THE 4TH INDUSTRIAL REVOLUTION AND ITS IMPLICATIONS FOR MINING DEPENDENT COUNTRIES

INSIGHTS FROM SOUTH AFRICA AND ZAMBIA IN THE SADC REGION

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1 INTRODUCTION

1.1 Background

The mining industry is key to the economic fortunes of many countries in Africa. The sector is a major earner of foreign exchange, a significant source of employment and a potential catalyst to the industrialisation of the continent.

The continent dominates the production and export of mineral commodities. Despite this, the continent remains poor, characterised by inconsistencies in economic progress- linked to the over dependence on this mineral wealth. Despite this in many countries, the mining sector remains key to economic and social development. Recently, there has been a renewed interest in using mining and mineral resources as a catalyst to local industrialisation, a key pre-requisite for sustainable improvement of the wellbeing of the region's citizenry.

The mining sector in Africa traditionally, had to contend with different challenges including but not limited to low-value mineral resources export, fluctuating commodity prices, and transfer pricing. The emergence of the Fourth Industrial Revolution (4IR) and accompanying technologies pose both threats and opportunities in mining countries.

This revolution is characterized by a range of new technologies that are blending the physical, digital and biological worlds in virtually all disciplines, economies and industries. This blending is blurring distinctions between humans and machines. Most concerning is that the various forms of this revolution that among others include machine learning and artificial intelligence (AI) could lead to a loss of familiar and well established professions and jobs. The mining sector is source of employment in many countries particularly in Africa and change in the industry under the 4IR drive could lead to a loss of jobs in the sector. Indeed some jobs will be made redundant and others created. However, the latter outcome does not quell fears particularly in countries with high unemployment rates. The recognition that the 4IR technologies will lead to job losses and disruptions to the local socio-economic system, requires proactive introduction of intervention measures to manage these undesirable effects of the revolution. The processes towards such interventions need to be informed by technologies that mining companies currently have, and are likely to introduce under the 4IR era. Furthermore, it needs insight into how these technologies affect people at all levels of the mining value chain.

Due to the strategic nature of technology in the mining business environment, mining companies may not be willing to divulge in detail the technology they plan to introduce in the future. However, an examination of the technologies that new mining companies introduce is a proxy indictor of the emerging technologies in the sector and potentially the trajectory of future technological advances. The effect of these technologies can also be observed through the employment and socio-economic impacts of the new technologies in communities where new mines are located compare to those in old and established mines.

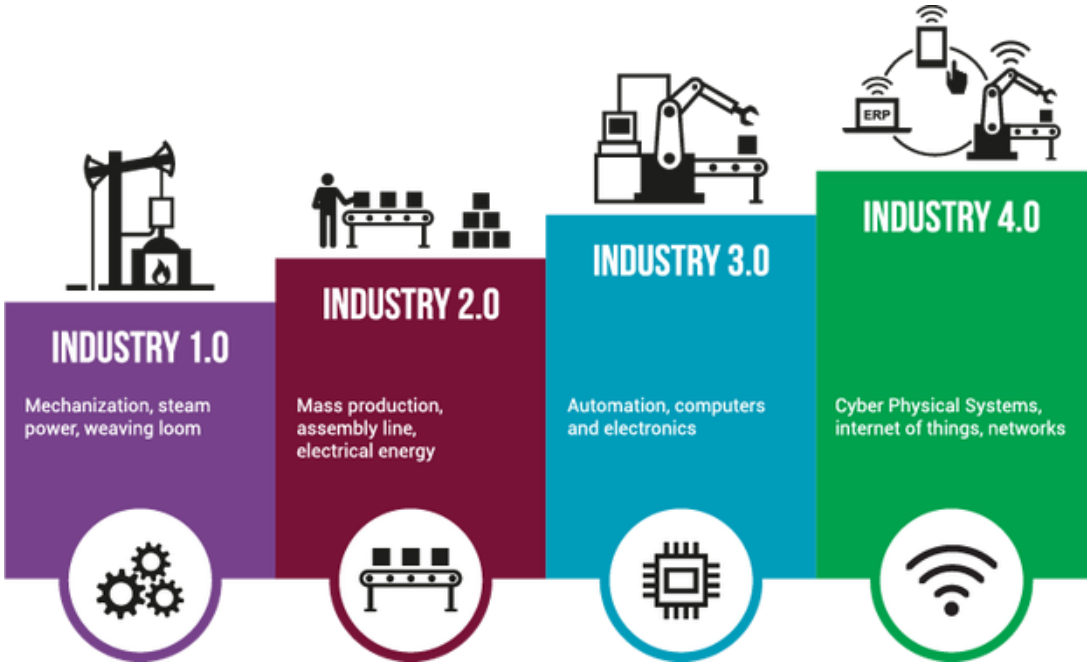
The second element of changing technologies under the 4IR and socio-economic development of mining-dependent countries relates to how this will affect the aspiration of local industrialisation and trade efforts. Local industrialisation and external trade are key in creating sustainable jobs beyond the extractive sector and general improvement of people's welfare in a country.

