the research objectives. Each theme was analysed in detail by considering how they interacted and what they revealed about the data (Hecker and Kalpokas, 2025). For example, themes had to explain the effectiveness of early warning systems. The implications of the identified

themes were to draw meaningful insights from the research study (Bazen, Barg, and Takeshita, 2021).

3.8 Ethical Considerations

The study was sensitive to ethical behaviour, as it involved researching people and their relationships with one another and the world (Walliman, 2011). The study adhered to acceptable ethical conduct to minimise potential harm that might result from conducting or publishing this study (Walliman, 2011).

3.8.1 Research aims and objectives

This study's research aims and objectives aligned with the UFS's ethical standards. Thus, the research aims and objectives did not harm the reputation, dignity or privacy of the population under study; instead, the study results aimed to benefit society by recommending policies concerning tailings dam disasters and the role of early warning systems.

3.8.2 Use of language

The research study utilised terminology as accepted by the UFS. Therefore, the study avoided bias, discrimination and stereotyping.

3.8.3 Dealing with participants

This study utilised qualitative secondary analysis; therefore, the researcher did not interact face-to-face with participants. However, participants' confidentiality in secondary data was assured by using data that included provisions for secondary data analysis in the original consent form (Tripathy, 2013). In addition, the study utilised data that did not contain participant identity information, and the ownership of the original data was acknowledged in the research study.

3.8.4 Storing data

The Protection of Personal Information Act 4 of 2013 (POPIA) stipulates the conditions for collecting personal information. The Act outlines the rights of participants and the responsibility of the compilers and holders of the information. This study protected the data by storing it in a secure storage system that was protected from unauthorised

access (Tripathy, 2013). Data in the form of hard copies was stored in secure, locked storage, and data in the form of soft copies was stored in encrypted files on a laptop, protected by a password.

3.8.5 Cite and reference the data

The data sources used in this study were cited and referenced in accordance with the Harvard referencing method. A list of references is included at the end of the study, detailing all the data sources used and their original authors. This step was essential to avoid plagiarism and enhance the credibility and trustworthiness of the research study (Bazen, Barg, and Takeshita, 2021).

3.9 Limitations

The use of a secondary dataset presented the following limitations:

- Warning-related questions were indirect.
- As interviews were conducted months after the disaster, some participants had no clear recollection of what transpired during the disaster.
- The transcripts were a difficult read due to the translation from the participants' languages into English.

Despite these limitations, the dataset provided rich and insightful qualitative evidence on how community members in Jagersfontein perceived and acted upon hazard warnings, offering lessons for improving CBEWS in similar areas.

3.10 Conclusion

A secondary qualitative data approach was used to analyse existing data, documents, reports and academic literature. The use of credible and relevant secondary data ensured that the study explored the research objectives. This methodological approach was therefore well-suited to the nature and scope of the study, providing a solid foundation for the results and findings presented in the chapters that follow.

CHAPTER 4:
RESULTS

4.1 Introduction

This chapter analyses secondary data and external sources collected before and after the Jagersfontein tailings dam disaster. The secondary data used for this study were obtained from UFS. The dataset comprised 56 interviews conducted from May 2023 to August 2023 with Jagersfontein disaster victims, community first responders, and government and mining officials. The external sources included academic journals, online reports and memoranda written by the community of Jagersfontein. The dataset aimed to explore the experiences and responses of residents during the catastrophic event. For this study, the analysed data were used to understand the extent to which CBEWS existed and functioned before and during the disaster. As highlighted in previous chapters, limited data exists on the effectiveness of CBEWS in mining towns. Communities are often regarded as recipients of alerts rather than active participants in disaster risk management and mitigation.

By analysing community accounts, this chapter presents the gaps between policy intentions and community realities, particularly in relation to risk communication, preparedness, and response coordination. The analysis further examines how local knowledge, informal warnings, and social networks influenced the speed and effectiveness of the response following the collapse of the dam wall. These insights are critical for understanding the socio-institutional dynamics that shaped the disaster outcomes in Jagersfontein and for informing the development of more inclusive, community-centred early warning systems in mining regions.

The chapter is structured as follows: Section 4.2 outlines the historical battle for the mine ownership between De Beers and the community of Jagersfontein. The section aims to reveal the deep-rooted social, economic and institutional issues that contributed to the vulnerabilities within the community and the tailings disaster. Section 4.3 presents the central theme of pre-disaster warnings that emerged from the data, including enforcement of regulations, neglect of community warnings and undermining local knowledge. Section 4.4 discusses the theme of early warning and

communication systems, including sub-themes such as structural warning signs present before the disaster, the false sense of security the community experienced, and the communication methods used by residents to warn each other of an imminent catastrophe. Lastly, Section 4.5 provides an analysis of the community's response capacity during the disaster, examining their speed of response, how the community acted as first responders in the absence of emergency services, and the lack of institutional coordination during the disaster event.

4.2 Historical Governance and Ownership Conflict in the Jagersfontein Mine

The history of the Jagersfontein tailings dam revealed that the mine ownership dispute had created vulnerability within the community. In 2002, the government introduced the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA), which aimed to transform South Africa's mining industry and make the country's mineral resources accessible to all citizens (Marais et al., 2024). The Act required all mine companies to reapply for new order rights. However, De Beers, the owner of the Jagersfontein mine, refused to relinquish its old order rights. This resistance delayed reform and led to lengthy legal and regulatory disputes.

4.2.1 Legal ambiguities and loopholes in mineral ownership

The Beers argued in court that the diamonds from the tailings were not minerals but movable assets. MPRDA used the term "stockpile" to describe debris, discarded tailings, waste rock, slimes, slurry, or any other waste generated from mining activities (MPRDA 2002). The term "tailings" only appears in the Minerals Act 50 of 1991 and thus refers to old order rights; therefore, the MPRDA had no jurisdiction over tailings formed before 2002 (Marais et al., 2024). This legal confusion over what should be classified as tailings further weakened government control.

Based on De Beers' agreement, the court determined that the tailings dam was an ordinary dam, which was not subject to mining laws but was required to comply with dam legislation (Marais et al., 2024). NEMA and the DWS provided oversight in this matter. This meant there was no single authority to inspect and operate the tailings dam, leading to poor enforcement of safety regulations. The legal confusion undermined the intention of the MPRDA. It highlighted the poor coordination between

government sectors, which later contributed to the inadequate oversight of the dam structure.

