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Critical literature review on safety and health hazards as operational risks affecting mining productivity: A case of Konkola copper mine, Zambia

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Abstract
This paper undertook a critical literature review on safety and health hazards that pause huge potential of affecting operations at Konkola Copper Mine (KCM), Zambia. The article argues that safety and health hazards as operational risks that if remain unchecked, would affect productivity in the mining industry. Zambia is one of the nations that heavily depend on copper hence the contribution of the mining industry to macro and micro economy remains significant. The paper therefore tasked itself to critically evaluate and provide details on safety and health hazards of mining, how it is done, techniques, importance, challenges and sustainable ways of making the mining industry effective and efficiency. The point of departure will be a critique, conclusion and recommendations that emerged from the desk research findings. The analysis of the various activities conducted at KCM revealed that operational risk management with a focus on safety and health was taken seriously within the mining operations. This was evidenced by the over whelming information on risk management documented within the organization. It was further revealed that operational risks concerning safety and health at KCM were managed through Safety management programmes. However statistics from the analysis brought to light an urgent need to further strengthen and modernize accident prevention initiatives and technologies in order to enhance productivity thereby positively contributing to Zambia's economic and social development. In this regard, the paper submit that central to the successful ability of any mining company in order to achieve its mining, milling recoveries and produce a saleable mineral product, is the management of operational risks. Based on the findings of the analysis, the paper recommends that risk management should cover all the safety and health issues at the mine and that the operational risk system management should be embedded into the operations of the mine as part of its culture. A further recommendation to the mining firm was to enhance their employees` skills of managing safety and health issues as the later and former are potential risks to mining productivity.

Keywords: safety, health hazards, operational risk, productivity

1. Introduction
Mining, by its nature, presents a range of safety and health hazards that are different from those in other sectors. Hazards, such as ground instability, are inherent in the underground environment. Others are introduced through complex mining activities and processes, which bring potential hazards into the underground environment including hazards from mobile equipment such as large vehicles that may limit visibility for the driver. Risks can increase as mines get deeper and more expansive. A report from Ontario Canada mine (2014) [17] indicates that if these hazards are not managed properly using appropriate controls, they can result in serious traumatic injuries, death or occupational illness. Therefore it can be argued that to significantly improve health and safety in mining and milling activities, there is need for consented effort from all teams to mitigate the risk associated with mining. There is also need for the safety system partners and mining sector stakeholders to identify and rank the hazards that pose the greatest risk and warrant the highest level of attention.

1.1 Safety and Health Hazards of Mining
Mining involves various activities and processes to come up with a finished saleable product. The nature of mining brings about safety and health hazards. Ontario Canada mine report (2014) [17] outline five main priority hazards that can create a range of health and safety issues as follow: worker fatigue, ground control hazards, occupational disease hazards, hazards associated with water management and hazards associated with mobile equipment. A detailed account of each one is given hereunder.

1.1.1 Worker fatigue
This is identified as one of top concerns of the mining sector and is it ranked as priority in risk management. Prial and Dey (2015) [18] indicate that worker fatigue has previously been a process of safety and health system. However given the current level of concern about this hazard, there is need to improve worker/employee participation in risk management activities in order to improve understanding of the extent to which worker fatigue affects mining productivity as it results

in injuries and fatalities. Worker fatigue is mostly as a result of irregular shift schedules.

In order to improve on risk mitigation of worker fatigue, it is imperative to learn from progress other sectors have made in addressing worker fatigue issues. There is need to identify strategies that can be explored to address the problem of worker fatigue to enhance productivity. The paper is of the view that Zambian mining companies should invest heavily in innovative strategic technologies aimed at averting workers fatigue. Such technologies may include but not limited to fatigue monitoring system (such as Driver Safety System - DSS), Hazardous Area Signaling and Ranging Device (HASARD), Automated Temporary Roof Support (ATRS) and even the adoption of automated underground mining (Kuytu & Bolat, 2016) [12].

1.1.2 Ground Control Hazards

Ground Control Hazards emerge as a result of blasting which causes ground failure and seismicity as reported by Auditor general's report (2015) [22] and Chifungula, (2015) [3]. There is need to consider the mine life to come up with an appropriate design of the mine that will reduce the hazards associated with seismicity and rock-bursting. According to Ontario Canada mine report (2014) [17], improving and mitigating risk hazards through grounds control require the improvement of operational control methods. The mining sector in Zambia can benchmark with other mining firms from developed countries' advanced technologies such as those that have been developed in South Africa, United States of America to mention but a few.

1.1.2.1 Appropriate Operational Control Methods

There is need for appropriate methods that will help reduce or minimize the occurrence of ground failure, of occurrence of seismicity and rock-bursting in underground mines. For instance, system such as the Automated Temporary Roof Support (ATRS) could be adopted in this regard. Due to the risk posed by ground failure, the Ontario Canada mine (2014) [17] indicated the need to improve the ability to identify any prediction for seismicity and rock bursting at the mine design stage including better reliance on risk assessment methods and better quality geotechnical data. The various process operational controls relating to distressing of blasting potables and the use of re-entry protocols following rock burst should be improved as this will bring about prudence in the way micro sonic results are managed and interpreted therefore contributing to effectiveness in the management of safety and health hazards (Alli, 2008) [1].

