ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

Disaster Management Practices and Occupational Health and Safety in a Large-Scale Mining Operation in Chingola, Zambia: With Reference to the Nchanga Operations of Konkola Copper Mines

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Publication Date: 2026/07/31

Abstract: The mining sector remains central to the Zambian economy, yet it continues to expose workers to a wide spectrum of hazards capable of escalating into disasters. This study assessed the effectiveness of the disaster management systems and emergency preparedness measures at the Nchanga operations of Konkola Copper Mines in Chingola. A qualitative case study design was adopted, and data were gathered through semi-structured interviews with fifteen purposively selected participants drawn from safety, operational and managerial functions. Interview transcripts were analysed thematically with the assistance of NVivo software, which supported coding, word frequency analysis and the visualisation of emerging patterns. Seven themes were generated, namely hazard identification and risk assessment, emergency preparedness and response planning, safety training and competency development, communication and early warning systems, resource adequacy and emergency equipment, regulatory compliance and safety governance, and barriers to disaster management effectiveness. The findings indicate that the operation maintains a documented and broadly functional disaster management framework anchored on statutory requirements, periodic drills and an established mine rescue capability. Participants nonetheless identified persistent weaknesses relating to inconsistent drill frequency, ageing emergency equipment, uneven communication during shift handovers and a compliance posture that is at times driven more by inspection than by internalised commitment. The study concludes that emergency preparedness at Nchanga is moderately effective but constrained by resource and behavioural factors. It recommends sustained investment in emergency equipment, more frequent scenario-based drills and the deliberate strengthening of a proactive safety culture.

Keywords: *Disaster Management; Emergency Preparedness; Occupational Health and Safety; Mining; Risk Assessment; Safety Culture; Konkola Copper Mines; Zambia; Qualitative Research.*

How to Cite: Lewis Kampamba Nunkwe; Francis Mulwazo Sichilima (2026) Disaster Management Practices and Occupational Health and Safety in a Large-Scale Mining Operation in Chingola, Zambia: With Reference to the Nchanga Operations of Konkola Copper Mines. *International Journal of Innovative Science and Research Technology*, 11(7), 2037-2050. https://doi.org/10.38124/ijisrt/26jul971

I. INTRODUCTION

Mining occupies a position of singular importance in the economic life of Zambia. Copper in particular has shaped the country's industrial history, its labour relations and its public finances, and the Copperbelt Province continues to host some of the largest mining operations in the Southern African region. The Nchanga operations of Konkola Copper Mines, situated in Chingola, form part of this industrial heartland and combine extensive open pit and underground mining with concentrating and smelting activities (Konkola Copper Mines Plc, 2021). While such operations generate employment and foreign exchange, they also concentrate a dense array of hazards within a single site, ranging from ground instability and the inrush of water in underground workings to fires, explosions, exposure to dust and gases, and the failure of heavy machinery.

These hazards are not merely theoretical. Empirical work on the Zambian Copperbelt has shown that injury and fatality rates in copper mining have historically exceeded those reported in comparable operations in industrialised economies, and that the underground environment remains the most dangerous (Besa & Bunda, 2018). Across the wider African mining sector, analyses of injury data continue to identify recurring failures in hazard control, supervision and emergency response as the proximate causes of serious incidents (Stemn, 2019). The persistence of such events,

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

even within operations that possess formal safety systems, suggests that the existence of a disaster management framework is not in itself a guarantee of its effectiveness.

Disaster management, understood as the organised effort to prevent, prepare for, respond to and recover from emergencies, has evolved considerably over the past decade. The Sendai Framework for Disaster Risk Reduction 2015 to 2030 placed a renewed emphasis on the reduction of underlying risk and on the protection of human health within disaster planning (United Nations Office for Disaster Risk Reduction, 2015). Within the workplace, this agenda intersects directly with occupational health and safety, since the systems that protect individual workers from routine hazards are frequently the same systems that must contain a hazard before it cascades into a site-wide disaster. For a large-scale mining operation, therefore, the quality of emergency preparedness is inseparable from the maturity of its day-to-day safety management.

Despite the recognised significance of these systems, there remains limited published evidence on how disaster management and emergency preparedness function in practice within Zambian large-scale mines, and in particular on how those who operate, supervise and govern these systems perceive their effectiveness. Much of the available literature is either statistical, focusing on injury frequencies, or normative, describing what good practice ought to look like. The lived experience of safety officers, supervisors, rescue personnel and operators, which often reveals the gap between documented procedure and operational reality, has received comparatively little attention.

This study responds to that gap. Its objective was to assess the effectiveness of the disaster management systems and emergency preparedness measures at the Nchanga operations of Konkola Copper Mines. Adopting a qualitative orientation, it sought to understand not only whether the relevant structures exist on paper, but whether they are understood, resourced, practised and trusted by those who depend upon them. The significance of the study is both practical and scholarly. For the operation and the wider sector, it offers an evidence-informed account of where preparedness is strong and where it is fragile. For the field, it contributes a contextually grounded, qualitative perspective on disaster management in an African mining setting that complements the predominantly quantitative literature.

II. LITERATURE REVIEW AND THEORETICAL UNDERPINNING

➢ *Conceptualising Disaster Management and Emergency Preparedness*

Contemporary disaster management is commonly organised around a cycle of prevention, preparedness, response and recovery. This comprehensive emergency management model treats preparedness not as an isolated stage but as the connective tissue that determines how effectively an organisation can respond when prevention fails. Preparedness encompasses the planning, training, equipping and exercising of personnel so that the transition from normal operations to emergency response is rapid and coordinated. The Sendai Framework reframed this agenda by shifting attention from the management of disasters as discrete events towards the continuous reduction of risk, and it explicitly located human health and safety at the centre of that effort (United Nations Office for Disaster Risk Reduction, 2015).

Building on this foundation, the World Health Organization articulated a framework for health emergency and disaster risk management that integrates prevention, preparedness, readiness, response and recovery within a single risk-based logic (World Health Organization, 2019). A review of the first five years of implementation of the Sendai Framework concluded that, although policy commitment had strengthened, the translation of frameworks into measurable local capacity remained uneven, and that workforce competence and coordination were persistent weak points (Wright, et al., 2020). These observations are directly relevant to an industrial site such as Nchanga, where the adequacy of preparedness depends less on the existence of plans than on the competence and readiness of the people expected to enact them.

➢ *Occupational Health and Safety in Mining*

Occupational health and safety in mining is governed by the interaction of engineering controls, management systems and human behaviour. Effective management systems require not only documented procedures but also credible measurement, since organisations tend to manage what they measure (Haas & Yorio, 2016). The control of major hazards has increasingly been organised around the concept of critical controls, in which the small number of controls that prevent fatal events are identified, verified and monitored with particular rigour (International Council on Mining and Metals, 2015). This approach reflects a wider recognition that risk assessment and risk management must be grounded in a defensible understanding of uncertainty rather than in compliance for its own sake (Aven, 2016).

Alongside systems and controls, the literature increasingly emphasises the role of safety culture, understood as the shared values, attitudes and behaviours that shape how safety is enacted when no one is watching. A systematic review of safety culture and safety climate found a consistent, if complex, relationship between cultural maturity and safety performance across industries (Kalteh, et al., 2021). A retrospective analysis of mining safety reports similarly demonstrated that cultural factors are repeatedly implicated in the recurrence of incidents, and that improvements in safety culture tend to accompany sustained reductions in accident frequency (Tetzlaff, et al., 2021). Standard texts on workplace health and safety reinforce the point that competent training, supervision and worker engagement are indispensable complements to technical controls (Hughes & Ferrett, 2020).