4.2.2 Exclusion of the local community from the tailings dam ownership

De Beers was under pressure to sell the mining rights to the Jagersfontein Community Trust, which involved 6,000 struggling community members (Kwon Hoo, 2010). In 2010, De Beers sold the movable assets to an unconnected local black economic empowerment consortium, the Superkolong Consortium Company (Marais et al., 2024), prioritising economic interests over community concerns. The community sought to access the municipal dumps to build brick-making facilities and other projects, which would have employed residents and boosted the local economy (Kwon Hoo, 2010).

This forced exclusion of the community from mine ownership added to the social injustice in the mining town. The sale of the mine to the Superkolong Consortium resulted in minimal community benefits, with a 10% shareholding, which was a significant reduction from the 26% that the community would have stood to benefit from had they been successful in purchasing the mine (Kwon Hoo, 2010). This left residents outraged, contributing to the growing distrust of the mining sector and the government.

4.2.3 Socio-economic decline and community vulnerability

Jagersfontein experienced a decline since the mine closed in 1972, with limited employment opportunities and a lack of development projects (Kwon Hoo, 2013). The community's exclusion from the mine purchase contributed to its vulnerability, leading to social protest and multiple court applications, as residents felt betrayed by the government and De Beers (Marais et al., 2024). The Jagersfontein Community Trust spokesperson claimed senior government officials helped steamroll the sale, stating as follows: "*We are not happy with the arrangement and were never consulted. The sale came as a surprise, and the process was forced on the community without their consent*" (Kwon Hoo, 2010). He added, "*For years, we attempted to engage with them (De Beers) but were rejected*" (Kwon Hoo, 2010).

4.2.4 Synthesis

The governance and ownership history of the Jagersfontein mine illustrates how ambiguous legal frameworks and the absence of local communities as owners have

contributed to ongoing social and environmental vulnerabilities. The MPRDA, passed in 2002, aimed to reshape South Africa's mining sector by ensuring that all citizens benefit from the country's mineral resources. However, De Beers' reluctance to switch from old order rights to new order rights delayed this transformation, creating a regulatory gap that reduced government oversight at the mine.

The court decision that classified the tailings dam as an "ordinary" dam meant that the mine company was not obligated to have a social and labour plan (SLP). This plan is a legal document required by the DMRE for all mine companies as part of their mining rights application under the MPRDA (Department of Mineral Resources, 2002). The goal of the SLP is to ensure that the mine operates responsibly, develops and shares benefits with the host community (Department of Mineral Resources, 2002). Under the Act, the mine company is required to report on its progress annually, and failure to do so can result in the suspension or revocation of its mining rights (Department of Mineral Resources, 2002).

In the case of Jagersfontein Development, the company's social obligations to the community were voluntary and not enforced. This meant that the company had no obligations to invest in community development, job creation and a disaster preparedness plan. Consequently, the community was excluded from benefiting from the mine's profits, participating in risk discussions, and receiving early warning information. This led to mistrust and growing resentment towards the mine, as the community was left unprotected and uninformed. The community suffered the risks of living in an unsafe environment without receiving any social benefits. This increased the level of social and environmental vulnerability, ultimately leading to the catastrophic failure of the tailings dam in 2022.

4.3 Pre-Disaster Warning

Pre-disaster warnings refer to the dissemination of hazard information to the at-risk community before a disaster occurs (United Nations, 2025). These warnings must be timely, reliable and trusted to safeguard lives and livelihoods. In the context of the Jagersfontein tailings dam disaster, this section presents findings related to the theme of pre-disaster warnings, along with three sub-themes: enforcement of regulations, community warnings, and undermining local knowledge. The evidence demonstrates

how the gaps between the community, mining company and local authorities reduced the effectiveness of early warning signs.

4.3.1 Enforcement of regulation

Jagersfontein Development utilised high-tech machines to mine the tailings and 11 dumps, subsequently creating new waste. The documents analysed revealed that the tailings dam showed pre-disaster warning signs from 2018 to 2022. According to the mine manager (A1.23), Jagersfontein Development had submitted requests to dump the tailings into the pit for the past 10 years, without success. The move was based on economic and environmental considerations, as well as to mitigate the risk of dam failure (Marais et al., 2024). Additionally, the company cited concerns about the high costs of constructing a new dam that would potentially pollute an additional 100 hectares of land (Marais et al., 2024).

Despite the potential safety benefits, obtaining consent from the community was required for the application to backfill the pit. However, the community continued to oppose the application (A1.23). The community's refusal stemmed from their perception of the pit as a heritage site. Moreover, they believed that supporting the application would result in many locals, like miners and teachers, losing their jobs (A1.09). Because the community denied backfilling the pit, the mine company expanded the existing tailing dams on the west and east sides (Marais et al., 2024).

The court case against Jagersfontein Development alleged that the mine owners raised and altered the existing dam without appointing a professional team to design the new facility (State v Jagersfontein Development (Pty) Ltd, 2025). The mine company further failed to assess and register the new dam structure, which poses safety risks, in contradiction with the Dam Safety Regulation made under the National Water Act 36 of 1998 (NWA) (State v Jagersfontein Development (Pty) Ltd, 2025). A dam with a safety risk must be registered with the DWS, enabling proper monitoring and classification (NWA 1998). Furthermore, Regulation 17 states that the dam owner must obtain written approval from the DWS before any alteration or enlargement of the dam, while Regulation 19 requires such an application to be supported by a detailed design report and drawings prepared by an approved professional engineer (NWA 1998). Additionally, Regulation 29 requires dam owners to formulate and implement an operations and maintenance plan that ensures safety procedures are followed

(NWA 1998). A breach of any of the provisions will result in an offence in terms of Regulation 48, read together with Section 151(1)(a) and (c) of the NWA 1998. This move increased the strain on the altered tailings facility.

The DWS issued several directives between 2019 and 2021 for non-compliance with the water license conditions, including unlawful operations within a watercourse, exceeding groundwater abstraction limits, and unauthorised tailings disposal (State v Jagersfontein Development (Pty) Ltd, 2025). In response, the company submitted an action plan outlining the remedial actions to be taken (Mabena, 2022). However, regulatory violations continued, highlighting weaknesses in the DWS's monitoring systems. The Minister of the DWS later stated that the Department had limited resources to monitor dam safety and compliance effectively (Richards, 2022). Consequently, the Department had accumulated a backlog of approximately 474 reports awaiting evaluation (Richards, 2022).