1.1.3 Occupational Disease Hazards

Research by WHO (2014) [24] indicates that air bone hazards such as diesel particulate and silica in underground mining have been on an increase. It is important to limit exposure to hazards that can cause occupational illness including not limited to airborne hazards which require ventilation systems. The Zambian government has taken a stance to continuous address the occupational diseases hazards through the occupational safety and health Act No.36 of 2010, the functions of the institute include:

(a) Provision of occupational laboratory service: for enhancement of health services and quick detection of diseases that threaten the health of employees with potential of affecting mine productivity in the long run. The mines are highly dependent on good health of employees to ensure continuous mining activities and increased output. (b) Investigating and detecting occupational diseases and injuries at work places: This will help the Zambia government and the mine not to just concentrate on preventing traumatic injuries that can be handled quickly but will also provide information on occupational illnesses that develop symptoms after many years. (c) Promoting studies and carrying out investigations and research on occupation health and safety: This will bring about information on any new occupational diseases and better methods of managing occupational safety and health issues with the view of enhancing forecast productivity. (d) Conducting medical examinations for occupational diseases and injuries at work places: This will help in preventing sadden deaths as a result of early detected occupational diseases. In so doing the required human capital will be effective in carry out their various duties and will contribute positively to mine productivity therefore fostering economic and social growth through gains from the mining sector. (e) Develop and implement programs to provide incentives for employers to implement measures to eliminate or reduce risks to health or safety or to improve occupational hygiene. Occupational disease hazards remain a danger to mining productivity if not addressed adequately.

1.1.4 Hazards Associated with Water Management

Water management remains an internal function to managing risks associated with water hazards. At the design stage of a mine a consideration of how water will drain away from the ore body, the passage of waste and chutes must be of great importance. There has to be a deliberate act to seal all holes that may cause unnecessary water in the mine. An accumulation of unnecessary water in the mine can ground a mine to a halt resulting in zero productivity as access to the mine would not be possible and all mining activities and process would be affected. A plan for water management in this case is vital as it will reduce water- related hazards. The mine management needs to come up with strategies such as sealing of exploration diamond drill holes that emanate from the surface and grounding fragmented rock masses that could become a passage/conduit for water transmission. There is need for training programs as well as ingestion programs where possible inclusion of converge systems to detect water that inadvertently enters ore and waste passes and chutes; and put the controls for pass control gates in position that are safely accessible. Water management programs should ensure safety of the mine by ensuring management of cracks subsistence of the mine surface is done profoundly to avoid accumulation of water in the mine (Australian Institute of metallurgy, 2001) [2].

1.1.5 Mobile Equipment Hazards

Heavy mobile equipment poses a hazard to mine safety. In the past 20 years, mobile equipment has displaced ground control issues as major sources of falaties and injuries in mining. Both underground and open pit mines make use of large mobile equipment that pose a hazard, especially in instances where

the operator's visibility is distracted due to the size of the equipment (Hermans, 2007) [7]. Operators of the equipment are unable to see other vehicles and pedestrians and this results in unsafe working conditions as more fatal accidents and injuries occur due to inability of the operators to have a clear view of the physical work environment. There is need to embrace more technological detections that will contribute to a safe work environment. For example, mining safety systems such as Hazardous Area Signaling and Ranging Device (HASARD) can be employed. The relevant authorities should encourage research in this area to address the problem of hazards created by heavy mobile equipment.

1.1.6 Occupational Health and Safety in Mining (OHS in Mining)

Mining like any other industry in Zambia subscribes to Occupation and health and Safety (OHS) legislation. Globally, OHS is generally a new discipline that is still in its infancy stage, as statistics of accident and occupational diseases indicate low global access to it.

In the current state, there is no express provision made in the Constitution of Zambia for the safety and health of workers. Nevertheless, under Part 3 of the Constitution which addresses the "Protection of the Fundamental Rights and Freedoms of the Individual", issues of public health and public safety have been alluded to in general terms. Further, Article 14 provides for the protection of individuals from forced labour. The only provision in the Constitution that is closely related to occupational safety and health is clause (1) of Article 24 which states that "A young person shall not be employed and shall in no case be caused or permitted to engage in any occupation or employment which would prejudice his health or education or interfere with his physical, mental or moral development…".

In 1964, Zambia after gaining independence immediately became a member of the International Labour Organization (ILO). It since then ratified 39 ILO Conventions including the core conventions concerning the promotional framework for Occupational Safety and Health. Apart from the Safety and Health in Mines Convention (1995) [19], Zambia has not ratified the main conventions relating to Occupational Safety and Health and these endorsements still fall far below the scheduled 177 technical conventions. However, based on the legislative framework, Zambia relies on Main laws on Occupational Safety and Health enacted to provide health and safety to the working population. These laws provide guidelines in different sectors of industry on handling matters on safety and health.

2. Main laws on Occupational Safety and Health

The laws provide a frame work and detailed guidelines on safety and health of various factories including the mining sector and these are as follows:

2.1 The Factories Act, Chapter 441

The Act generally provides for the regulation of the conditions of employment in factories and other places as regards to the safety, health and welfare of persons employed therein. The Act is specific in provision of: supervision of safety and health in factories; inspection of factories and certain plant and machinery by inspectors from the Occupational Safety and Health Services Department; and reporting and investigation of occupational accidents and diseases. The Factories Act is divided into fifteen parts, namely: Part I – Preliminary; Part II – Administration; Part III – Registration of Factories; Part IV – Appeals; Part V – Health: General Provisions; Part VI – Safety: General Provisions; Part VII – Safety: Lifting Machinery; Part VIII – Safety: Steam Boilers, etc; Part IX – Welfare: General Provisions; Part X – Health, Safety and Welfare: Special Provisions and Regulations; Part XI – Notification and Investigation of Accidents, Dangerous Occurrences and Industrial Diseases; Part XII – Special Applications and Extensions; Part XIII – Miscellaneous; Part XIV – Offences, Penalties and Legal Proceedings; and Part XV – General.