As the various African countries contemplate economic diversification through industrialisation, the mining industry is in flux trying to contribute to the effort simultaneously managing the typical sector challenges that include minerals price volatility, the highly dynamic and unpredictable geopolitical environment, the politics of labour relations and the spiralling costs of mineral production. The 4IR adds an additional challenge most notable is the issue of balancing issues of productivity, profitability and safety on one hand and the availability and safety of some jobs on the other hand. Clearly this revolution presents both opportunities and threats.

Despite the emerging diffusion of 4IR, the mining sectors of different countries are still at various stages of technology transformation to adopt and adapt to changes in this space. This makes it imperative to reflect on technology deployment in the mining industry. This reflection is important in shaping and broadening the understanding of not only the stage at which the mining companies are operating in this context, but also the complex dynamics and implications of the current and future changes to the mining sector. To better comprehend and deepen the understanding the next section looks at the evolution of the Industrial Revolution.

Evolution of the Industrial Revolution.

Figure1: The major technological advances that characterise each of the industrial revolutions leading to the 4IR



Source: NetObjex, 2019

The 1st industrial revolution mechanised means of production. The revolution witnessed a switch from a self-sustaining organic economy to a mineral resource depleting inorganic economy particularly in countries such as Britain, Belgium, France and German. A significant discovery of the era was the use of steam power which increased the demand for coal (Robert Wilde, 2018). During this period coal became a key factor in the success of industrialization; it was used to produce the steam power on which industry depended. The 19th century thus heavily relied on fossil fuels for steam powered mechanical production (Hermanus, 2018). The advent of the 2nd industrial revolution also known as the era of mass production and technology revolution (Mid-19th Century) brought new innovations in steel production, petroleum and electricity. The period witnessed the burgeoning of the industrial base particularly in Europe. Likewise in Sothern Africa the discovery of minerals during the late 19th Century brought about significant change to the society. Notably, the discoveries of gold and diamonds deposit in South Africa that exceeded those in any other part of the world, led to a substantial foreign capital investment injection into the country. Over the course of the 20th century, South African mining companies such as Anglo American, De Beers, Rand Mines, JCI, and Gold Fields grew to become global giants. Until well into the 1980s, these companies invested across and beyond the mining value chain. In the early years, as mining grew, small engineering works and companies supplying support services were established around the gold mining industry, and

local production of much of the equipment essential for deep-level mining got also developed. These developments drove industrialization in South Africa (Turok, 2014; Innes, 1984).

The third industrial revolution has been characterised by electronics and driven by semi-conductor industry well known as the phase of automation. Evidence from World Semiconductor Trade Statistics (WSTS) points towards exponential growth propelled by block chain technology through internet of things. Phones, computers and intelligent robots which are used in this regard (WSTS, 2018).

The fourth Industrial revolution is ushering in a new dimension of advanced technological innovation. The revolution is driven by among other issues machine learning and artificial intelligence complemented with block chain technology and the internet of things. In the mining sector automation is gaining favour particularly to overcome difficult working conditions, poor deposits and other efficiency and productivity concerns across the value chain.

1.2 Problem Statement

Whether the 4IR can contribute substantively to broad based economic growth and income security remains a subject of intense debate. Fears around this revolution are intractable particularly in the developing countries that face high levels of unemployment. With its bulging and increasingly educated youth population, Africa, is seized by this debate. The mining sector is important to the economies of many economies in Africa where it is major earner of foreign exchange as well as a source of employment. However, the industry faces many challenges that include increasing production costs relating to labor, exhausting surface mineral deposit as well as environmental and employee safety concerns. The importance of these issues is rising at a particularly inauspicious time as the 4IR gets underway. In this realm there are fears of the 4IR rendering the parts of traditional workforce and their tasks redundant due to increased automation. This is against the vision of creating jobs to address the entrenched high levels of unemployment typical in many developing countries particularly in SSA. How the 4IR is and will affect the mining sector – the mainstay of many countries in the region and their national development dynamics is yet to be fully explored. Existing literature presents numerous speculations on the impact of this revolution on the mining sector with limited empirical evidence. There is a paucity of comprehensive analysis of the 4IR-linked emerging trends across value chains in the mining industry and the overall contribution of the sector to national development. This research seeks to address this paucity.