The section highlighted the challenges to institutional capacity faced by the DWS, which weakened dam oversight and regulatory enforcement (DWS, 2025). The focus has been limited to the technical aspects of the dams, contrasting with the extensive requirements outlined in the GISTM for developing disaster management and response plans (ICMM, 2025). Furthermore, because this operation was not a mining operation, it also meant that it did not have to comply with tailings dam regulations (DMRE, 2025).

4.3.2 Community warnings

According to the interview data, the DWS's ineffective dam monitoring led the community of Jagersfontein to raise concerns about the stability and height of the tailings dam. Residents reported that they communicated their frustration through protests, writing memoranda and social media posts. Respondents (A1.09; A1.11) recalled multiple demonstrations, particularly in 2009, 2014 and 2019, during which memoranda were submitted to mine management, raising alarms about the dam's increasing height and potential instability. Another memorandum was addressed to the Deputy President, requesting access to inspection reports on the dam, following the non-attendance of dam inspectors at community meetings (A1.01; A1.11). According to the mayor (A1.01), these inspectors were tasked with monitoring the dam's safety and issuing compliance licences. However, the community received no official

feedback on their submission. The lack of responsiveness from the mine led the mayor to post a public warning on social media in 2020, drawing the government's attention to the issue. The mayor stated that the mine had operated for a decade without an approved water management plan, placing nearby households at serious risk (Mabena, 2022). He cautioned that, should the dam fail, it could result in '*muddy water ruining lives, cause deaths and damage to the community*', further accusing Kopanong Local Municipality of being comfortable with the mine's illegal connection of water (Mabena, 2022).

However, the contents of the hard copy of the memoranda contradict the accounts provided by the interviewed participants. A 2010 memorandum submitted by the Jagersfontein Community Trust to De Beers outlined demands relating to royalties, employment and the opportunity for local companies to purchase the mine dumps (JFCT, 2010). Unfortunately, there was no representative from De Beers to receive the memorandum. Similarly, a 2012 memorandum submitted jointly by the Jagersfontein Community Trust and residents focused on the pending application for prospecting rights in respect of the Jagersfontein tailings dumps (JFCT, 2012). Neither document raised concerns regarding the dam's height or structural integrity. This suggests that while the interviewed participants stated that safety concerns drove the protests, the documented memoranda reflected economic and ownership grievances rather than concerns about dam stability. This highlights the complexity between socio-economic motives and risk awareness, which ultimately contributed to the tailings disaster. It is evident that the need to address social inequalities overshadowed dam safety requirements and the development of local disaster response plans. Not mentioning this potential disaster in the Integrated Development Plan suggests that the local municipality and officials did not take the risk seriously.

4.3.3 Undermining local knowledge

According to the data, the mine workers had been aware of the dam's deteriorating condition long before the disaster occurred. One mineworker recalled, "*We told the mine management that this thing was going to cause trouble, but they did not listen, and we were told that nothing was going to go wrong*" (B1.16). Despite repeated warnings, management, due to their lack of formal engineering qualifications, dismissed the miners' concerns. Another respondent noted that the mine manager

reportedly stated, "*The miners did not know anything*" (B2.02). However, one respondent (B1.04) argued that although miners were not formally educated in the field of dam engineering, they possessed indigenous knowledge and experiential knowledge acquired through years of working at the mine. Therefore, this knowledge allowed them to recognise early warning signs of structural instability.

In May 2019, miners observed that the dam wall cracked above the waterline, resulting in a temporary closure of the site (B1.16). The wall reportedly again cracked the following day (B1.16). The respondents claimed that the mine did not disclose this incident to the surrounding community or the DWS. The mine's failure to report the incident was a direct contravention of Regulation 32(5)(c), (d), (e), and (f), read with Regulation 48 of the Dam Safety Regulations made under the NWA 1998 (State v Jagersfontein Development (Pty) Ltd, 2025). The regulation requires the dam owners to regularly inspect the dam, address any identified deficiencies, maintain accurate inspection and maintenance records, and submit periodic reports and incident notifications to the Department (NWA 1998). The failure to notify the DWS within the prescribed timeframe is a breach of reporting requirements and a failure to manage a dam with a recognised safety risk (Minerals Act 1991). This reflects technical neglect and disregard for local knowledge, which could have prevented the tailings disaster. This incident should have been noted as one of the first early warnings. The lack of transparency meant that neither the regulator nor the community received the information.

4.3.4 Synthesis

The data revealed the presence of early warning signs. However, weak enforcement of regulations, disputes over mine ownership, and the neglect of community input weakened the effectiveness of the pre-warnings. It is evident that the historical battle between the community and the mine company over mine ownership overshadowed pre-warnings. The community was focused on mine ownership rather than on the potential risk posed by the tailings facility. The community's refusal to fill the pit further contributed to the risk. On the other hand, the mine company prioritised production over the safety of its employees and the surrounding community, resulting in an incident in 2020 where the mine's tailings polluted the environment, contaminated

water resources, and threatened people's livelihoods (Van Wyk, Phakisi-Portas, and Sefuli, 2023).

The DWS inconsistencies further contributed to dam instability by allowing the mine company to process tailings without a dam safety licence. A company is not authorised to start operation before such a permit is granted (Van Wyk, Phakisi-Portas, and Sefuli, 2023). According to the DWS spokesperson, such a permit prevents the dam from causing harm to the surrounding community (Van Wyk, Phakisi-Portas, and Sefuli, 2023). However, the department did not treat this matter with urgency, despite being responsible for ensuring that the country's water resources are "*protected, used, developed, conserved, managed and controlled*" in a sustainable manner (Van Wyk et al., 2023).

4.4 Early Warning and Communication Systems

Adequate early warning and communication systems are crucial for reducing disaster risk. They help create a shared understanding of risk and promote behaviour change that helps to minimise disaster impact (United Nations, 2025). The early warning and communication systems emerged as the central theme for understanding how early warning signs were managed and how risk was communicated in the days leading to the Jagersfontein disaster. Three sub-themes frame this discussion: structural warning signs, false sense of security and communication failure.