Further, there are regulations under the Act that cover safety and health in the construction sector, electrical installations and woodworking machinery among others. Employers and employees are assigned various duties in various sections of the Act. The Act's scope includes factories belonging to or in occupation of the Republic and building operations and works of engineering construction undertaken by or on behalf of the Republic. The mining sector and explosives manufacturing/assembling factories are excluded from its coverage because these sectors are covered by other Acts of Parliament. Because of the Act's limited interpretation of a factory, a number of sectors such as the agricultural and service sectors are either partially covered or not covered at all.

2.2 Core Regulations under the Factories Act

Regulations	What it provides for
The Construction (Safety and Health) Regulations	These regulations provide for the regulation of safety and health in building operations and works of engineering construction.
The Factories (Electricity) Regulations	These regulations provide for the regulation of safety and health in the generation, transformation, distribution and use of electrical energy in any undertaking.
The Woodworking Machinery Regulations	These regulations apply to the safe use of woodworking machines in any undertaking.
The Factories (Benzene) Regulations	These regulations provide for safety and health in the use of benzene.
The Factories (First-Aid) (Prescribed Standard of Training) Regulations	These regulations provide for the standard of training in first-aid treatment for first-aiders.
The First-Aid Boxes Regulations	These regulations provide for the regulation of the contents of first-aid boxes or cases.

Source: Factories Act

2.3 The Mining Regulations

These regulations provide for the supervision of safety and health in mines, inspection of mines by inspectors from Mines Safety Department (MSD), reporting and investigation of occupational accidents, and the compilation and publication of statistics on accidents, occupational diseases and dangerous occurrences. These regulations also provide for the responsibilities, duties and conduct of mine owners/ employers and workers (The Constitution of the Republic of Zambia, 1991) [23]. The principal act under which the Mining Regulations fall is the Mines and Minerals Act. The application of the Mines and Minerals Act is specific to the mining sector, including quarrying.

2.4 The Occupational Health and Safety Act, 2010

This Act provides for the following: establishment of the Occupational Health and Safety Institute and its functions; establishment of health and safety committees at workplaces and for the health, safety and welfare of persons at work; the duties of manufacturers, importers and suppliers of articles, devices, items and substances for use at work; the protection of persons, other than persons at work, against risks to health or safety arising from, or in connection with, the activities of persons at work; and related matters.

2.5 The Ionizing Radiation Act, Chapter 311

The purpose of the Ionizing Radiation Act is to protect the public and workers from dangers arising from the use of devices or materials capable of producing ionising radiation. The Act stipulates the Occupational Exposure Limits (OELs) for various categories of workers. It also regulates the possession, sell, disposal, importation and exportation of radioactive materials. Furthermore, it regulates the installation, servicing and maintenance of radioactive devices and radiation premises. This Act also requires that n those who venture into prospecting and/or mining of radioactive minerals apply for a license prior to commencement of operations. In order to operationalise its provisions, the Act has provided for the appointment of a Board and Radiation Protection Officers under a Radiation Protection Authority (RPA).

2.6 The Workers' Compensation Act, Chapter 271 (Act No. 10 of 1999

This Act provides for the establishment and administration of a Fund for the compensation of workers who are disabled by accidents or diseases contracted by such workers in the course of their employment. It also provides for the payment of compensation to dependants of workers who die as a result of such accidents or diseases, and for the grant of pensions and allowances to certain dependants of workers who being in receipt of pensions for such disablement die from causes not connected with such accidents or diseases. The Act further provides for the payment of contributions to such a Fund by employers. Regulations established under the Act include among other things, a schedule of occupational diseases and employers' register of accidents to workers. The Act excludes members of the public service and the Zambia Defence and Security Forces/Services.

2.7 Conceptual Framework on Occupational Health and Safety in the Mining Sector

Conventions and Acts have been formulated on Occupational health and safety (OHS) to offer guidelines to effectively manage health and safety in organizational operations. Therefore a conceptual framework is essential to ensure that an OHS management has been carefully constructed and customized to an individual organization. The overarching intention is to simplify the implementation process and make the benefits of OHS more obvious. Three main elements have emerged for dealing with workplace hazards to bring together the merits and will in this case particularly focus on the mining industry organization. The three main elements are also recurrent in Zambia's main Occupation health and safety Laws and will further indicate the impact on economic, environment and social dimensions (Makin & Winder, 2008). The elements combine together to create an organization's operations. These comprise the following: Firstly, the people engaged to work in the organization and to whom a duty of care is owed. Second the physical workplace that people use or convert in order to produce goods and/or services; and third the management employed to organise and direct the transformation of resources into organizational outputs. The three components exist within an external environment that impact on the nature of the organisation, which sometimes is beyond its control. Hazards in the workplace may emerge from within, from changes to, any of these three elements; at the interfaces between these elements; or at the boundaries with the external environment.