Adopting the value chain framework approach is important because it presents intuitions on strategies that could develop general and specific industry infrastructure leading to a viable African mining industry that is integrated into and out of both local and global value chains. This is critical to the continent's industrialisation efforts. The 2030 agenda for sustainable development dictates that industrialisation simultaneously addresses broader social and environmental factors. This calls for the need to develop a re-imaging and restructuring of the discourses in the exploitation of mineral resources to advance the development of an Africa domicile manufacturing industry base that considers the local and global contexts. The 4IR is critical in this endeavour.

1.3 Broad Research Objective

Against the backdrop of global developments and trends, this proposed interdisciplinary study broadly seeks to determine the scope, nature of opportunities and threats the 4IR presents to the mining industry in Africa. It examines these threats and opportunities along the entire mining value chain. Essentially it seeks to respond to a few broad questions;

- How is the mining sector in Southern Africa engaging with the 4th Industrial Revolution, if at all?
- How is the 4th Industrial Revolution and accompanying technologies affecting labor dynamics in new, and mature mine ventures and mining business in general?
- What are the implications of 4IR for socio-economic development of mining countries? Where applicable a focus on the differences and similarities between the mineral and mining approaches ventures in Africa?
- What proactive measures can be undertaken to mitigate the negative socio-economic effects of 4IR in the mining sector on the continent.

1.4 Specific Objectives

The specific objectives were to:

a. Undertake a baseline assessment of technology application across mining value chain in the selected case study countries.
b. Establish the awareness level of 41R in the mining sector.
c. Assess the impact of the 4IR-related technologies on labor dynamics for both new and existing mining ventures.
d. Establish what elements of mining and mining business are being rendered obsolete by the 4IR technologies.

e. Evaluate the impact of 4IR-related technologies in the mining sector on local industrialization imperative.
f. Recommend how to mitigate adverse socio-economic effects of 4IR-technologies for the mining sector in the selected SADC regional countries.

2 REGIONAL MINING LANDSCAPE

2.1 Context of Mining in Southern Africa

The mining sector remains one of the key cornerstone shaping the social, political and economic landscape of most Southern African Development Community (SADC) member States. Essentially the mining industry is part of the SADC-regional developmental processes which creates wealth, employment and a market for other industries such as manufacturing and services. Most of the countries are endowed with their unique mineral commodities which make a significant contribution to the national gross domestic product and most of the countries depend on mineral exports for their foreign exchange earnings. Approximately fifty percent of the world's vanadium, platinum, and diamonds comes from the region, in consort with 36% of gold and 20% of cobalt (SADC, 2019).

Given the pivotal role played by the mining industry in the region, SADC launched a protocol on mining which guides and harmonised policies, standards, legislative and regulatory framework for mineral resources exploration and extraction in the region. Central stakeholders in this sector are the state, citizens and the private sector. Essentially the mineral resources belong to the citizens, and mineral rights are vested in the State for the benefits of the citizens. Private sector companies are granted the rights to exploit these minerals on specific terms of benefits to Government while also realizing returns to shareholders on their investments. A closer look at the mining landscape of each of the selected countries will aid in understanding how technological innovation has a bearing on the mining sector for the selected countries (South Africa, Zimbabwe, Zambia and Tanzania) and how this shapes the mining sector in general and the labour dynamics given the specific mineral commodities endowed in these countries.

2.2 South Africa's mining landscape

For several years the mining sector has been the backbone of the South African economy. Among the several mineral commodities mined in the country, gold, diamonds, platinum and coal and metals are the most minerals mined. In addition chrome, vanadium, titanium and a number of other lesser commodities are among the numerous minerals endowed and well-known in the country. According to Department of Mineral Resources, in 2018 the mining sector contributed R351 billion to the South African gross domestic product (GDP). The same year a total of 453,543 people were employed in the mining sector (MCSA, 2019). Table 1 illustrates the disaggregated fast facts for a few selected mineral commodities which points to the significance of the mining sector in the country. Evidence show that the sector has for many years attracted valuable foreign direct investment to South Africa.

An overview of selected key mineral commodities

Commodity	***Main Region***	***Total Employed***	***% Total national employment mining Sector***	***Revenue***	***Production (million tonnes-(Mt))***
Coal	Mpumalanga	86,919	19%	R139 billion	252.6 Mt
Gold	Witwatersrand Basin (NW, FS & Gauteng)	101,085	22%	R69.9 billion	132.2 tonnes
Diamonds	Kimberley, Transvaal	16,666	3.7%	R16.3 billion	10.5Mct
Platinum	Bushveld Igneous Complex	Dominated by Gencor, JCI and Lonrho. Corporate actions eventually saw the mines in these groups housed under Implats, Amplats and Lonmin respectively, the majors in the sector, and responsible for producing up to 80% of the world's PGM supplies.			