4.4.1 Structural warning signs

The analysed data revealed that structural warning signs were present as early as September 2022, with mineworkers continuously reporting these warnings to the mine management. A respondent (B3.01) recalled that the miners working night shift between September 8 and 11, 2022, reported to their supervisor that the dam was starting to show structural signs of failure. The matter was escalated to the mine manager. The mine manager (B1.02) instructed the miners to continuously throw soil into the dam. On Saturday night, September 10, 2011, a respondent (A1.11) recalled that the dam began to crack and water was flowing out. Again, the miners raised their concerns with the mine manager, fearing that the dam might burst. However, the manager responded, "*Oh, no man, do not worry, just throw the soil there*" (B1.02). The

findings suggest that structural warning signs were present. However, they were not acknowledged or acted upon, reflecting a breakdown in conveying technical risk.

The issue of the dam persisted, with respondents recalling the mine manager's dismissive responses: "*Try to close it up*" (B2.02), "*It happens, it is normal*" (A1.18), and "*No, this thing is not going to do anything*" (B1.16). The non-responsiveness of mine management to the miners' concerns reflects the company's management culture; the company prioritises productivity and financial returns over safety (Kemp et al., 2024). This creates a culture in which production is valued over addressing potential risks. Management, therefore, normalises potential risks, resulting in consistent underestimation and minimisation of hazards, even with visible structural warning signs (Kemp et al., 2024).

4.4.2 False sense of security

From midnight on Sunday, September 11, 2022, until the early morning hours, respondents recalled rumbling, whistling, and roaring noises that sounded like passing trucks and a boiling kettle. Because mining activities produce noise, a respondent (B1.10) believed that the noise was the result of a broken machine at the mine, while other respondents (B1.19; A1.04) thought the noise was due to a project taking place at the mine or road maintenance.

The community did not perceive the noise as a sign of danger because the mine company had created the impression that adequate safety and monitoring measures were in place. Furthermore, the mine company had never conducted community-based education or training to equip the residents to distinguish between routine mine activity sounds and abnormal noises that signal danger.

4.4.3 Communication methods

When a community is unprepared for a disaster, it has a limited ability to receive, understand, and respond to warning messages (United Nations, 2025). The lack of effective early warning mechanisms in Jagersfontein led the community to rely on its own informal systems to share important information about the failure. Between 5 am and 6 am on September 11, the dam's rupture became visible, and residents began alerting each other through multiple channels. Families, neighbours and community groups acted as the first line of communication, ensuring that those closest to them

were informed. They employed various methods of communication, which are discussed next.

- Text messages and phone calls as warnings

Text messages and phone calls played a significant role in disseminating warning alerts among the Jagersfontein community. These methods of communication are generally accessible and reliable, and capable of reaching individuals quickly and efficiently. However, in this case, the early warning system of communication was ineffective in alerting first responders due to the widespread power outage caused by the disaster. The power outage disrupted communication networks and the flow of information. One respondent (B1.15) recalled how a resident struggled with the network connection while attempting to contact the local police station to report the dam failure. As a result, residents were forced to rely on alternative methods to warn their neighbours. Furthermore, the absence of a municipal disaster management plan meant that residents lacked knowledge of emergency procedures and contact numbers. Without prior education or awareness campaigns, many residents were unaware of whom to contact or how to coordinate rescue efforts, resulting in valuable time being lost.

It is important to note that phone calls and messages served as the primary line of communication in the absence of early warning signals, such as sirens or official announcements. The peer-to-peer alerts played a crucial role in warning family members and neighbours. One respondent mentioned that they received a message from a friend: "*Get up, everybody! The dam has broken*" (A3.02). Another called their family members and neighbours to warn them, "*Hey! Hey! The mine is breaking down!*" (B3.01), while some used social media to post warnings: "*The dam is breaking, prepare yourselves for the worst*" (B2.05). While another described (A3.02) receiving a call from his sister saying, "*Hey, please come out! The dam has burst*".

Although these communication methods helped spread the risk message, many residents did not respond immediately to the warnings because some did not understand the contents of the warnings. In contrast, others were unsure of the steps to follow after receiving the warning. A respondent (A3.02) recalled that he could not understand what the sister meant when she said that the dam had burst. As a result, people stood and watched the mudflow instead of evacuating.

- Face-to-face warning

Face-to-face warnings proved to be the most effective form of warning during the disaster. In the absence of formal early warning systems, community members resorted to physically warning each other by knocking on doors and windows, shouting in the streets and waking family members and neighbours. This communication method resulted in the rapid dissemination of information within the affected areas of Charlesville and Itumeleng.

A respondent recalled throwing rocks at the neighbours' houses to alert them about the dam rupture. As neighbours would peep out the window, he would point them in the direction of the dam (B1.20). Upon seeing the danger, some people ran to higher ground. Another respondent recalled a woman in Skoti screaming in the street, alerting people to the dam rupture (B1.06). Residents in Skoti responded by simply gathering outside and watching as the mud swept through Charlesville. Another reported warning was dismissed by the mine manager, who said it was "*just a silly story*," and informed the police, who responded, "*What are we going to do?*" (B1.04).

Although face-to-face warnings effectively spread awareness, their impact was limited by the community's lack of knowledge about disaster response. Many residents were not aware of the magnitude of the threat and the appropriate action to take when they received a warning. The absence of evacuation procedures led to inconsistent responses, and residents underestimated the risk.

4.4.4 Synthesis

The breakdown in risk communication highlighted how information about the instability of the tailings facility was not communicated to the community at risk. The analysed data revealed that early structural warning signs were present but not addressed or communicated by those responsible. The failure of the mine management to communicate warning signs at the beginning of the month was the first layer of failed communication, contributing to a false sense of security among the surrounding community. Moreover, the continuation of mining operations despite visible signs of structural failure created an impression in the community that the structure was stable and under control. The community did not receive any formal warning communication and thus assumed that they were safe.

An early warning system encourages a mine company to have a communication and response plan in place that will ensure the protection of lives and infrastructure (United Nations, 2025). The company must be transparent in its tailings management, and all potential signs of failure at the facility must be taken seriously and communicated to the affected individuals (Global Tailings Review, 2020).

The absence of a prior risk communication strategy in Jagersfontein meant that there was no clear line of communication outlining how warnings are issued, who issues them, and how communities should act when they receive warnings. As a result, residents were in disbelief and confused. This likely added to the breakdown in communication, as many had never experienced such a disaster before.