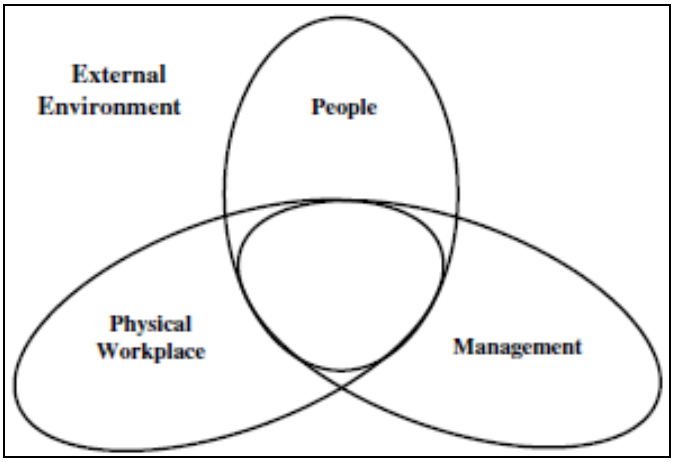

Fig 1: Areas that experience hazards at a workplace

Source: Edwards (1988) [6]; McLeroy *et al.*, (1988) [14]; Stephenson, (1991) [21]; Cox and Tait, (1998b) [4]

Recognition of these three critical areas as individual factors have emerged as a recurring theme in literature, however there has been a general tendency to focus on one particular area rather than consider the total hazard landscape. A systematic examination of these three areas will enable a unique Hazard Profile of the organisation to be determined. Some hazards might not appear in every organization and therefore examples that will be given will be purely to illustrate how the framework may be applied. What is to be understood is, the term ''hazard profile" is used here to indicate the particular

blend of characteristics within a given work environment that have the potential to cause harm or loss to those whom a duty of care is owed.

3. Challenges of Safety and Health Hazards to Mining and Employees

The challenges of safety and health hazards to mining and employees can be explained through the following:

3.1 Physical workplace

At a workplace, we focus on operational flows of a mining industry. Operational flow of mining includes the exploration of the mineral, development of the planning, extraction of mine, then processing of the ore. In the mine industry operations, mining techniques are divided into two common excavation types which are underground and surface mining. This means that when the ore is close to the earth's surface, surface mining matters for extraction the mines. This might be a relatively lower fixed infrastructure cost, however surface mining causes to emerge a significant amount of mining waste. Hence underground mining matters for operation. For example The Mine Union of Zambia's (MUZ) position on occupational health and safety has been to ensure that work is made safer by modifying the workplace and any unsafe work processes. This means that the solution has been to eliminate hazards, not to try to get workers to adapt to unsafe conditions. Requiring workers to wear protective clothing which may not be suited or designed for an environment at work is an example of forcing workers to try to adapt themselves to unsafe conditions, which is also shifting the responsibility from management to the worker. In the case of Zambia, mining industry operate on similar legislation of global OHS. Finally, hazards may result from changes or modifications to the physical workplace such as when new equipment is installed, new employees, storms or natural disasters which may also create changes to the hardware and operating environment, triggering emergency situations.

3.2 The people engaged

Hazards may be generated from within the ‘‘people" which is a section of the organisation, not only from the individuals themselves, but also from the way in which people relate to others; or as a result of interactions between people and the physical workplace, management and/or the external environment. Harm may arise from within the people component of the organisation which stem from singular or combined psychological, biological or socio-cultural factors (ILO, 2017).[9] Such examples may include discrimination on the basis of gender, sexuality, religious beliefs, pregnancy, disability, or family care requirements, bullying, sexual or racial harassment, horseplay, practical jokes or ‘‘initiation rites", conflict, mistrust and antagonism where workplace relationships have broken down between management and the people, impaired judgment resulting from cases of substance abuse or workers experiencing grief or loss, contagious illnesses and disease; and communication problems, including instances where people are at risk because they are working in isolation or where language barriers exist with instances of engaging a lot of expatriates. This is in the case of the mining sector in Zambia which engages expatriate employees because of the industry owned by foreign investors. Examination of the interface among the people and the hardware and operating environment may reveal hazards associated with poor design, human error and the limitation of humans as information processors.

3.3 The management

In mining operations, hazards generated from within management may derive from lack of leadership, commitment or competence. In order to develop a successful health and safety programme, it is essential that there be a strong management commitment and strong worker participation in the effort to create and maintain a safe and healthy workplace. If there is an effective management, it must address all work-related hazards, not only those covered by government standards. Almost all levels of management must make health and safety as a priority. They must communicate this by going out into the worksite to talk with workers about their concerns and to observe work procedures and equipment (Moyo, 2015 and Mrema et al, 2015) [115, 16] In each workplace, the lines of responsibility from top to bottom need to be clear, and workers should know who is responsible for different health and safety issues. If management fails to acquaint themselves with their legal OHS obligations or keep informed of changes may also place employees at greater risk of illness and injury. Hazards may also develop in response to the culture of the organization (ICMM, 2014) [11]. In this case, if reporting of incidents were discouraged, or the extent to which safety is valued by the organization, then it will not save the purpose of the effective management of the OHS system. On the interface between management and the people section, hazards arise from a lack of consultation, poor supervision and willful violations from people in response to over specification of procedures or generally poor procedures. Hazards related to changes on a managerial level may originate from the failure to communicate revisions to work methods and procedures, or failure to consider those affected or impacted by changes. Also included here are hazards linked to too much flux and instability within the workforce, for example when the downsizing or restructuring of operations is occurring. In the case of the downsizing that occurred in Mopani Copper mines in Zambia in 2015.

4. Impact of Safety and Health hazards on mining operations and the Environment

The variables of a workplace, people and management, blend in well when considering the impact of health and safety in mining operations. This means, a safe workplace, will have a positive impact on the country's economy with significant contribution through taxes and license fees, while providing employment opportunities and important economic viability in the community of micro economic benefits. The main effective elements of economic impact in the mining sector as regards to a safer place of work can be stated as follows:

4.1 Macro-micro economic benefits

The mining sector is one of the most important wealth sources due to the contribution of local and national economy. The report from Central Statistics office (2016) [5] indicates that copper export is the main stay of the Zambian economy. The

mining industry accounts for 70% of the Gross Domestic Products (GDP) of Zambia of which 28% is from Konkola copper mine. The monthly production of the mine as at June 2017 was 7000 metric tons indicating a total revenue value of $47million which indicates a significant contribution to national income.