Source: Table drawn based on figures from Mineral Council of South Africa, 2019.

2.3 Zambia's mining landscape

Zambia is internationally recognised as a major producer of copper and cobalt (ranked as the seventh and second highest world producer respectively). It also produces precious **metals** (gold, silver), gemstones (amethyst, aquamarine, emerald and tourmaline), and coal and industrial **minerals**. Essentially Zambia's copper mining, has been the backbone of the economic and socio-economic development since the discovery of Cu-Co deposits in the Copperbelt province. The mining industry in Zambia, is dominated by Copper and Cobalt commodities. Internationally, Zambia is ranked as the seventh and second-largest producer of copper and cobalt respectively. It possesses the world highest-grade deposit of copper and has

substantial reserves of copper (690 million metric tons) and cobalt (270 thousand metric tons). The majority of Zambia's copper deposits yield a high grade between 2–3 percent in comparison with the global average yield of roughly 0.8 percent. Zambia is expected to become one of the world major copper producers in future due to high grades reserves and several expansion plans by current mining companies. Besides copper and cobalt, Zambia also produces precious metals (gold, silver), gemstones (amethyst, aquamarine, emerald and tourmaline), and coal and industrial minerals, potential energy resources including uranium, coal and hydrocarbons. Zambia produces nearly 20 % of the world emeralds and is among the world top three producers. Although Zambia is the least coal producer in southern Africa, it has substantial coal reserves and production is expected to grow from 281 000 tons in 2014 to more than 2 million tons. Lead and Zinc are the next in importance to copper and cobalt production with 11 metric tons of ore containing 40 % combined zinc and lead. Kabwe has the highest-grade zinc and lead deposit in the world.

Other key commodities mined in Zambia include emeralds, gold and nickel. The top producer of emeralds in Zambia is Gemfields. The company has a mining joint venture with the government of Zambia and produces ethical, conflict-free gemstones, with a clear certification of origin. The company accounts for nearly 20 percent of the global emerald supply. In Zambia, emeralds are found in the Miku-Kafubu area. Zambia houses the world's largest emerald mine, Kagem mine and Gemfields holds a 75 percent share in it.

Since the year 2000, the mining industry of Zambia has attracted investments of nearly USD 8 billion. The mining industry employs more than 80 000 people formally. The mining sectors accounted for 12 % of Zambia Gross Domestic Product (GDP) and more than 78 % of the exports in 2015. Minding industry is a significant source of government revenue and formal employment both directly and indirectly. The Mining industry has long been considered the bedrock of Zambian economy. According to the Central Statistical Office, GDP from mining in Zambia averaged 3.3 ZMK Billion per quarter from 2010 until 2020, reaching an all-time high of 3,8 ZMK Billion in the second quarter of 2020 with a growth rate of 14.2%.

Rapid economic growth and new mining developments have increased the demand for power in the past years. Hydropower accounts for 95 % of the power production. Increasing coal production is expected to alleviate power supply deficits.

The country currently has 13 major mining projects owned by 12 companies. These include Lubambe copper mine, Mopani copper mines, Konkola copper mines, Barrack gold mining

corp and First quantum minerals, Kagem mining, Gemcanton mining services, Kalumbila copper mine, Chibuluma mine, Kasenseli Gold Mine, and Chambeshi copper smelting company to mention a few.

Government has recently acquired 100 percent of Glencore's Mopani Copper Mines and Vedanta's Konkola Copper Mines – KCM local operations in the past two years. The takeover of KCM was however through ZCCM IH liquidation process, after complaints by local contractors and suppliers of not being paid for extended periods of time.

3 METHODOLOGY

3.1 Introduction

Addressing the stated question requires the study of mining ventures in almost all the SADC region. However, financial and time limits do not permit this. Consequently the study adopts a discrete case study design that employs multiple qualitative and quantitative methods (Yin, 2009). Where applicable the study employed a comparative analysis between and within selected countries, their mineral commodities and mining firms. This case study approach permits a concurrent examination of organisational, sectoral and sub-sectoral as well country specific dynamics simultaneously with the investigation of temporal, cross-sector and cross-country subtleties (Levi-Faur, 2002).