In the absence of formal communication, residents relied on informal channels to alert one another of imminent danger. The lack of official communication channels and trusted early warning systems further limited the community's capacity to respond effectively, resulting in delayed evacuations and increased exposure to danger.

It is evident that the mine company must implement a formal alert system, such as a siren or text message system, in collaboration with the disaster management unit. This must involve conducting regular community awareness campaigns and training workshops, where residents participate in evacuation drills. The municipality can assist by using ward committee members to distribute information on emergency contact numbers, evacuation routes and warning signals.

Therefore, the breakdown in risk communication was a systemic issue resulting from the poor interpretation of structural warning signs, a lack of confidence in the dam's stability, and the absence of formal and inclusive risk communication channels. These gaps revealed how inadequate risk communication could transform a preventable hazard into a disaster.

4.5 Response Capacity

Response capacity refers to the ability of communities, institutions, and disaster management systems to respond to and effectively manage the impact of disaster events (Domingos and Nagamatsu, 2024). This is achieved through collective disaster education programmes, contingency plans based on available resources and assigning roles and responsibilities to local leaders (Domingos and Nagamatsu, 2024).

Response capacity is a key component in disaster risk reduction, representing the community's readiness to act promptly, efficiently, and in a coordinated manner when a disaster occurs. In the context of the Jagersfontein tailings dam disaster, this section presents findings on the shortcomings in the response capacity of the community and emergency services. Three sub-themes frame this discussion: time sensitivity and speed of response, absence of first-line responders and limited institutional coordination.

4.5.1 Time sensitivity and speed of response

The data revealed that time sensitivity and speed of response were major weaknesses during the Jagersfontein disaster. Although there were visible warning signs of instability in the days and hours leading up to the dam failure, community responses were delayed. According to the mayor (A1.01), the failure began with a small opening through which water started to flow. Only a few residents who were awake at that time noticed the breach and managed to alert others. Within fifteen minutes, the dam wall had completely ruptured, forcing residents to flee. Those living in Charlesville ran towards the nearby farm, while residents in Skoti ran to the other side of town. The dam broke between the two areas of Itumeleng and Charlesville, leaving the entire settlement vulnerable.

The community's reactions were largely reactive rather than proactive. In Charlesville, where the collapse first occurred, several residents underestimated the threat, choosing to take pictures and videos rather than evacuating. A woman (B1.01) recalled being woken up by her brother, who warned that "*the dam wall has broken*". Believing that '*the water was not going to get that high'* (B1.01), she remained in the house until the floodwater burst through her kitchen door, sweeping her twelve kilometres downstream. Another woman (A1.07) described being woken up by neighbours screaming. She attempted to flee with her two grandchildren, but was unable to drive away as the mud reached her car. She lifted the children onto the roof of the vehicle before being swept away by the sludge. Similarly, another resident (B1.19) noticed unusual activity at the mine and sent her grandchildren to buy airtime so she could call for help. Before they returned, the mud reached her home, forcing her to flee to higher ground.

While Charlesville was being destroyed, residents in Itumeleng initially watched from a distance as the floodwater engulfed houses, assuming it would not reach them. Some even laughed and took pictures and videos. However, when the mud changed direction through the canal towards Skoti, panic ensued. A respondent (B1.07) described being warned by a neighbour not to drive to work because "*the mud was nearby*" (B1.07). Moments later, the floodwater forced his door open and filled the house, leaving him floating as if he was "*flying on a ship, in the ocean*" (B1.07). Another woman (B1.18) recalled how the mud broke down the door, swept away her partner and his brother, and collapsed the house's walls on top of her. Several other respondents described trying to retrieve identity documents and valuables, only to become trapped in the mud.

The absence of a coordinated emergency protocol slowed the residents' responses. When residents in Itumeleng realised that the mud was heading their way, it caused panic. Instead of evacuating, many began shouting instructions such as, "*Get all of your important things, like IDs, your bank cards, whatever, your patient cards with you*" (B3.01). This confusion led some to rush to their homes, while others rushed to their vehicles, and some to higher ground. The lack of disaster preparedness training or evacuation education meant that residents did not prioritise life over possessions, resulting in preventable delays and increased loss of life.

4.5.2 Community members acted as first responders

The analysed data revealed how community members acted as first responders by searching for and rescuing trapped victims before the arrival of emergency services. An estimated eight community rescuers relied on courage, collective action and strategies to save lives. The spontaneous community response was initiated by an incident involving a man who became trapped in his vehicle alongside his wife and two neighbours. The respondent (A1.02) recalled that he shouted for help, but no one initially responded, as people were too afraid to enter the mud. His son and nephew, however, demonstrated courage by jumping into the mud to rescue them.

Following the successful rescue, the respondent (A1.02) recalled seeing three people trapped inside a nearby house. He instructed his son and nephew, stating, "*Let's go look for them*" (A1.02). Despite warnings from onlookers shouting, "*It's going to take you, please come back!*" (A1.02), they proceeded and managed to rescue two men and one woman. Encouraged by their success, the respondent's son identified more

people in distress and called for additional community members to assist. This collective action led to the spontaneous formation of a community-led rescue team, illustrating the community's emergent response capacity under extreme conditions.

The rescuers assisted a victim trapped in a car by opening the boot to retrieve an object to break the window and free the grandmother (B3.06). Another broke the windows of the houses to release pressure and allow the mud to subside, enabling them to rescue trapped occupants (A3.02). The rescuers formed a coordinated line and moved from house to house, shouting, '*Anybody here?*' Once a response was heard, they would force entry either by pushing the door open or breaking windows to reach the victims (B3.05). Some rescuers focused on extracting victims, while others carried them to higher ground (B3.06).

Community members used objects to move through the thick mud, prioritising the rescue of elderly residents while the water levels were still high (A1.09). They found victims on top of furniture, on the roof of the house and trapped in cars. According to one rescuer, the team worked for hours checking every home to ensure that nobody was left behind: '*We did not leave a stone unturned, we rolled all the stones to see if there was a human being*' (B3.04). In total, they managed to rescue around seven children and several adults.

When the official search and rescue team arrived later in the day, a rescuer recalled telling them: "*You have come too late. We have already rescued the people*" (A3.02). Most victims suffered minor injuries or shock and were taken to the hospital for observation.