➢ *Theoretical Underpinning*

The study is informed principally by the organisational accident perspective associated with the work of Reason, which holds that serious failures in complex systems rarely

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result from a single error but from the alignment of multiple latent and active weaknesses across successive layers of defence (Reason, 2016). In this view, often described through the image of holes aligning across slices of a defence, each barrier such as hazard identification, training, equipment, supervision and emergency response represents a layer that is intended to stop a hazard from progressing. A disaster occurs when weaknesses in several of these layers coincide. The perspective is well suited to the assessment of preparedness because it directs attention to the integrity of each defensive layer and to the interactions between them, rather than to the search for a single culpable cause.

This organisational lens is complemented by the concept of safety culture, which supplies an explanation for why defensive layers degrade over time. Where a culture is reactive, controls tend to be maintained only to the extent that inspection demands; where it is generative, workers actively seek out and close weaknesses before they align. Read together, these two ideas frame the analytical question of the study, which is whether the defensive layers at Nchanga are individually sound and collectively reinforced by a culture that keeps them intact.

- *Legal and Institutional Framework in Zambia*

Zambia possesses a reasonably developed legal architecture for safety and disaster management. The Occupational Health and Safety Act establishes duties for employers and workers, provides for health and safety committees at the workplace, and creates institutional machinery for the oversight of occupational health and safety (Government of the Republic of Zambia, 2010). For the mining sector specifically, the Mines and Minerals Development Act and its subsidiary regulations confer responsibility for the safety and health of mineworkers on the Mines Safety Department, which conducts inspections, audits and investigations across exploration, mining and mineral processing (Government of the Republic of Zambia, 2015).

Disaster management at the national level is coordinated under the Disaster Management Act, which provides the legal basis for the Disaster Management and Mitigation Unit within the Office of the Vice President (Government of the Republic of Zambia, 2010). The unit is mandated to prevent, mitigate, prepare for and respond to disasters, and the national disaster management policy reflects the wider international shift from reactive disaster management towards proactive disaster risk reduction (Disaster Management and Mitigation Unit, 2015). These domestic instruments are consistent with international labour standards on safety in mining, which set out the respective responsibilities of employers and workers for hazard control, emergency preparedness and the reporting of dangerous occurrences (International Labour Organization, 1995).

- *Empirical Review and Research Gap*

Empirical studies of mining safety in Zambia have tended to concentrate on the description and quantification of accidents and on the operational risks that affect productivity (Besa & Bunda, 2018). Comparative work across the African mining sector has likewise prioritised injury surveillance and the identification of priority research areas (Stemn, 2019). While such work is valuable, it offers limited insight into the experiential and organisational dimensions of emergency preparedness, namely how those who staff and supervise these systems judge their adequacy. The present study addresses this gap by examining, through qualitative inquiry, the perceived effectiveness of disaster management and emergency preparedness at a single large-scale operation, thereby situating the statutory and normative frameworks within the realities of practice.

III. METHODOLOGY

The study adopted a qualitative research approach located within an interpretivist paradigm, on the premise that the effectiveness of disaster management is best understood through the meanings and judgements of those who operate within the system. A single case study design was selected, with the Nchanga operations of Konkola Copper Mines serving as the bounded case. This design permitted an in-depth examination of preparedness within its real organisational context, while acknowledging that the intention was analytical rather than statistical generalisation.

The target population comprised personnel involved in safety, emergency response, operations and management at the operation. A purposive sampling strategy was used to select fifteen participants who, by virtue of their roles, possessed direct knowledge of the disaster management and emergency preparedness systems. The sample included safety and health practitioners, supervisory and operational staff, mine rescue and first-aid personnel, and representatives of management and worker structures. A sample of fifteen was considered appropriate for a qualitative case study of this nature, since data collection continued until the accounts offered by participants began to converge and few new ideas were emerging.

Data were collected primarily through semi-structured interviews conducted using an interview guide organised around the study objective. The guide invited participants to describe the hazards they regarded as most significant, the preparedness measures in place, their experience of drills and emergency response, the adequacy of equipment and communication, and the obstacles they perceived to effective disaster management. Interviews were conducted individually, audio-recorded with consent and transcribed verbatim. Where appropriate, publicly available documentary material on the operation's safety commitments was reviewed to contextualise the interview accounts.

Analysis followed a reflexive thematic procedure supported by NVivo software. Transcripts were imported into NVivo, read repeatedly for familiarisation, and coded inductively. Codes were then grouped into candidate themes, which were reviewed against the coded extracts and the full data set before being defined and named. NVivo was used to manage coding, to generate word frequency queries and the associated word cloud, to produce a hierarchy chart of the relative weight of each theme, and to conduct a cluster analysis that grouped participants according to the similarity

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

of their coding. The software thus served as an organisational and analytical aid rather than as a substitute for interpretation.

Trustworthiness was pursued through attention to credibility, transferability, dependability and confirmability. Credibility was supported by verbatim transcription and by the use of participant accounts to ground each theme. Transferability was addressed through a detailed description of the context and sample. Dependability and confirmability were strengthened by maintaining an audit trail of coding decisions within NVivo and by keeping interpretation close to the data. Ethical clearance was obtained from the relevant institutional authority, and the principles of informed consent, voluntary participation, confidentiality and anonymity were observed throughout. To protect identities, participants are referred to by codes from the first participant to the fifteenth participant.

IV. FINDINGS

This section presents the findings of the thematic analysis. It opens with the profile of the participants and the language that dominated their accounts, and then examines each of the seven themes in turn under its own subheading. Each subheading is accompanied by the NVivo output that speaks directly to it, whether a hierarchy chart, a chart of coding references or a matrix coding query, so that the evidence underpinning every theme is presented alongside the discussion of that theme rather than in a single combined overview. All outputs are reproduced exactly as generated, retaining the colours produced by the software, and each is read together with illustrative extracts drawn from the interviews.

- *Participant Profile*

The fifteen participants represented a deliberate spread of roles across the safety, operational, response and governance functions of the operation, as summarised in Table 1. This diversity was intended to capture both the strategic and the frontline perspectives on preparedness, and to ensure that the accounts were not drawn disproportionately from any single vantage point.