In 2007 KCM recorded 72 lost time injuries due to mine accidents. In instances of mine accidents due to unsafe and hazardous conditions the mine has had to close for almost a week in certain shafts for recovery of employees trapped in the mine as cited in an accident that occurred in 2015. The implication is that the mine losses part of its revenue and this impacts on the national treasury as the effect trickles down to reduced revenue collection through taxes as productivity is lost for the period of mine accidents. If operational risks such safety and health hazards are not managed effectively, the likely hood is that the mine operations could be halted resulting in a negative effect on marginal revenue of the mine and a negative impact on the Zambian economy through reduced tax collection, trade imbalances, and static employment rate as the mine will not be able to expand as a result of reduced productivity which results in reduced revenue and consequently affecting profitability and survival of the mining business.

4.2 Employment and Productivity in the Mine

According to the International Council on Mining and Metals (ICMM) (2014) [8] and the Zambia Chamber of Mines (2014:7) [26] the average production per staff member at Konkola Copper Mine (KCM) is 15 metric tons. The effect of safety and health hazards on members of staff in instances of accidents will cost the mine in the long run as productivity will be affected negatively. According to ICCM (2014:7) [8] as the industry shifts to higher productivity cost structure, it is expected to result in a more skilled (and highly paid) labour force, with a lower number of total employees, thus the total labour wage bill will remain largely constant, preserving the opportunities from induced employment as these salaries are spent in the local economy. In addition there is scope to increase opportunities for job creation though stronger economic linkages from mining. This can be verified from the number of local suppliers that have built businesses and created employment in the private sectors.

4.2.1 Local Procurement

A report from the Central Statistics Office (2014) [5] indicates that KCM procures an estimate of $800 million of goods and services and almost all services are provided by Zambian nationals. The only disadvantage is that despite a high participation of Zambian nationals in the supply chain to KCM, almost 90% percent of the goods are not manufactured locally they are either imported or supplied through local subs diaries: of international foreign companies that import goods elsewhere. This has caused the Zambian mining supply to face declining competitiveness as the business activities are confronted with high costs (for land, labour, inputs and taxes) difficult credit and high interest rates, which significantly reduce competitiveness.

4.2.2 Human Capital Development

KCM Being the biggest mines in Zambia with a high demand of skilled man power to enhance its productivity and mitigate operational risks, largely invest in human capital development. The investment is done through technical training, managerial training, scholarships and apprenticeships for employees and contractors. The Mine also supports local trade schools and by so doing, there is an indirect support to human capital development. Such initiatives help to address labour force skills gaps. According Zambia chambers of commerce (2014) [26] it is reported that mining companies spent over $5 million on training in 2012. Many of those who receive training or additional qualifications, through these routes would not otherwise have had access to these skills or qualifications.

4.2.3 Employment source

The mining companies offer an important employment source for the local communities since the locations of them may be far away from the industrial areas. Therefore, mining companies may be the primary income source in their located regions for instance KCM employees approximately 16,000 people direct and indirectly this figure indicates a good economic gain through collected taxes and disposable income. However, the economic gain is seen as the most important dimension, than health and safety in most mining industries and governments due to the industrialization impetus in both developed and expanding economies. According to the International Labour Organization report (2015) [10] millions of workers worldwide are at risk of various types of work-related diseases. Occupational diseases such as pneumoconiosis remain widespread, whereas relatively new occupational diseases, such as mental and musculoskeletal disorders, are on the rise with no adequate preventive, protective, and control measures. Despite millions of people being at risk, about 2 million workers die every year from occupational illnesses globally.

Table 1: Zambia's mine fatal accidents Recorded

Industry	2011	2012	2013	2014	Totals %	Totals
Agriculture, Finance and Insurance	4	15	14	18	51	13.6
Bulding Construction	5	18	11	18	52	13.9
Charities, Religious, political and trade organizations	1	1	2	0	4	1.1
Chemical industry etc.,	0	0	1	0	1	0.3
Educatational Services	0	2	2	4	8	2.1
Entertainment	0	0	0	0	0	0.0
Food, Drink and Tobacco	4	5	3	4	16	4.3
Glass, brick, tiles, Asbestos etc.,	0	1	0	0	1	0.3

Iron, Steel Industries etc.	3	6	8	13	30	8.0
Leather Industries	1	0	0	0	1	0.3
Local Authorities	0	0	0	1	1	0.3
Medical Services	0	0	0	0	0	0.0
Mining, Quarrying Industries	13	10	10	26	59	15.7
Personal services, Hotels etc.	8	11	15	20	54	14.4
Printing, publishing & Paper Industry	1	1	1	1	4	1.1
Professional Services etc.	2	1	7	2	12	3.2
Textile Industries	2	2	2	2	8	2.1
Trade and Commerce Etc.	7	1	8	5	21	5.6
Transport and Communication	4	0	14	11	29	7.7
Wood and furniture industry	0	2	3	1	6	1.6
Unregistered	9	0	0	0	9	2.4
Totals	67	77	104	127	375	100.0
Percentage increase (%)	0	15	55	65		

Source: Workers Compensation Fund Control Board

The Table 2 indicates the highest number of fatal accidents in the mining industry at 59%. This brings out the aspect that mine safety especially in Zambia has a challenge though there have been some improvements, much needs to be done. In general, health and safety in workplaces has improved in most industrialized countries over the past 20 to 30 years. However, this is a different situation in developing countries. This has been due to relatively unclear largely inadequate accident and disease recognition, record-keeping and reporting mechanisms.