The community of Jagersfontein, acting as first responders, exposed the institutional weaknesses. The delay in the arrival of emergency services indicated a lack of planning, coordination and early warning systems. While the community's action mitigated the impact of the disaster, it also highlighted the absence of integrated response structures meant to protect the residents. Therefore, it is essential to recognise the role of local actors, especially in disaster preparedness efforts and disaster training, because the first few hours after a disaster are critical.

4.5.3 Limited institutional coordination

Institutional coordination plays a crucial role in ensuring effective and timely disaster response (United Nations, 2025). During a disaster event, coordinated efforts among

emergency services, government departments, private companies, and community organisations are essential to minimise loss of life, property damage, and environmental impact (United Nations, 2025). The analysed data revealed that institutional coordination during the Jagersfontein disaster was limited and ineffective. Emergency services reportedly arrived after the community had begun rescue efforts.

One respondent (A1.02), who was part of the community rescue team, recounted an incident where a paramedic refused to transport victims to the hospital, reportedly saying he did not want to "*get full of mud and get dirty*" (A1.02). In response, the respondent's son told him, "*Stand aside and give me this ambulance*" (A1.02) and proceeded to transport injured individuals himself, taking up to ten patients at a time. Another resident assisted using his taxi to take victims to the hospital. Priority was given to those on medication and children; however, this resulted in long waiting periods for others. One respondent recalled, "*They stood there for hours*" (B1.15) because the ambulance could only transport a limited number of people at a time.

Respondents recalled that the police arrived late, after the disaster had already occurred, and that if they had arrived earlier, they could have helped people escape (B1.08). Another respondent (B3.06) described how the police stood by on a nearby hill, watching as residents rescued one another from the mud. Another mentioned how the police were standing on the road taking pictures (A1.02). This suggests that there was a lack of immediate direction and coordination.

Once survivors were rescued, emergency personnel provided basic assistance, such as helping people wash the mud off their faces and transporting some to the hospital. After being rescued, one respondent (B1.01) recalled being taken to Trompsburg hospital, where she stayed for two days. During her stay, her family was never informed of her admission, leaving them unaware of her whereabouts. Moreover, she reported that neither a social worker nor a government official visited or provided support during her two-day hospital stay.

Moreover, there was a lack of logistical coordination and communication regarding the distribution of relief and temporary shelter. This uncertainty caused some residents to leave with their families, while others waited for instructions from municipal officials. Respondents stated that survivors were left without drinking water or food until late in the afternoon, and that no clear information was given about where they would spend

the night. One respondent described (A1.04) standing alone on a hill, cold and without any family members to assist her. A resident took her into her home, allowed her to wash and provided her with clean clothes to wear.

Only later that evening was a meeting convened at the community hall, where it was decided that displaced residents would be temporarily accommodated at the Bloemfontein President Hotel, Sandstone, Fauresmith and a guesthouse in Jagersfontein.

The Jagersfontein case study highlighted the importance of robust institutional preparedness and effective coordination during disaster response. A lack of early coordination between emergency services, municipal officials and relief organisations delayed critical interventions, which contributed to community distress and revealed weaknesses in the local disaster management system.

4.6 Conclusion

The Jagersfontein tailings dam disaster is a stark indication of how governance failure, weak regulatory enforcement, and the absence of community inclusion can turn a hazard into a catastrophic disaster. The court decision classified the tailings as an “ordinary” dam, exempting the company from SLP requirements, thereby permitting the mine to operate without accounting to the host community. This regulatory loophole created a condition that excluded the community from sharing in the mines’ benefits and participating in risk discussions and disaster preparedness initiatives.

The dispute in ownership conflict continued into the pre-disaster phase, where competing interests of the community and the mine company overshadowed the potential risk posed by the tailings dam. Similarly, the inconsistent enforcement of dam safety regulations by the DWS allowed for unsafe mine operations to continue. As a result, pre-warning signs failed to translate into preventive action.

Furthermore, structural warning signs were not communicated to residents or the department, resulting in a breakdown in early warning and communication systems. Residents gained a false sense of security as they saw mine operations continue. Moreover, the absence of official communication systems during the disaster forced residents to rely on informal communication networks to warn one another, resulting in confusion, delayed evacuation, and increased exposure to the hazard.

Lastly, the disaster exposed the mine and the local municipality's inadequate response capacity because residents acted as first responders in the absence of emergency services. The absence of a functional disaster management plan meant that institutional roles were not outlined in the event of an emergency. The Local Government: Municipal Systems Act 32 of 2000, in conjunction with the Disaster Management Act 2002, mandates that such a plan be included in the municipality's Integrated Development Plan (IDP). This ensures that disaster risk reduction and management are integral to municipal development planning.

Furthermore, the local community was not educated in disaster response and evacuation routes. As a result, affected community members found themselves becoming first responders, and victims found themselves standing for hours on the hill, waiting to be allocated shelter. This highlighted the urgent need for collaborative initiative between the municipality and the mine company in training and educating the surrounding community on disaster risk initiatives.

Therefore, the Jagersfontein disaster highlighted how the legal ambiguities and the prolonged conflict over mine ownership created regulatory gaps that increased the risk of hazards. The DWS's lack of consistent oversight further enabled unsafe mining practices that contributed to the dam's structural instability. Additionally, the lack of collaboration between the municipality and the mine weakened the community's ability to respond effectively when the tailings disaster occurred. Thus, effective disaster risk reduction requires vigorous regulatory enforcement and collaboration among key stakeholders.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses the study's findings of the availability of early warning signals and responses by the community, government and the mine in Jagersfontein to the tailings disaster. The study achieved this by analysing early warning signals that existed before the tailings disaster and the responses to such warnings by government officials, the local community and the mining company. The findings will inform policy recommendations regarding tailings disasters and the role of early warning systems.

The chapter is structured as follows: Section 5.2 provides an overview of previous chapters, and Section 5.3 discusses the findings. Section 5.4 presents recommendations based on the findings, while Section 5.5 identifies gaps for future research, and Section 5.6 concludes the study.

5.2 Overview of Previous Chapters

This section provides an overview of the previous chapters covered in the study, highlighting how each chapter contributed to the understanding of CBEWS.

Chapter 1 introduced the research topic of CBEWS with reference to the Jagersfontein tailings dam disaster. The chapter presented the background of the study area, which was the community of Charlesville and Itumeleng located downhill of the tailings dam and consequently affected by the disaster event. The chapter also outlined the problem statement, noting the limited availability of data or information on the presence of CBEWS in mining towns, and further presented the study's aim and objectives. The study concluded with a list of key terms and definitions frequently used throughout the study.