3.2 Focal Countries

The selection of the focal countries is mainly based on a set of criteria that ensures broad-based representation of the mining industry within the SADC region. Some of the considerations were:

- Focus on mining dependant countries: Countries whose economies largely depend on mining
- Mining foot prints
- Commodities for exploration
- Presence of Multi-national companies.

The four case countries; South Africa, Zambia, Zimbabwe and Tanzania have experiences with large-scale and small scale mining. South Africa has the largest and perhaps most sophisticated

mining industry among the four case countries. This industry is served by an equally sophisticated input goods and services industry. Zimbabwe had a fairly sophisticated mining industry which has since collapsed with the national economy. Nevertheless, the country's mining industry still remains and efforts to revive it faces a number of challenges. Copper has been and remains the mainstay of the mining industry in Zambia. The industry is currently dominated by firms from China. It will be interesting how influences from China are shaping how the mining industry in Zambia is engaging with the 4IR. However Tanzania is an emerging mining economy. This has to a large extent led by the gold mining industry. A key focus of the research is how this relative young mining economy is engaging with the 4IR compared to the relatively mature industries in the other countries.

This report, however, focuses on two and not four focal countries--Zambia and South Africa which are part of phase one of the study. The study was phased because of time and resource constraints, and the impact of Covid-19 on fieldwork across the original four countries.

3.3 Methods

In each country the research gathered a diverse set of both qualitative and quantitative data using multiple methods that include interviews, surveys, and document reviews. Key questions used during data collection were developed taking into account the study specific objectives. The study itself was intensely participatory in nature to enable meaningful inputs and buy-in from key stakeholders as well as ultimate ownership of the knowledge-products deriving therefrom by the stakeholders in the focal countries and other key actors on the continent. Relevant literature, policy and legislative documents were reviewed to build the knowledge base on technology innovation in the mining sector.

As aforementioned, empirical fieldwork work was carried out in Zambia to obtain both qualitative and quantitative data revealing the prevailing situation on the ground regarding new technology deployment in the mining sector for extraction of selected mineral commodities. The fieldwork included a rapid assessment using a semi-structured questionnaire-based survey instrument for in-depth interviews carried out with key informants. Due to Covid-19 restrictions, the questionnaire was converted to an electronic one which was sent to all potential participants for self-administration.

Additionally secondary data (quantitative and qualitative) was collected and collated to build the data-base we needed. This included analysis of public opinion data from the chamber of mines and statistics and other relevant institutions in each country.

Specific methods and procedural steps to be followed during the study are as follows:

Step 1: Desk-based documentation review

During this phase, a detailed review of relevant literature and policy documents was carried out to gain a broad understanding of the prevailing situation of mining in the selected case countries.

Among others, relevant strategic documents at national and regional levels were reviewed as well as global level literature on industrial revolution and the labour dynamics in the mining sector.

Step 2: Sampling

The study was originally set to be implemented in four focal countries in Southern Africa, namely, South Africa, Tanzania, Zambia and Zimbabwe. Only South Africa and Zambia were studied in Phase I as aforementioned. Purposive, and snowball sampling was done to determine the key respondents to be targeted during the study. Personnel from relevant government departments, unions, academics, and the civil society active in the mining sector were contacted so that they can provide the bulk of the respondents for this study. The targeted number of respondents was 15 officials per country.. If the Researchers managed to reach out to more respondents, it was considered as an added advantage. In other words, the study targeted those key informants who are already known or expected to have knowledge about developments of fourth industrial revolution in this sector. These targeted respondents were contacted through telephone and physical visits (that is, before Covid-19) and invited for the interviews.

For each country a minimum of 4 commodities was to be selected considering the convenience and limited time frame to undertake the field work. Again for each commodity a minimum of 2 mining companies were selected if the researchers manage to visit more than 2 again that was

to be an added advantage. Apart from interviewing the executive management the technical directors, the field workers were also interviewed—a target of at least 10 workers per mine.

A comprehensive list of potential respondents and key stakeholders to target was be drawn up and purposively selected as a first step in enabling the researchers to carry out the in-depth interviews and or sending the electronic questionnaire link for self-administration.

Step 3: Development of data collection instruments

The researchers designed and pre-tested relevant data collection instruments such as questionnaires and/ interview guides to be used during the fieldwork. Pretesting was done in one of the coal mines in Mpumalanga. Essentially the instrument was divided into two sections namely Management and Non-Management. An online link was developed and circulated to the targeted respondents.