It has been estimated that at least 250 million occupational accidents occur every year worldwide (ILO, 2015 & World Bank, 2016) [9, 25]. The figure of 335,000 of these accidents is fatal (result in death). (Since many countries do not have accurate record-keeping and reporting mechanisms, it is assumed that the real figures may be much higher than this.) The number of fatal accidents is much higher in developing countries than in industrialized ones as indicated by ILO report of 2015. This difference is notable primarily due to better health and safety programmes in place of improved first-aid and medical facilities in the industrialized countries and active participation of workers in the decision-making process on health and safety issues.

4.3 Identifying cause of an accident

In instances, the cause of an industrial injury is easy to identify which he case for Zambia might be due to media reports. However, very often there is a hidden chain of events behind the accident which led up to the injury. In such cases, accidents are often indirectly caused by negligence on the part of the employer who may not have provided adequate worker training on health and safety, or a supplier who gave the wrong information about their product. There have been consistently high fatal accident rates in developing countries and that emphasize the need for occupational health and safety education programmes that focus on prevention.

Table 2: Pneumoconiosis and tuberculosis in mining companies per 100 000 miners and Ex-miners examined

Type of disease and Stage	2010	2011	2012	2013	Average number of cases	% of average number of cases
Pulmonary Tuberculosis	231	183	157	148	180	75.5
Pneumoconiosis stage I	54	45	19	22	35	14.7
Pneumoconiosis II	17	7	1	12	9	4.0
Pneumoconiosis III	6	11	9	4	7	3.1
Pneumoconiosis +Tuberculosis	6	11	9	4	7	3.1
Total Certified Cases of P and TB	319	249	193	192	238	100.0

Source: Occupation Safety and Health Institute

The table indicates cases of contracted pneumonia and tuberculosis for both miners and ex-miners. A number of occupational diseases have been recognized for many years, and affect workers in different ways depending on the nature of the hazard, the route of exposure, the dose. A number of well-known occupational diseases among those identified in table 2 may include: Asbestosis-caused by asbestos, Silicosis-caused by silica, very common in mining industry, lead poisoning-caused by human contact with lead, and noise-caused by noise (may cause induced hearing loss), which is common in many workplaces, including airports. They are a number of potentially crippling health problems that can be associated with poor working conditions which may include: heart disease, musculoskeletal disorders such as permanent back injuries or muscle disorders, allergies, reproductive problems and stress-related disorders.

However many developing countries have reported only a small number of workers affected by work-related diseases as indicated in table 2. These numbers look small for a variety of reasons that might include inadequate or non-existent reporting mechanisms and lack of occupational health facilities and lack of trained health care practitioners to diagnose work-related diseases. Due to these reasons and others, it is reasonable to assume in reality that, the numbers of workers afflicted with occupational diseases are much higher. Overall, it has been noted that the number of cases and

types of occupational diseases are increasing, not decreasing, in both developing and industrialized countries.

4.4 Environmental Impact

Mining sector under the environmental aspects leads to a number of threats affecting workplace operations due to the activities and are especially challenging. The main effective elements of environmental dimension of the mining sector can be stated as follows:

1. ***Carbon emissions*** – *Air pollution:* CO_2 emission occurs due to the mine extraction processes and transportation of the minerals over long distances significantly causing air pollution. Blasting as well releases harmful gases into the underground environment. This also has an effect to climate change;
2. ***Ecologic damage:*** *S*ome metal types are associated with the acid drainage problem that can cause a long-term acidification of waterways and can also affect biodiversity and human health. This is explained through a sulphuric acid of 2006 that drained in the main water source for the community around the mine causing hazardous exposure to the community and affecting the ecology of organisms in the affected water streams.
3. ***Intensive use of fossil fuels:*** Since the mining companies' locations are generally far away from residential areas, they mostly provide their energy needs from the non-renewable fossil fuels using generators. The mining sector has been responsible alone for 4-7% of the consumption of the world fossil fuel resources.
4. ***Disturbance landscape:*** Extraction activities cause a visual impact on the landscape and primarily mining community is affected by this visual pollution.
5. ***Noise pollution:*** Mining sector can damage mining community by noise pollution because of their intensive blasting activities, heavy equipment; sorting and milling of rock. This noise pollution also exposes the people in surrounding communities to a negative psychological impact even as early as from birth to all the time that they live in such communities.

4.5 Social impact

The Social aspect in the mining sector is related with the effects of mining activities on people engaged as employees. It is considered that they are nearly 250-300 million people relying on mining, including dependents, around the world and are affected by the mining activities in either a positive or negative way. The main effective elements of social dimension of the mining sector can be stated as follows:

1. **Occupational health and safety:** An analysis of the long-term accident statistics like on tables 1 and 2 can be understood that the mining industry poses above-average risks to employees. This highly recommends a need to put in place an effective OHS management system.
2. **Employee welfare:** This focuses on the social needs of employees such as equity, healthcare, education and employee benefits. Some mining companies may implement policies in unfairly low wages, employed child labor or uninsured workers and they can transmit the already unsustainable working conditions to a worse condition. Any of the mining company has to pay attention to welfare needs of employees and this becomes a source of organizational unrest.
3. **Public welfare:** The reasons such as occurring large quantity of toxic substances due to the mining activities, air, land and water pollution may pose a threat for the mining community according to their health and safety aspects. For these negative outcomes of mining, sometimes people in mining area relocate to raise their life quality or put mining firms to adhere to regulations of a Corporate Social Responsibility.
4. **Acceptance of society:** Mining companies require ensuring the acceptance of society to continue the activities due to the caused damages to people with their form of operations. Communication with the society is the most effective and important way for achieving the community acceptance. A good case was that of Barrick Lumwana mine in North Western province of Zambia. In this case the settlers around the mining area delayed the mining project due to refusal to release their land despite lucrative re-settlement packages that were offered. The mining firm incurred more costs as a result of hiring a team of social workers to negotiate for acceptance of the mine in their area. The mining sector, despite the large opportunities for scientific and practice initiatives, the assessment of the social impact of mining activities is still in its infancy due to the fact that economic dimension is seen as the most important dimension, then environmental and social dimension.