Chapter 2 presented the literature review and theoretical framework. The chapter provided an overview of early warning systems and their significance in disaster risk management and the reduction of mining-related incidents. The chapter further described TSFs, emphasising the importance of integrating early warning systems to monitor and mitigate potential risks posed by these facilities. Moreover, the chapter also emphasised the importance of including at-risk communities in the risk

assessment, mapping, preparedness, and communication processes. Lastly, the chapter outlined international best practices for managing tailings facilities that mining companies should endeavour to adopt.

Chapter 3 presented the research methods employed in the study. The study utilised qualitative secondary data whereby disaster victims, first responders (including community first responders), and government and mining officials were interviewed to gain insight into their lived experiences during the disaster. The study also utilised external sources, including academic journals, online reports, and memoranda written by the community of Jagersfontein, to explore the experiences and responses of residents during the catastrophic event.

Chapter 4 presents the results of the experiences and responses of residents to early warnings during the Jagersfontein tailings dam disaster. The chapter identified the gaps between policy intentions and community realities, particularly in relation to risk communication, preparedness, and response coordination. The chapter examined how local knowledge, informal warnings, and social networks influenced the speed and effectiveness of the response following the collapse of the dam wall. This insight was critical in understanding the socio-institutional dynamics that shaped the disaster outcomes in Jagersfontein and for informing the development of more inclusive, community-centred early warning systems in mining regions.

5.3 Main Findings

This section presents the main findings of the study, focusing on the analysis of CBEWS using the Jagersfontein tailings dam disaster as a case study.

5.3.1 Weak regulatory oversight and compliance result in ineffective disaster response planning

According to the literature, tailings dams contain mine waste that is harmful to the environment and surrounding communities. These facilities require strict regulatory oversight, continuous monitoring and preparedness and response planning (Lumbroso et al., 2019). Structural instability, inconsistent construction methods, inadequate regulatory enforcement, and high maintenance costs are among the key factors contributing to the failures of tailings dams globally (Rico et al., 2008).

The GISTM emphasises that tailings operators must implement a comprehensive monitoring system to track the stability of the facility throughout its lifecycle (Global Tailings Review, 2020). An independent tailings review board must oversee the monitoring and assess the risk of the facility. Similarly, the NWA 1998 requires owners of facilities that pose a safety risk to register for dam classification. Once the dam is classified, the dam owner is legally required to appoint an approved professional person (APP), who will be responsible for conducting and reporting on dam safety evaluations, as well as maintaining the dam in accordance with safety standards (NWA 1998). The failure to register these facilities can pose a threat to lives, property, and the environment.

The findings revealed that the DWS failed to conduct regular dam inspections or enforce corrective measures despite visible signs of instability. Although the department issued several directives between 2019 and 2021 due to non-compliance, the mine continued to operate without implementing the required safety measures.

Furthermore, the Jagersfontein Development Company failed to register the dam as a facility posing a safety risk despite the embankment's height and storage volume exceeding the thresholds stipulated in the Dam Safety Regulation under the NWA 1998. Due to non-registration, the company did not appoint an APP to conduct a safety evaluation. This resulted in the absence of a comprehensive monitoring system to assess and track risk conditions. The fact that the operations fell outside of the mining legislation and were not a TSF also meant that other guidelines like the Global Industry Standards for Tailings Management were not applicable (also because the mine did not belong to the ICMM). The lack of such systems weakened early warning detection of instability and contributed to delayed response actions.

5.3.2 Lack of a simple, uniform communication plan prevented adequate responses during the disaster

There has been a global call from society, governments, international agencies, and the media for the mining industry to disclose the interactions between TSFs, communities, and the environment (Kemp et al., 2024). This call follows a series of failures in which the local community and workers had limited prior knowledge about the risks associated with tailings dam failures (Kemp et al., 2024). Mining companies often withhold tailings-related information from local communities, as this provides

companies with a proprietary advantage over local populations in developing and operating hazardous tailings facilities (Owen et al., 2020). However, the population is often the first to respond in the event of a tailings dam failure and also the first to suffer the adverse effects (Shakeri, Vizvari, and Nazerian, 2021). Therefore, the mining companies should provide early warning messages and relevant information on hazards to these communities (Macherera and Chimbari, 2016).

The EWS framework, the GISTM (Global Tailings Review, 2020), and the Disaster Management Plan (2002) emphasise the need to develop an inclusive communication plan that is accessible and understood by all stakeholders. The Local Government: Municipal Systems Act 2000, together with the Disaster Management Act 2002, further outline the legal requirement of such a plan to be included in the municipality's IDP. This ensures that disaster risk reduction and management are integral to municipal development planning. Therefore, such a plan must ensure that risk-related information is accurate, timely and disseminated through multiple official channels to affected individuals (UNDRR, 2025a). The information must outline the steps to be followed in the event of an emergency. Moreover, the plan should be proactive by continuously communicating information about the tailings-related risks, as required by the GISTM (Global Tailings Review, 2020). Continuous communication not only strengthens preparedness but also fosters community trust and community understanding of the risk associated with a tailings facility.

The findings revealed that the local municipality's Integrated Development Plan did not include a disaster management plan as stipulated in Section 26(g) of the Local Government: Municipal Systems Act 2000, and Section 53(2)(a) of the Disaster Management Act 2002. As a result, there was no formal emergency communication plan in place to alert the community of imminent danger. Further evidence suggests that the mining company failed to disclose information about the structural conditions of the tailings dam. Both the GISTM and the EWS framework emphasise the need for continuous and transparent risk communication with affected communities. The absence of such early warning mechanisms weakened community preparedness.

The findings also revealed that although Jagersfontein Development Company engaged the community regarding its proposal to dump the tailings into the pit, the engagement did not prioritise risk-focused communication. This approach is inconsistent with GISTM, which requires the mining company to have meaningful and

transparent engagement with the community on issues concerning their safety (Global Tailings Review, 2020). Consequently, community members were more concerned with socioeconomic and cultural issues than with safety-related problems, indicating that they were not adequately informed about the risks associated with the facility.