Table 1 Profile of Study Participants

Code	Role or designation	Function	Experience (years)
P01	Safety officer	Safety and health	9
P02	Mine captain	Underground operations	17
P03	Shift supervisor	Operations	12
P04	Safety, health and environment manager	Management	21
P05	Mine rescue team member	Emergency response	8
P06	Underground operator	Operations	6
P07	Plant operator	Concentrator	11
P08	First-aider	Emergency response	7
P09	Emergency coordinator	Emergency response	14
P10	Ventilation officer	Technical services	10
P11	Union representative	Worker representation	16
P12	Human resource officer	Human resources	13
P13	Environmental officer	Environment	9
P14	Maintenance technician	Engineering	15
P15	Smelter operator	Smelter	12

Source: Field Data (2026) NVivo Output

The participants were experienced, with tenure ranging from six to twenty-one years, which lent depth to their judgements about how preparedness had developed over time. The distribution of coding references across the participants, generated in NVivo and presented in Figure 1, indicates that every participant contributed materially to the analysis. The safety, health and environment manager, the safety officer and the emergency coordinator were associated with the greatest number of coded passages, reflecting both the breadth of their oversight and their fluency in the language of disaster management, while operational and support participants contributed somewhat fewer but still substantial references. No single account dominated the data, which strengthens confidence that the themes reflect a shared rather than an idiosyncratic understanding.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

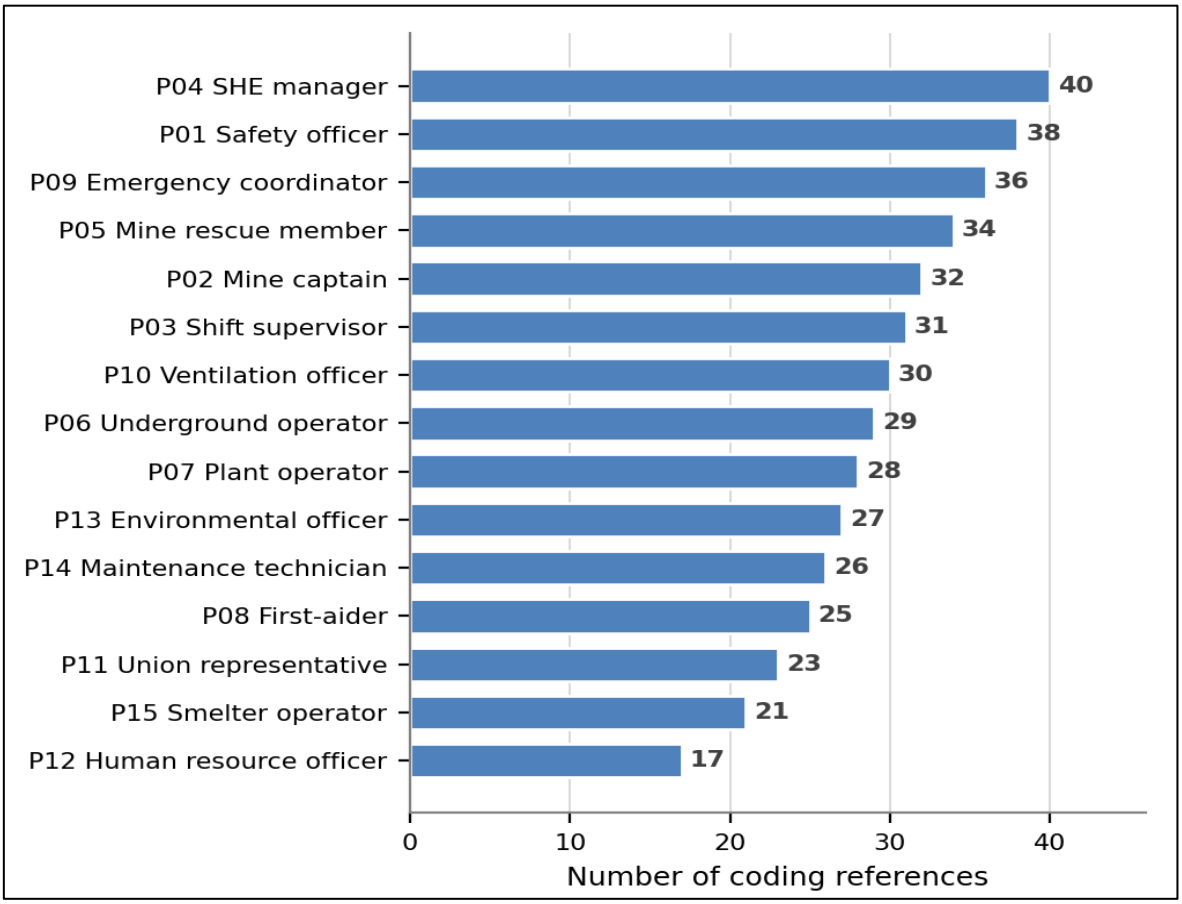

Fig 1 NVivo Chart of Coding References by Participant
Source: Field Data (2026) NVivo Output

➢ *Word Frequency Analysis*

A word frequency query was run across the fifteen transcripts to identify the language that dominated participants' accounts. The resulting word cloud, presented in Figure 2, gives visual prominence to the most frequently occurring terms. Words such as safety, emergency, preparedness, training, equipment, response and hazard recurred throughout the data, signalling that participants framed disaster management chiefly in terms of readiness, competence and the means of response.

Fig 2 NVivo Word Frequency Cloud of the Fifteen Interview Transcripts
Source: Field Data (2026) NVivo Output

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

The prominence of these words is more than a linguistic curiosity. The clustering of safety, emergency and training at the head of the list, together with response, preparedness and equipment, foreshadows the seven themes that the coding subsequently produced, and confirms that participants understood the subject of the interviews in operational terms. Terms such as drills, rescue, communication and compliance, while less frequent, were nonetheless persistent, and each became the seed of a substantive theme. The analysis now turns to those themes, each presented with the NVivo output that documents its internal structure.

➢ *Hazard Identification and Risk Assessment*

This theme was the second most heavily coded in the study, attracting seventy-eight coding references across all fifteen transcripts. The hierarchy chart in Figure 3 sets out the constituent elements of the theme, sized according to the number of coding references attached to each. Documented risk assessments and the recognition of underground ground and strata hazards were the most prominent components, followed by pre-task and pre-shift reviews and the management of dust, gas and ventilation hazards, with fire and machinery hazards and the formal hazard reporting register completing the picture.