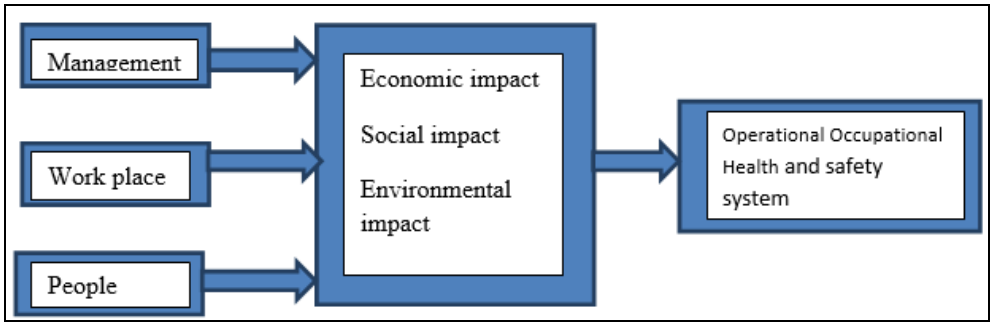

Fig 2: Factors involved in managing an occupational health and safety system.

An operational Occupational health and safety system is enhanced by being responsive of the impact of the economic, social and environment. The impact of the three dimensions is influenced by the operations of the industry and in this

particular case the mining sector. The operations of the industry are influenced by the people engaged, the existing workplace, which is physical and the management who are a group of committed and skilled leaders of the entity.

The mining industry operates on the three elements of people, workplace and management which performance is determined by economic, social and environmental impact. The impact also determines how effective the operation of Occupational health and safety system is.

The economic impact on the mining industry anchored on matters of health and safety is basically two sided in that if a safe workplace exists for its employees, then the economic benefits are realized. The industry will offer quite a significant contribution through taxes and license fees and providing employment opportunities. However if health and safety is overlooked, it will result in an economic impact incurring indirect and direct costs due to fatalities and diseases which can be prevented. Preventing work-related diseases and accidents must be the goal on occupational health and safety in the mining industry, rather than attempting to solve problems after they have already developed as they have a negative impact (Smith, et al, 2013) [20].

The interaction of the three elements positively impact on the operations of the mining industry and improves performance bearing in mind that there is a workable occupational health and safety system in place. The economic, social and environment are parameters that are an avoidable in the mining industries. These parameters measure the role that mining industries play in complying with the health and safety regulations.

5. Implications

It has often been difficult to determine the cause of work-related diseases. One factor identified has been the latency period (the fact that it may take years before the disease produces an obvious effect on the worker's health (Ontario Canada mine report 2015) [17], by the time the disease is identified, it may be too late to do anything about it or to find out what hazards the worker was exposed to in the past. Other factors such as loss of employment, retirement, changing jobs, or personal behaviours (such as smoking tobacco or drinking alcohol) further increase the difficulty of linking workplace exposures to a disease outcome. There is appreciation that nowadays more is understood about some occupational hazards than in the past, however, every year new chemicals and new technologies are being introduced which again may present new and often unknown hazards to both workers and the community. These new and unknown hazards present great challenges to workers, employers, educators, and scientists, that is, to everyone concerned about workers' health and the effects that hazardous agents have on the environment.

However, a work environment that has incurred diseases and fatal injuries as shown in table **1** and **2** has huge social and economic implications for those affected individuals, their families and the community. It has been estimated that work-related accidents or diseases are very costly and can have many serious direct and indirect effects on the lives of workers and their families. For workers some of the direct costs of an injury or illness might be the pain and suffering of the injury or illness of prolonged hospitalization, the loss of income in case of retirement on medical grounds for being incapacitated, the possible loss of a job and health-care costs. The estimated indirect costs of an accident or illness have been pegged at four to ten times greater than the direct costs, or even more. An occupational illness or accident may have so many indirect costs to workers and has been often difficult to measure them. One that has been the most obvious indirect costs is the human suffering caused to workers' families and community, which cannot be compensated with money.

The employers' cost of occupational accidents or illnesses, have also been estimated to be enormous. A mining industry might incur some direct costs to include payment for work not performed, medical and compensation payments, repair or replacement of damaged machinery and equipment, reduction or a temporary halt in production, increased training expenses and administration costs, possible reduction in the quality of work, negative effect on morale in other workers and pressure from the community and government. Some indirect costs an employer may incur may be the injured/ill worker has to be replaced, a new worker has to be trained and given time to adjust, it takes time before the new worker is producing at the rate of the original worker, time must be devoted to obligatory investigations, to the writing of reports and filling out of forms, accidents often arouse the concern of fellow workers and influence labour relations in a negative way and poor health and safety conditions in the workplace can also result in poor public relations.

Generally, the costs of most work-related accidents or illnesses to workers, community and their families and to employers are very high. It has also been estimated on a national scale, that the costs of occupational accidents and illnesses can be as high as three to four per cent of a country's gross national product (GDP). In a certainty, no one would know the total costs of work-related accidents or diseases because there are multitudes of indirect costs which have been difficult to measure besides the more obvious direct costs. Nevertheless, as indicated in the two tables, the accident and ill-health record of the mining sector compares poorly to that of other sectors such as and manufacturing, construction and chemical industry, leading to the mining sector's reputation as the most hazardous sector.