Step 4: Data Collection - Key informant interviews

Relying on a pre-determined minimum sample size, the researchers used face-to-face in Zambia and telephonic and online meetings were used (where possible) to engage and obtain information from the respondents. The interviews followed a semi-structured questionnaire which was designed to guide these interviews. The questionnaire was designed to addresses the key objectives of the study and the major thematic areas of labour dynamics and the fourth industrial revolution. Where possible, the researchers attempted to ensure gender-balanced coverage by interviewing both females and males during this study

Step 5: Data analysis and research report writing

This data was analysed through the thematic analysis approach (Braun and Clarke, 2006). The analysis was done at both the semantic and latent levels in each case seeking to generate plausible insights into how firms and countries are engaging with the 4IR discourse in both the policy and practice spheres of their mining industries. A consolidated report covering the case countries was developed.

3.4 Research questions to be covered by Data Collection Tools

Semi-structured questionnaires/ interview guides were used to collect the data basically covering three main thematic areas namely, General mining experiences, 4th industrial revolution and labour dynamics, and Impact of Industry 4.0 on mining value chains. Some of the main research questions targeting both new and existing mine ventures that were included on the questionnaire are as follows:

i. Are there any latest 4IR specific technologies that have been deployed or you intend to deploy to enhance mining operations?;
ii. What labour effects if any have you envisaged from the introduction of new technologies
iii. Are there any elements of mining business that have been rendered obsolete by the fourth industrial revolution?
iv. What can be done to mitigate the effects of the 4IR?

NB: More questions are encapsulated in the attached instrument

3.5 COVID-19 and its Impact on the Project

The Covid-19 pandemic and response has impacted research activities and outputs across the Research and Development (R&D) sector in many ways. Travel, social and funding restrictions imposed in response to the COVID-19 pandemic have taken a toll on scientific research worldwide. Similarly this project faced unprecedented disruptions.

In particular the confirmed field work visits with respective mines and identified key informants could not take place as planned. No one ever anticipated to see the restrictions prolonging beyond a full year from March 2020 to beyond March 2021.

Not only that, but this comes at a time when the sector has had to adapt at speed to new ways of working all while what the research enterprise does - drive new discovery and understanding to aid society - has never been more critical. In response to this the project team had to convert the data collection instrument to a virtual platform. Albeit obtaining authorisation from the respective mines remained a daunting task. Beyond the cloud of COVID-19 and uncertainty obscuring research planning, the slowdown and stifling of data collection means we may miss out entirely on new information and discoveries.

4 ZAMBIAN CONTEXT

4.1 Introduction

This section provides the profile of the Zambian mining companies that participated in this study (Table 1). Seven mining companies were represented, including Konkola Copper Mines (KCM), Mopani Copper Mines (MCM), Kansanshi Mine, and Lumwana Copper Mines, Kalumbila Copper Mine, and Non-Ferrous Company Africa. These mines represent a fair representation of the mining industry in Zambia as they include Zambia's biggest mines which are Lumwana, Kansanshi, MCM, and KCM, and they account for approximately 80 % of the copper production in the country. In addition, both new and old mines were represented. A large proportion (66.7 %) of the respondents represented mines which have been in operation for more than 20 years (Figure 1).

Table 1. Minning companies which participated in the study

Company	Mines	Location	Mine type	Commodities	Owners
Konkola Copper Mine (KCM)	Konkola Nchanga Nkana	Chingola Kitwe Chililabombwe Nampundwe	Underground and open pit	Copper	Vedanta Resources PLC- 80 % Zambia Consolidated Copper Mines Investment Holding Group- 20.6 %
Mopani Copper Mines	Mufulira Nkana	Mufulira Town Kitwe Town Copperbelt	Open pit & Underground	Copper & Cobalt	Zambia Consolidated Copper Mines Investment Holding Group- 80 %
Kansanshi	Kansanshi	Solwezi, North Western Province	Open pit	Gold Copper	First Quantum Mineral Ltd- 80 % Zambia Consolidated Copper Mines Investment Holding Group- 20 %

Lunwana	Malundwe and Chimiwungo	North-Western Province	Open pit	Copper	Barrick Gold Corp-100 %
Kalumbila Minreals Ltd	Sentinel mine	North-Western Province	Open pit	Copper	First Quantum Minerals Ltd-100 %
Luanshya Copper Mines		Luanshya, Copperbelt	Open-pit and Underground	Copper Cobalt Uranium	China Non-Ferous Metals Company Limited-80 % Zambia Consolidated Copper Mines Investment Holding Group-20 %
NFCA	Chambishi Main Mine Chambishi West Mine Chambishi South-East Mine	Kitwe, Copperbelt	Underground	Copper	China Non-ferrous Metals Company Limited ("CNMC")- 80 % Zambia Consolidated Copper Mines Investment Holding Group-20 %