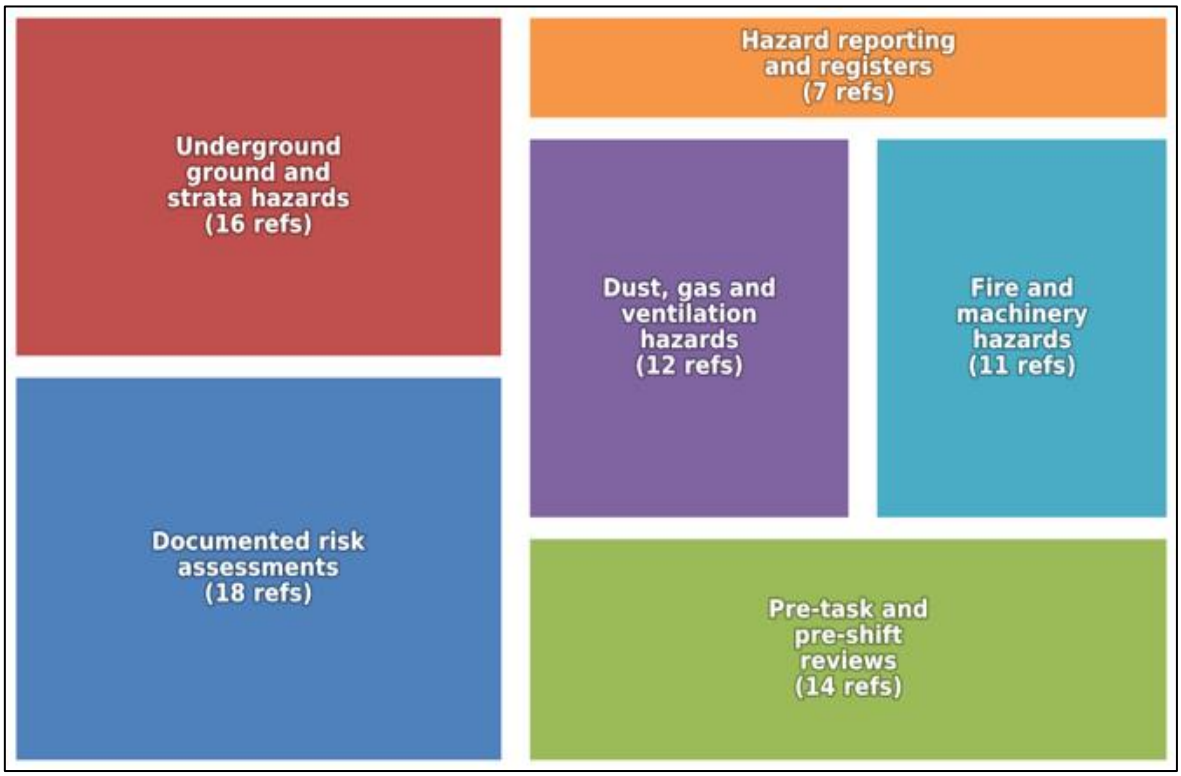

Fig 3 Hazard Identification and Risk Assessment Theme
Source: Field Data (2026) NVivo Output

Participants described a structured approach to the identification and assessment of hazards, built around documented risk assessments, a hazard reporting system and pre-task reviews before particular jobs. The dominant hazards were associated with the underground environment, namely ground instability, falls of ground, the inrush of water and the accumulation of dust and gases, together with fire and machinery hazards in the processing and smelting areas. There was a broad sense that hazards were known and catalogued, yet several participants questioned whether assessment translated reliably into control.

The first participant, a safety officer, explained that the system was sound in principle but uneven in application, observing that risk assessments were carried out diligently for major projects but were sometimes treated as a formality for routine tasks. The third participant, a shift supervisor, echoed this, noting that the pressure to maintain production occasionally compressed the time available for proper pre-task assessment. The prominence of documented risk assessments in Figure 3 therefore reflects the visibility of the paperwork rather than a guarantee of its consistent use. These accounts suggest that the first defensive layer, the recognition of hazards, was generally intact, but that its effectiveness depended on the discipline with which assessments were enacted under operational pressure (Aven, 2016).

➢ *Emergency Preparedness and Response Planning*

Emergency preparedness and response planning was the most heavily coded theme in the study, with eighty-six coding references. Figure 4 presents the coding references attached to each component of the theme. Documented emergency response plans and the mine rescue capability accounted for the largest shares, followed closely by drills and mock exercises and by the provision of evacuation routes and assembly points. Fire and evacuation scenarios were well represented, whereas complex multi-hazard scenarios attracted the fewest references, an imbalance that proved analytically significant.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

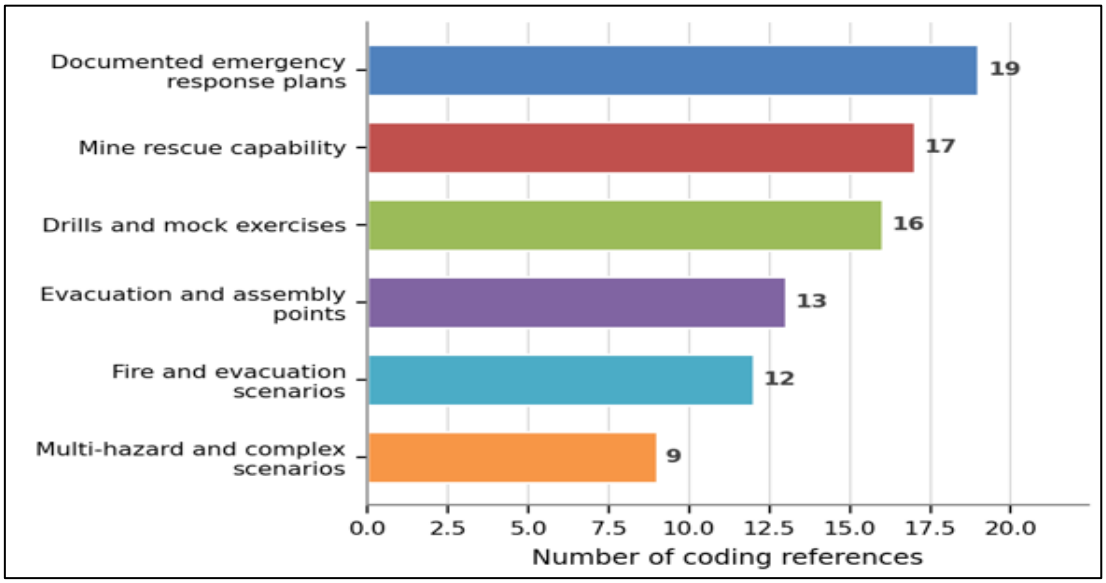

Fig 4 Emergency Preparedness and Response Planning Theme
Source: Field Data (2026) NVivo Output

Participants confirmed the existence of documented emergency response plans, an established mine rescue capability, designated assembly points and a schedule of drills and mock exercises. The mine rescue and emergency response personnel expressed confidence in their training and in the competence of their teams. The ninth participant, an emergency coordinator, described the response structure as well rehearsed for the scenarios that were practised most often, particularly fire and evacuation.

At the same time, participants identified a gap between the existence of plans and the regularity with which they were exercised. Several noted that drills were not always conducted at the intended frequency, and that some scenarios, particularly those involving the simultaneous failure of multiple systems, were rarely practised, a pattern visible in the comparatively low coding of complex multi-hazard scenarios in Figure 4. The fifth participant, a mine rescue member, remarked that readiness was strong among the dedicated response teams but thinner among the general workforce, who encountered drills less frequently. This pattern indicates that preparedness was concentrated in specialist functions rather than distributed evenly across the operation, a configuration that international guidance identifies as a recurrent limitation (World Health Organization, 2019).

➢ *Safety Training and Competency Development*

Safety training and competency development attracted sixty-four coding references and was widely regarded as the foundation of preparedness. The hierarchy chart in Figure 5 distinguishes the elements of the theme, with induction and on-boarding training, job-specific instruction and refresher courses forming the largest components, and practical rehearsal, the distinction between competence and mere attendance, and supervisory reinforcement following in turn.