6. Conclusion and Recommendations

The analysis of the various activities conducted at KCM instigate that operational risk management with a focus on safety and health was taken seriously within the mining operations and this was observed by the over whelming information on risk management documented within the organisation. The evidence revealed that operational risks concerning safety and health at KCM were managed through Safety management programmes. However the research also revealed that there was a concern in terms of the occupational health and safety and accident statistics at the mine. The statistics showed that the mines still had an urgent need to address the performance of their management of occupational health and safety issues and accident prevention efforts in order to enhance productivity and positively contribute to economic growth and social development to Zambia as a country in which the mining activities are conducted.

The understanding of safety and health issues is one thing, but

managing them is another. The reason being that managing safety and health issues involves planning, organisation and control of production operations, the people and the operational risks associated with the production activities. It goes beyond merely understanding safety and health issues. Therefore, KCM management should ensure that the management of operational risks is fully treated as a fully-fledged function within the organizational set up of KCM. Such an action would have the following spin-offs: Benefits-The benefits that would result from the action would be the clear distinctions of the boundaries between operational risk management and mere understanding and supervision of safety related issues. This would probably increase the perception of operational risks among workers when handling the risks faced by the mine. Costs-The most important cost to the organisation would be changing the approach or programme on how they address operational risk, health, environment and safety responsibility. The constraints associated with this recommendation are that it would require senior management commitment and it would also need some expenses. Risk of doing it-The only important risk is that it could destabilize the functioning of the safety management programme resulting in making the strategies ineffective as a result the purpose of implementing risk management strategies would be defeated. Accident Reviews- This could be done by reviewing the training that was given to personnel where accidents were common than in other departments and areas. The benefit in the review is that the mine would have been able to formulate new teaching practices that would have made mine staff more conscious about accident prevention and in the long run this could translate into efficiency in operations and increased productivity and profitability. Such an initiative would require resources to ensure that the training is conducted to the expected level and also that the implementation is done as planned by management.

7. References

1. Alli BO. Fundamental principles of occupational health and safety, International Labour Office, Geneva: ILO, 2008.
2. Australian Institute of metallurgy. The Minerals Institute, Australia: AUSIMM, 2001.
3. Chifungula A. Report of the Auditor General on the Management of Occupational Health and Safety, Lusaka, 2015.
4. Cox S, Tait R. Safety, Reliability and Risk Management. Butterworth-Heinemann: Oxford, 1998.
5. CSO. The monthly Central Statistical Office Bulletin, Lusaka: CSO, 2016.
6. Edwards JC. Cfd Modeling of Fire Spread along Combustibles in a Mine Entry. Pittsburgh: PA, 1988.
7. Hermans A. Occupational Health and Safety in Mining-Status, New Development and Concerns, The Journal of the Southern African Institute of Mining and Metallurgy. 2007, 107.
8. ICMM. Enhancing mining's contribution to the Zambian economy and society. Lusaka: Chambers of Mines of Zambia, 2014.
9. ILO. Your Health and Safety at Work, Introduction to Occupational Health and Safety, Accessed, 2017. www.ilo.org/safework/info/instr/WCMS_113080/langen/index.htm
10. ILO. Zambia Country Profile on Occupational Health and Safety. Lusaka: ILO, 2012/2015.
11. International Council on Mining and Metals ICMM, the Chamber of Mines of Zambia, Zambia. 2014, 7-12.
12. Kuytu FY, Bolat HB. Conceptual Framework for Sustainable Mining Sector Evaluating Automation Technologies and Safety Risk, Dept of Logictics, Anadolu University Eskisehir, Turkey, 2016.
13. Makin AMC, Winder A. new Conceptual Framework to improve the Approach of Occupational Health and Safety Management System, Safety Science 46 (2008) 935–948, School of Safety Science, The University of New South Wales, Sydney, Australia. 2008.
14. McLeroy, *et al.*, Miners' Views about Personal Dust Monitors, Pittsburgh: PA, 1988.
15. Moyo D. Review of Occupational Health and Saftey, Organization in Expanding Economics, The case of Southern Africa, Annals of Global Health. 2015; 81:495-502.
16. Mrema E, Ngowi V, Mamuya S. Status of Occupational Health and Safety and related Challenges in Expanding economy of Tanzaia, 2015, Annals of Global Health. 2015; 81:539-54.
17. Ontario Canada Mine Report on Safety and Occupational Health Ontario-Canada, 2014.
18. Prial, Dey, Health and Safety Hazards: Mining Health, Safety and Prevention. Ontario: Ontario Ministry of Labour, 2015.
19. Safety, Health in Mines Convention. C176 - Safety and Health in Mines Convention. 1995, 176.
20. Smith P, Saunders R, Lamontagne A. Developing a framework understanding and measuring Occupational Health and Safety Vulnerability, Monash Centre for Occupancy and Environmental Health, Research Report # 2013, 1113-041-R1C.
21. Stephenson A. Managing Occupational Health and Safety: A Multidisciplinary approach: Thornton Bulterworth: London, 1991.
22. The Auditor General Report. Zambia, 2015.
23. The Constitution of the Republic of Zambia,1991
24. WHO. 2014 Occupational Health and Safety Summit Milestones; MHSC, 2014.
25. World Bank. Mining and environmental Remediation and implemented Project, 2016.
26. Zambia chambers of commerce. Mining for Zambia, Lusaka: ZACCI, 2014.