The findings indicated that the Jagersfontein community relied on informal communication channels to disseminate warning messages. This is inconsistent with the EWS framework, which requires the use of multiple official channels to relay warning messages (UNDRR, 2025a). As a result, warning messages did not reach all households simultaneously, leading to delayed reactions and evacuations. The absence of formal communication mechanisms also hindered collaboration among stakeholders, as there was no established process for sharing or verifying risk information. Stakeholders were thus unaware of the steps to be taken in the event of an emergency, an essential component outlined in the EWS framework. The absence of structured communication weakened the community's response capacity, contributing to delayed evacuation and exposing people to danger.

5.3.3 The lack of a predetermined response plan leads to people ignoring early warning signs

The literature suggests that response capacity is a crucial component in disaster risk reduction, as it represents the community's readiness to act promptly, efficiently, and in a coordinated manner when a disaster occurs (Domingos and Nagamatsu, 2024). Mining companies should engage with the government, first responders, local authorities, and other relevant stakeholders to ensure the effective implementation of emergency preparedness and response plans (Infrastructure News, 2025). At-risk mining communities must be equipped to respond to disasters through collective disaster education programmes, contingency plans based on available resources, and the assignment of roles and responsibilities to local leaders (Domingos and Nagamatsu, 2024).

The EWS framework promotes the inclusion of vulnerable populations in the response planning process, ensuring they understand, participate in, and ultimately take ownership of the plan (United Nations, 2025). It further requires that roles and responsibilities be clearly defined among emergency services to minimise confusion and promote coordinated efforts (UNDRR, 2025a). To strengthen response capacity

and avoid a top-down approach, the framework highlights the importance of empowering communities through continuous capacity-building initiatives (UNDRR, 2025a).

The findings revealed that no predetermined and well-communicated emergency response plan was in place in Jagersfontein. The data also showed that some community members heard unusual sounds from the mine hours before the tailings failure; however, these early warning signals did not prompt a coordinated community response. This was primarily due to the community's limited ability to understand and interpret risk-related information. The EWS framework emphasises the importance of continuous capacity-building programmes to enhance the community's ability to recognise, understand, and act upon early warning signs (United Nations, 2025).

The findings further showed that a formally established communication system did not exist through which community members could report early warning signs. As a result, residents who observed structural instability had no guidance on the appropriate steps to take or to whom to report the danger. The EWS framework emphasises the importance of involving vulnerable populations in response planning processes to ensure that they understand how the system functions and can act in a coordinated manner during emergencies (United Nations, 2025).

Additionally, the absence of coordinated response planning meant that emergency services were not mobilised in time. As a result, community members were left to act as first responders in the immediate aftermath of the disaster. The EWS framework emphasises the importance of clearly outlining roles and responsibilities among emergency services in the response plan to facilitate coordinated efforts (UNDRR, 2025a).

5.4 Recommendations

The recommendations were based on the main findings, and are outlined below.

5.4.1 Clarify regulatory responsibilities

The government should close regulatory gaps by ensuring that companies handling mine waste are subjected to the exact requirements as those applied to TSFs.

5.4.2 Integrate disaster management into municipal planning

Municipalities must ensure that their Integrated Development Plans include a disaster management plan as required by the Municipal Systems Act 2000 and the Disaster Management Act 2002.

5.4.3 Alignment with international best practice

Mining companies must be legally required to disclose information on the structural integrity of their tailings facilities to local municipalities, regulators, and surrounding communities.

5.4.4 Provide regular awareness and training

Local municipalities and mining companies must conduct regular awareness campaigns to educate communities on the early warning signs, evacuation procedures, and reporting channels for hazards.

5.5 Further Research

Further research can be conducted on countries that have integrated early warning systems in their laws and regulations for the effective management of TSFs. Such research should assess how these laws and regulations influence the risk management of tailings facilities. Furthermore, comparing case studies could identify the regulatory approaches that are most effective in reducing risk, improving transparency, and strengthening CBEWS. Such findings will inform policy recommendations, especially in areas with TSFs.

5.6 Conclusion

The study investigated and analysed the available early warning signals and responses from the community, government, and the mine company prior to and during the Jagersfontein tailings disaster. Guided by the study's objectives, the research first examined the existing early warnings that were present before the Jagersfontein tailings failure, highlighting the lack of monitoring and transparency. The study then assessed how the community, mine and government responded to these early warnings, revealing shortcomings in preparedness and coordination measures. Lastly,

the study provided policy recommendations aimed at strengthening early warning systems and promoting community participation in disaster risk management within the mining context.

The study's findings reaffirmed the problem statement that there is currently a lack of data or information on the presence of CBEWS in mining towns. Disaster management in mining towns often employs a top-down approach, where mining companies, the government, and emergency management agencies view communities as primarily receivers of warnings and assistance during a disaster event. Mining companies and municipalities often fail to involve the surrounding communities in risk assessment and preparedness measures. As a result, communities are less prepared to respond to and recover from emergencies resulting from tailings facility failures.

The study revealed that the absence of inclusive, transparent and coordinated early warning systems contributed to the Jagersfontein tailings disaster. Effective early warning systems require efficient regulatory oversight, institutional accountability and collaboration among stakeholders and affected communities. The findings highlighted the need for the mining industry to prioritise meaningful and continuous engagement with communities and continuous monitoring of the facilities.

Furthermore, the findings also highlighted that early warning systems in mining towns must be integrated into municipal disaster management plans and international best practices for tailings management. Therefore, the study highlighted that preventing future tailings disasters requires a combination of regulatory reform, improvements in monitoring technologies, and the involvement of communities and stakeholders in disaster risk management. This approach can significantly reduce the risks associated with TSFs and enhance safety in mining towns.

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Appendix A: Ethical Clearance Certificate

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

Registration Number: REC-112922-058

08-Jul-2025

Dear Ms Xola Mavundla

Application Approved

Research Project Title:
Community-based Early Warning Systems: The Jagersfontein Tailings Dam Disaster

Ethical Clearance number:
UFS-HSD2025/0610

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted via an Amendment on RIMS to the ethics office to ensure ethical transparency. Furthermore, you are requested to submit a Final Report on RIMS for your study/research project to the ethics office once the project has concluded. Should you require more time than the allotted 12 months to complete this research, please apply for an extension by submitting a Continuation/Report on RIMS. Thank you for submitting your proposal for ethical clearance. We wish you success with your research.

Outcome: Approval

Yours sincerely,

TS Marange

Dr Tatenda Marange
Chairperson: General/Human Research Ethics Committee

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