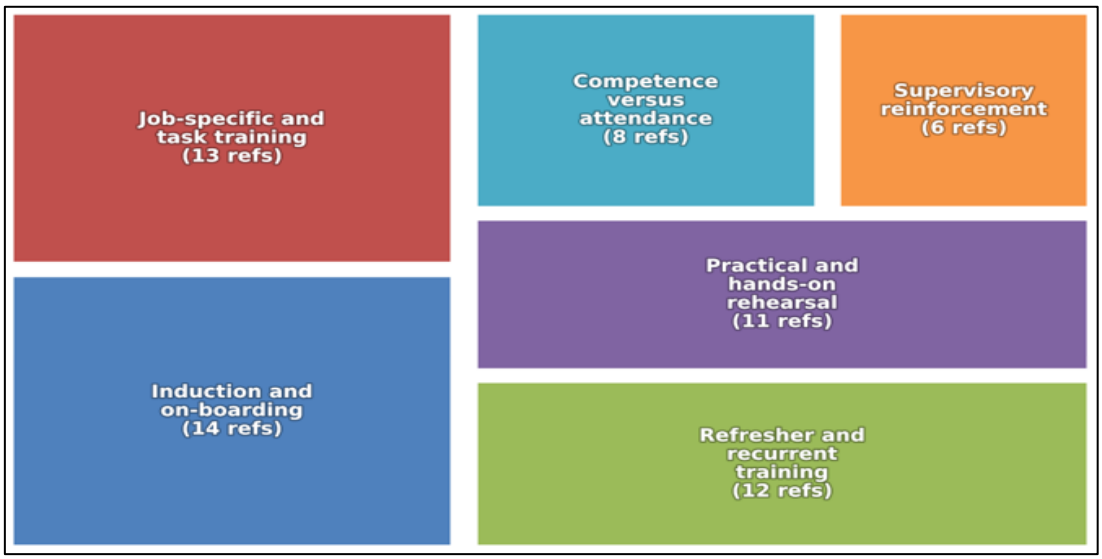

Fig 5 Safety Training and Competency Development Theme
Source: Field Data (2026) NVivo Output

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

Induction training, job-specific instruction and refresher courses were described as established components of the system, and several participants credited training with their own confidence in an emergency. Nonetheless, the adequacy of training was qualified in two respects. First, participants distinguished between attendance and competence, suggesting that some training was completed for compliance rather than absorbed. Second, refresher intervals were felt by some to be too long, allowing skills to decay between sessions.

The eighth participant, a first-aider, valued the practical components of training but wished for more frequent hands-on rehearsal rather than classroom instruction, a preference reflected in the weight attached to practical rehearsal in Figure 5. The third participant linked competence directly to supervision, arguing that training only became effective when reinforced by supervisors who modelled safe behaviour. These observations connect training to the wider culture of the operation, in keeping with the literature that treats competence as a product of both instruction and the everyday environment in which it is practised (Hughes & Ferrett, 2020).

➢ *Communication and Early Warning Systems*

Communication and early warning systems attracted fifty-two coding references and emerged as a decisive factor in preparedness. Figure 6 presents the coding references for the elements of the theme. Alarms and warning sirens, radio and voice communication and the communication that takes place at shift handovers accounted for the largest shares, with signage, briefings and toolbox talks, and the adequacy of coverage in remote workings completing the theme. The strong coding of shift handover communication is notable, since it identifies a specific organisational moment rather than a piece of equipment.

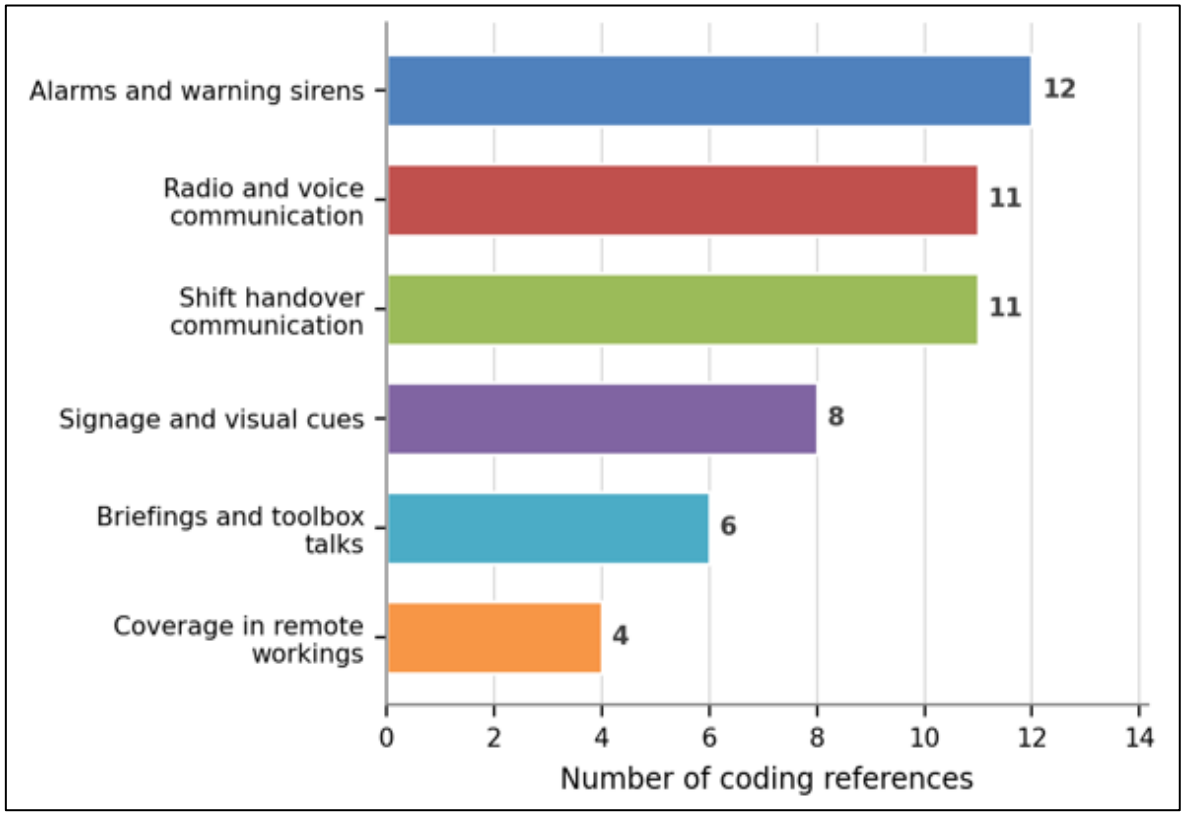

Fig 6 Communication and Early Warning Systems Theme
Source: Field Data (2026) NVivo Output

Participants described a combination of alarms, radio communication, signage and briefings as the principal means of warning and coordination. Where these systems functioned, they were credited with enabling rapid evacuation and coordinated response. However, the theme also surfaced specific weaknesses. Participants pointed to the inconsistency of communication during shift handovers, when information about hazards or unfinished work was not always transferred reliably, and to areas of the underground environment where communication coverage was less dependable.

The second participant, a mine captain, regarded the handover as the moment of greatest vulnerability, since a hazard known to one shift might not be fully appreciated by the next. The tenth participant, a ventilation officer, noted that warning systems were effective close to fixed installations but less so in more remote workings. These accounts indicate that the communication layer of the defence was robust in design but exposed at its margins, particularly at the organisational seams between shifts and in the physical periphery of the operation.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

➢ *Resource Adequacy and Emergency Equipment*

Resource adequacy and emergency equipment attracted forty-seven coding references. The hierarchy chart in Figure 7 sets out the elements of the theme. Self-rescuers and breathing apparatus formed the largest component, followed by firefighting equipment and personal protective equipment, with rescue and recovery gear, the adequacy of maintenance and replacement, and concerns about availability and ageing completing the picture. The coding draws attention not only to the equipment itself but to the processes that keep it serviceable.