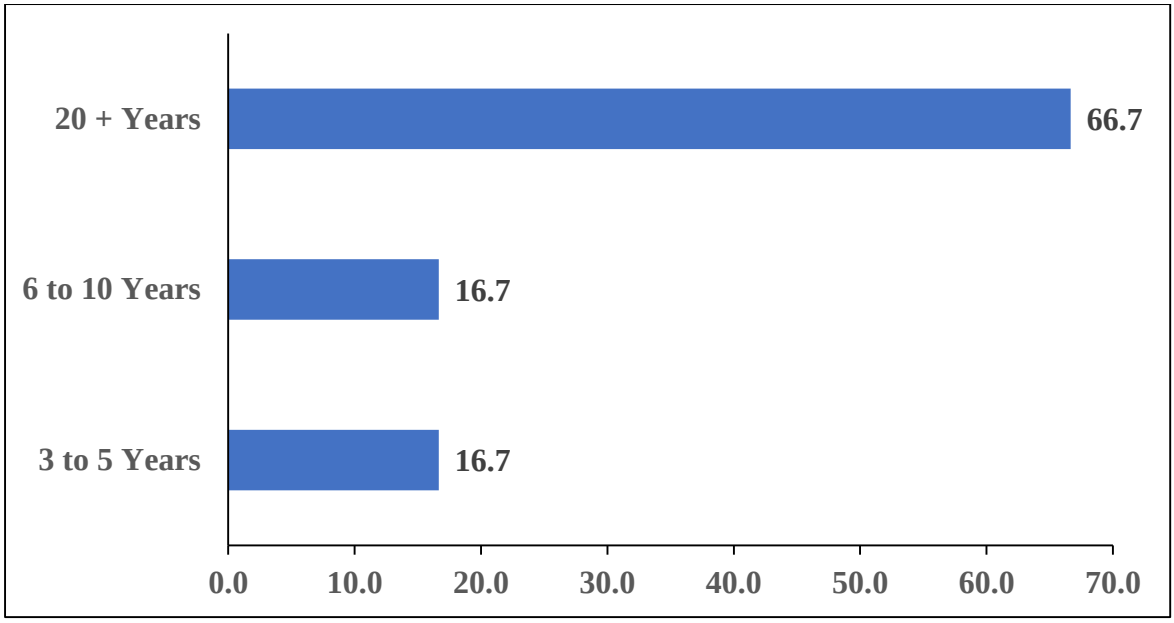


Figure 1. The number of years the mine has been in operation

4.2 Demographics

Figure 2 illustrates the demographic characteristics of the respondents who participated in the study. As depicted in Figure 1, most of the respondents were male (94.1 %). Less than 5 % of respondents were female. In terms of the employment position, approximately two-thirds (64.7 %) of the respondents were employed in non-management positions. Respondents employed in management position accounted for 36.3 %. About 29.4 % of respondents have been working for 11-20 years, while 23.6 % have only been working for less than 2 years. Only 11.8 % of the respondents were employed for more than 20 years. As revealed by the management, a larger proportion of the workforce is comprised of males. The female workforce makes up less than 20 % of the mine employees. In terms of racial distribution, most of the mine employees are black, while other races accounted for roughly 5 %.