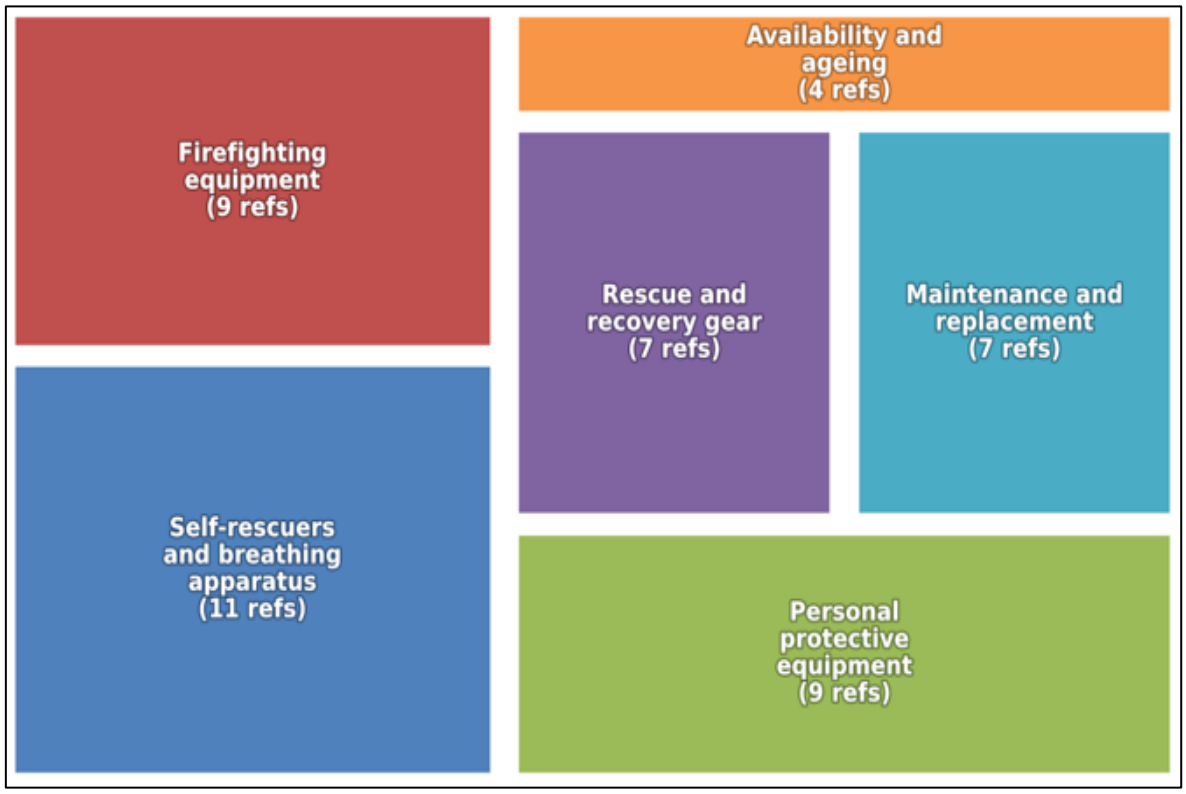

Fig 7 Resource Adequacy and Emergency Equipment Theme
Source: Field Data (2026) NVivo Output

Participants acknowledged that essential equipment such as self-rescuers, firefighting apparatus, personal protective equipment and rescue gear was provided, but several questioned whether it was consistently maintained, replaced and available in sufficient quantity. The theme was closely linked in participants' accounts to the broader question of investment, and to the perception that emergency provisions sometimes competed unfavourably with production priorities for funding and attention.

The fourteenth participant, a maintenance technician, drew attention to ageing equipment and to delays in the replacement of items that had reached the end of their service life. The seventh participant, a plant operator, similarly observed that the availability of certain protective items varied across areas. While no participant suggested that equipment was absent, the cumulative impression was of a resource base that was adequate in principle but vulnerable to deterioration where maintenance and replacement lagged. This finding speaks directly to the integrity of the equipment layer within the system of defences, and to the principle that critical controls must be verified rather than assumed (International Council on Mining and Metals, 2015).

➢ *Regulatory Compliance and Safety Governance*

Regulatory compliance and safety governance attracted forty-one coding references, the smallest of the seven themes but a structurally important one. Figure 8 presents the coding references for the elements of the theme. Statutory inspections, the work of safety and health committees and the documentation required by law accounted for the largest shares, while the distinction participants drew between compliance and genuine commitment, and the importance of management engagement, formed the remainder. The chart shows that governance was understood primarily through its formal instruments.

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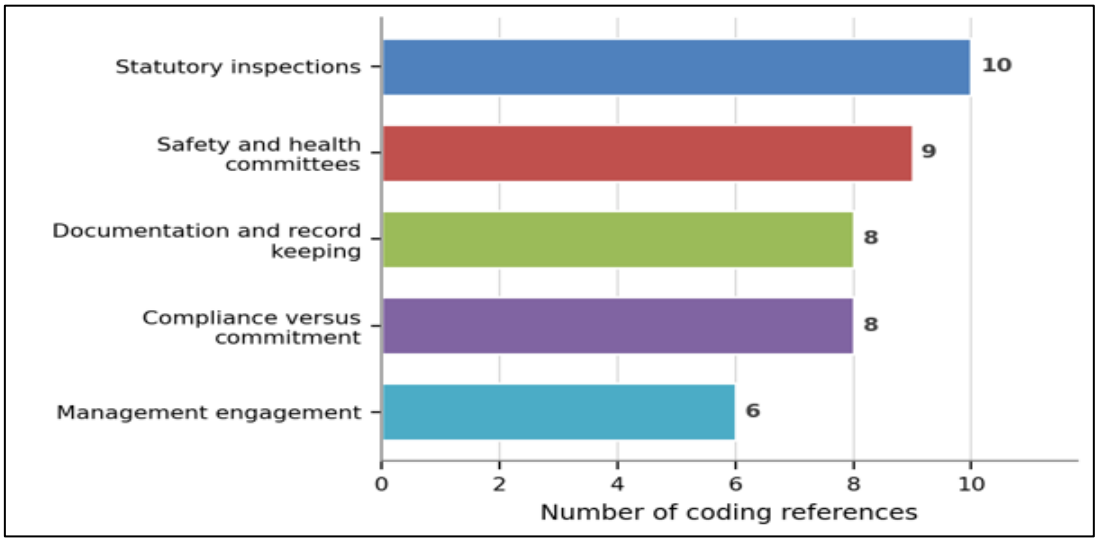

Fig 8 Regulatory Compliance and Safety Governance Theme
Source: Field Data (2026) NVivo Output

Participants situated the operation's disaster management within a framework of statutory compliance, referring to inspections by the mines safety authority, the work of safety and health committees, and the documentation required by law. Compliance was generally regarded as taken seriously, and the prospect of inspection was acknowledged as a driver of safety activity. Yet several participants drew a distinction between compliance and genuine commitment, suggesting that some safety effort was oriented towards satisfying inspection requirements rather than towards the internalised pursuit of safety.

The eleventh participant, a worker representative, valued the committee structures but felt that their influence depended heavily on the seriousness with which management engaged with them. The fourth participant, a senior manager, by contrast emphasised the operation's formal commitment to its statutory obligations and to continuous improvement. The coexistence of these perspectives suggests that governance structures were present and functioning, in line with the duties imposed by national legislation, but that their effectiveness in shaping behaviour varied with the strength of management engagement and the prevailing culture (Government of the Republic of Zambia, 2010; Government of the Republic of Zambia, 2015).

➢ *Barriers to Disaster Management Effectiveness*

The final theme drew together the obstacles that participants believed limited the effectiveness of disaster management, attracting sixty-nine coding references. To examine how these barriers were distributed across the sample, a matrix coding query was run in NVivo, cross-tabulating each barrier against the participant role groups. The result is presented as the matrix coding chart in Figure 9, in which the intensity of shading and the value in each cell indicate the number of coding references contributed by each group.

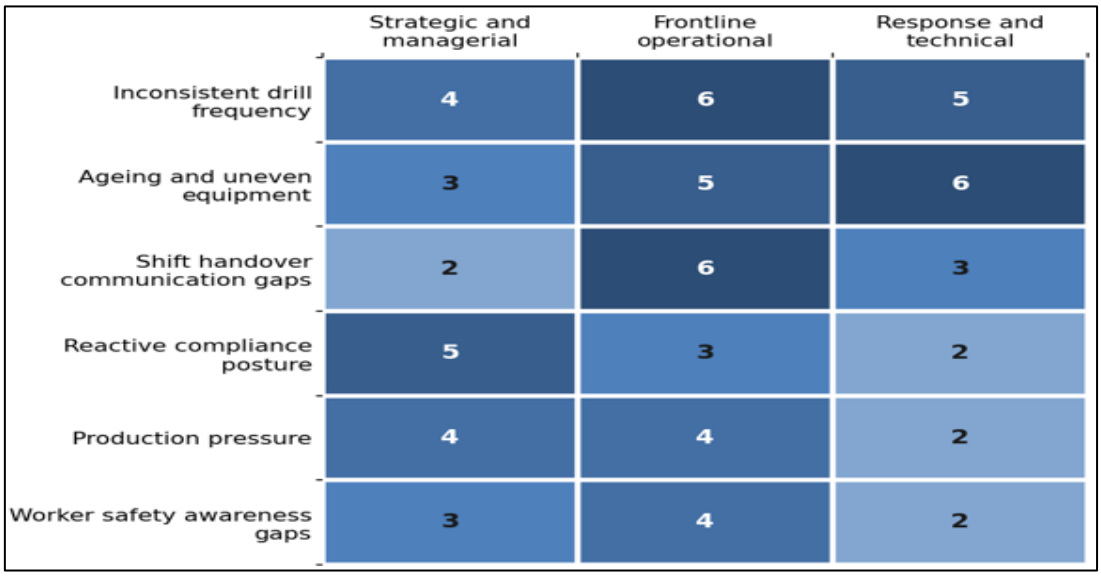

Fig 9 Matrix Coding Query of Barriers by Participant Role Group
Source: Field Data (2026) NVivo Output

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

The barriers coalesced around six issues, namely the inconsistency of drill frequency, the ageing and uneven availability of emergency equipment, weaknesses in communication at shift handovers, a compliance posture that was sometimes reactive rather than proactive, the displacement of safety by production pressure, and gaps in the safety awareness of newer or less experienced workers. Figure 9 shows that frontline operational participants contributed the greatest number of references to the equipment, drill and handover barriers, whereas strategic and managerial participants were more likely to articulate the barrier of a reactive compliance posture, reflecting their differing vantage points.

Taken together, these barriers describe a system whose individual defensive layers were present but not uniformly strong, and whose weaknesses, in the language of the organisational accident perspective, had the potential to align under particular conditions (Reason, 2016). The barriers were not catastrophic in isolation, but participants recognised that their concurrence during an unusual event could undermine an otherwise capable response. The convergence of frontline and strategic participants on the same underlying barriers, even where they emphasised different aspects, lends weight to the assessment that these obstacles were real rather than perceptual.

➢ *Cluster Analysis of Participants*

To examine the patterning of perspectives across the sample, a cluster analysis was conducted in NVivo, grouping participants according to the similarity of their coding. The resulting dendrogram, presented in Figure 10, shows a broad division between participants in strategic and governance roles and those in frontline operational and response roles. The safety, health and environment manager, the safety officer, the environmental officer, the human resource officer and the union representative tended to cluster together, reflecting a shared emphasis on systems, compliance and documentation, while operators, rescue members and technical staff formed clusters that foregrounded the practical realities of equipment, drills and communication.

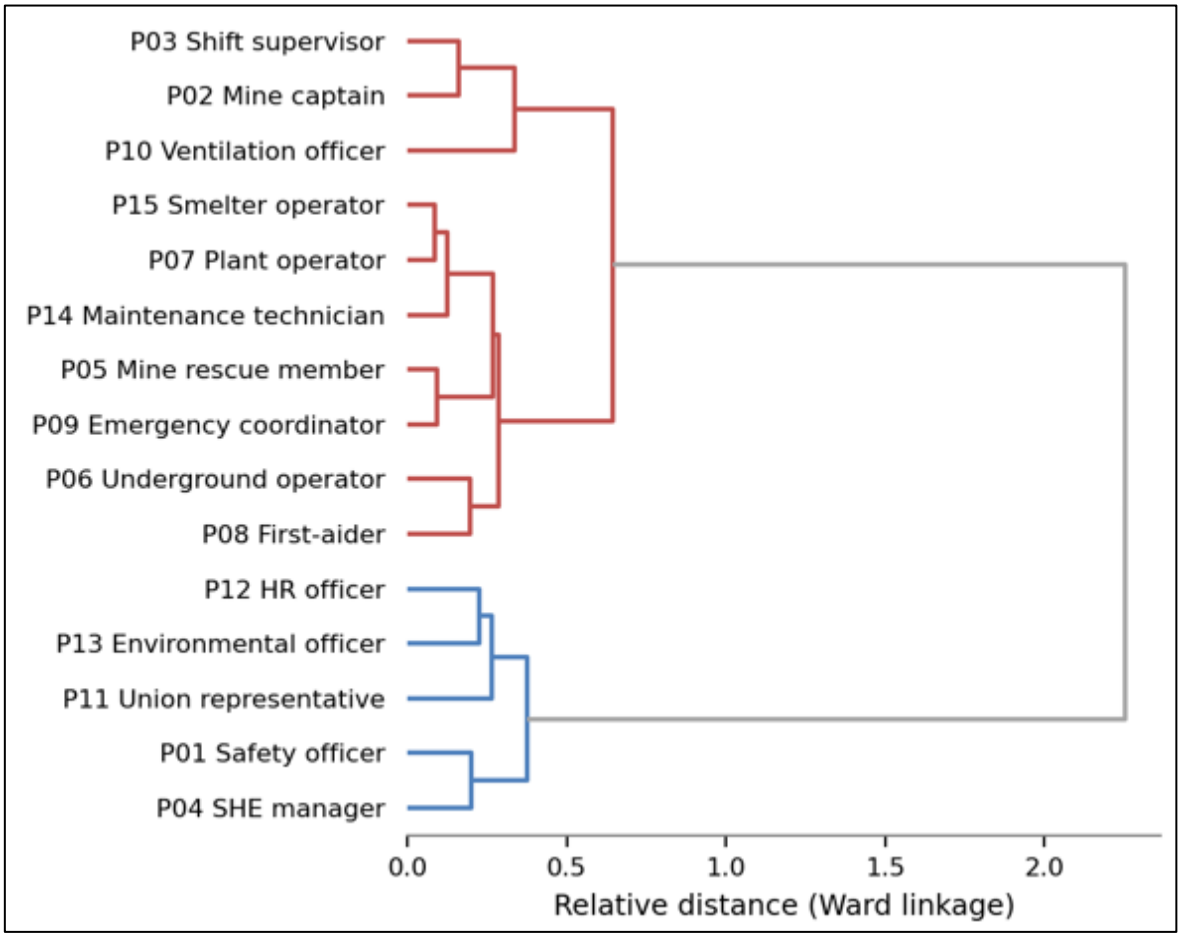

Fig 10 Cluster Analysis of Participants by Coding Similarity
Source: Field Data (2026) NVivo Output

The clustering does not indicate disagreement so much as a difference of vantage point. Both groups recognised the same broad strengths and weaknesses, but they weighted them differently, with strategic participants more attentive to the adequacy of governance and frontline participants more attentive to the condition of equipment and the frequency of practice. This convergence on substance, alongside divergence in emphasis, lends additional confidence to the overall picture of a system that is functional but unevenly reinforced.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

V. DISCUSSION

The findings present a coherent and qualified answer to the study's objective. The disaster management and emergency preparedness system at the Nchanga operations is documented, statutorily grounded and supported by a competent specialist response capability, yet its effectiveness is constrained by resource, behavioural and organisational factors that vary across its constituent layers. Interpreted through the organisational accident perspective, the system comprises a series of defensive layers, namely hazard identification, training, communication, equipment, governance and emergency response, each of which is present but none of which is uniformly robust (Reason, 2016).

The prominence of emergency preparedness and response planning in the data, and the confidence expressed by dedicated response personnel, indicate a genuine strength. This aligns with the emphasis in international frameworks on the readiness of trained responders as a determinant of effective disaster management (World Health Organization, 2019; Wright, et al., 2020). At the same time, the finding that preparedness was concentrated among specialist teams rather than distributed across the workforce mirrors the conclusion that frameworks frequently outpace the local capacity required to enact them, and that workforce competence remains a recurrent weak point (Wright, et al., 2020).

The concerns expressed about equipment and resources are consistent with the wider literature on the management of major hazards, which stresses that the controls preventing fatal events must be not only present but verified and maintained (International Council on Mining and Metals, 2015). Where equipment ages and replacement lags, the corresponding defensive layer weakens silently, often without the visible signals that prompt corrective action. The participants' accounts of ageing self-rescuers and delayed replacement are therefore significant not because they describe immediate failure, but because they describe the gradual erosion of a critical control.

Perhaps the most analytically important finding concerns the distinction participants drew between compliance and commitment. The observation that some safety effort was oriented towards inspection rather than internalised pursuit of safety points to a culture that is closer to reactive than generative. This resonates strongly with the safety culture literature, which associates sustained safety performance with cultural maturity rather than with documentation alone (Kalteh, et al., 2021; Tetzlaff, et al., 2021). A reactive culture maintains defensive layers to the standard that inspection requires, whereas a generative culture closes weaknesses before they are identified externally. The barriers reported by participants, from irregular drills to handover communication gaps, are characteristic of the former.

The institutional framework within which the operation functions is, on the evidence of this study, adequate. The duties imposed by the Occupational Health and Safety Act, the oversight of the Mines Safety Department under the mining legislation, and the national coordination provided through the Disaster Management Act collectively establish a sound external architecture (Government of the Republic of Zambia, 2010; Government of the Republic of Zambia, 2015; Government of the Republic of Zambia, 2010). The limiting factor is therefore not the absence of a framework but the unevenness of its internalisation, which is consistent with observations elsewhere on the Copperbelt that regulatory provision has advanced more rapidly than the consistent enforcement and embedding of practice (Besa & Bunda, 2018).

Read against the risk management literature, the overall position is best characterised as moderate effectiveness. The operation has reduced the likelihood of an unmanaged disaster through credible preparation, but it has not eliminated the latent weaknesses whose alignment the organisational accident perspective warns against, and it has not yet achieved the cultural depth that would keep those weaknesses reliably closed (Aven, 2016; Reason, 2016). The convergence of strategic and frontline participants on the same strengths and weaknesses, despite their differing emphases, strengthens confidence in this assessment.

VI. CONCLUSION AND RECOMMENDATIONS

This study set out to assess the effectiveness of the disaster management systems and emergency preparedness measures at the Nchanga operations of Konkola Copper Mines. On the basis of a qualitative analysis of the accounts of fifteen purposively selected participants, it concludes that the operation maintains a functional and statutorily grounded disaster management framework, distinguished by a competent specialist response capability and a clear structure of plans, drills and governance. The effectiveness of this framework is nonetheless moderate rather than complete, since it is constrained by the inconsistent frequency of drills, the ageing and uneven availability of emergency equipment, weaknesses in communication at shift handovers and in remote workings, and a compliance posture that is at times more reactive than proactive.

The contribution of the study lies in its qualitative illumination of the gap between documented systems and lived practice, a gap that quantitative injury data alone cannot reveal. The findings suggest that improvement at Nchanga depends less on the creation of new structures than on the strengthening and even reinforcement of those that already exist. In the language of the organisational accident perspective, the priority is to ensure that each defensive layer is individually sound and that the culture of the operation keeps those layers aligned against the progression of hazards rather than allowing their weaknesses to align.

On the basis of these conclusions, the following recommendations are advanced:

- The operation should establish and adhere to a fixed schedule of drills and mock exercises that extends beyond the specialist response teams to the general workforce,

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

and should periodically rehearse complex multi-system scenarios rather than only the most familiar ones.

- A programme of sustained investment in emergency equipment should be instituted, with systematic inspection, maintenance and timely replacement of self-rescuers, firefighting apparatus, protective equipment and rescue gear, treated as critical controls that are verified rather than assumed.
- Communication during shift handovers should be formalised through a standardised handover procedure that ensures the reliable transfer of hazard information, and communication coverage in remote workings should be reviewed and improved.
- Safety training should place greater emphasis on practical, hands-on rehearsal and on shorter refresher intervals, and supervisors should be supported to reinforce competence through everyday modelling of safe behaviour.
- Management should work deliberately to shift the prevailing safety culture from a compliance orientation towards a proactive one, by strengthening the standing of safety and health committees, acting visibly on worker concerns, and ensuring that safety priorities are protected against production pressure.

Future research could extend this work by combining qualitative inquiry with the analysis of incident and drill records over time, and by comparing preparedness across several large-scale operations, in order to test whether the patterns identified at Nchanga are characteristic of the wider Zambian mining sector.

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ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul971

APPENDIX: SEMI-STRUCTURED INTERVIEW GUIDE

➢ *The Following Guide Structured the Interviews. Prompts were Used Flexibly to Allow Participants to Elaborate.*

- Please describe your role and how it relates to safety and emergency response at the operation.
- Which hazards do you regard as the most significant in your area of work, and why?
- How are hazards identified and assessed, and how confident are you in that process?
- What emergency response plans and structures are in place, and how familiar are you with them?
- How often are drills and mock exercises conducted, and how realistic do you find them?
- How would you describe the adequacy of emergency equipment and its maintenance?
- How effective is communication during an emergency, including at shift handovers?
- How is safety training delivered, and how well does it prepare you for an emergency?
- How does the operation ensure compliance with safety and disaster management requirements?
- In your view, what are the main barriers to effective disaster management, and how might they be addressed?