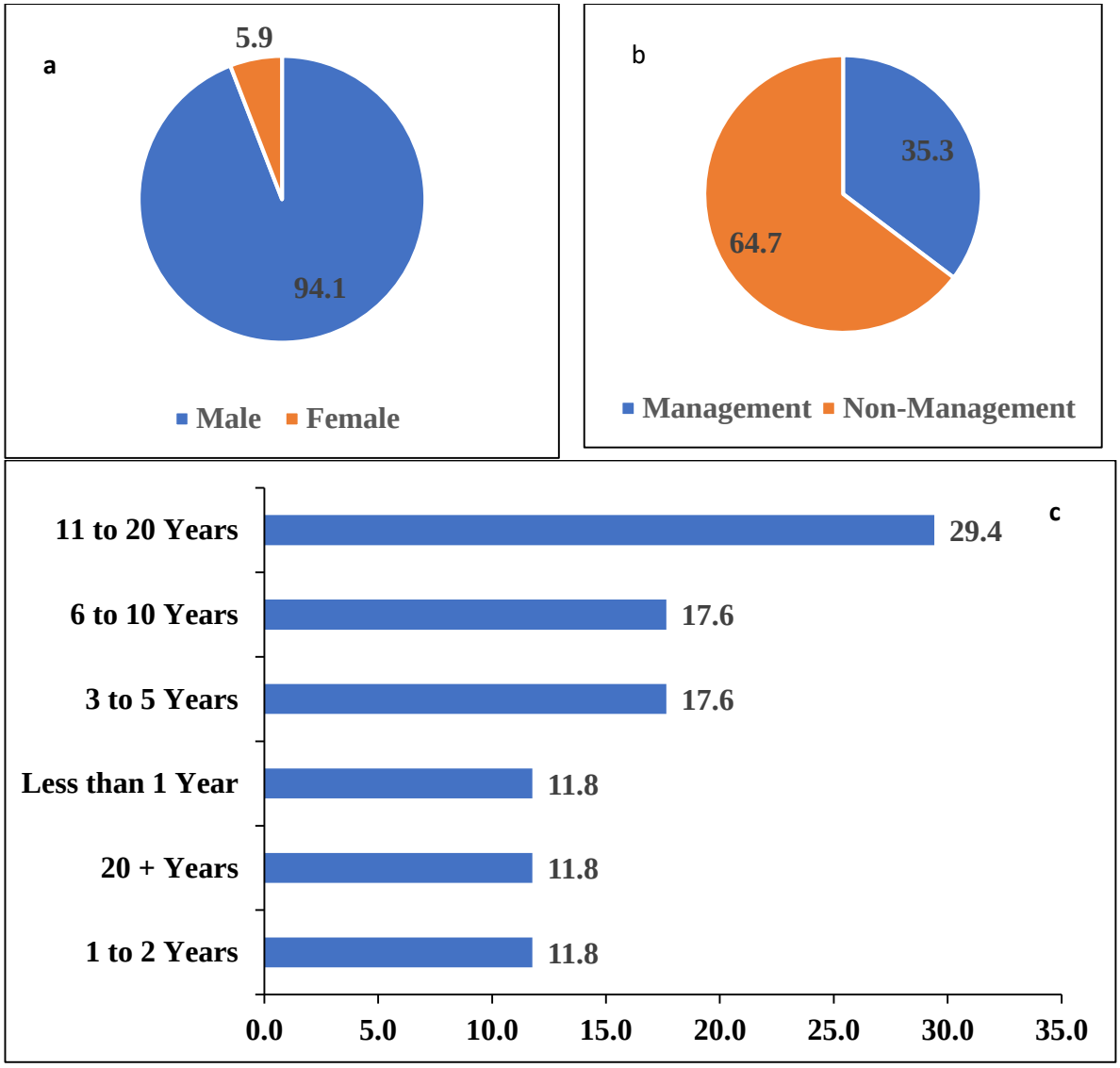


Figure 2. Demographics of the respondents: a) gender b) position and c) number of years employed.

4.3 Current Status Quo of Mining Technology

Privatization of mines from the late 1990s to 2002s brought about a lot of changes in the mining industry in Zambia. This was mainly driven by the state of the mining industry, which was characterized by the depletion of high-grade ores, low grades, low productions ores, and complex geology (Sikamo, Mwanza and Mweemba, 2016).

The results of our study show that some of the Zambian mines are making use of new technologies in their mining operations. Mines making use of the new technologies are new mines that are less than 10 years old; these mines include Kalumbila, Kansashi and Lumwana. These mines are characterized by lower grades, hence the deployment of high-tech machinery. Mining in Kalumbila started more than 50 years ago but was abandoned due to low grades. It

is only after the availability of new technologies that mining operations resumed. The old mines in traditional Copperbelt mines still use old mining technologies despite the better ore grades. It is primarily new mines where new technologies are adopted. In olds mines primarily located in the Copperbelt new technologies are used in new shafts. For example, new shafts in Mopani Copper Mines are deploying newer and modern technologies. Also, the mining operations are transitioning to a new concentrator. In 2001 at KCM, there were 10 fatalities due to landslide, which then became a catalyst for introducing new safety technologies.

Since then, slope monitoring radar has been in use for slope stability, and these were advanced tools meant for greater improvement in productivity and safety procedures. KCM mines have introduced anti-collision devices following horrific accidents the mines have experienced. Some of the mines in Zambia are using robotics technologies for the drilling process for safety reasons. 'You will be aware that the equipment such as drills and loaders, hauling equipment, dump trucks and supporting equipment's heavily lean on robotics in the way they operate' Key informant interview 1. Among the common technologies has been compressed airlines and nitro-controlled drilling. Although the mining industry in Zambia is slowly adopting new mining technologies, they face several challenges that hinder full adoption. Among the challenges is the issue of power cuts which are frequent and affects production and use of technologies. In addition, mines in Zambia are the primary sources of employment for most of the population, and the adoption of new technologies with the possibilities of changing labour dynamics pose serious challenges for mining companies. Most mining companies were granted permission to mine on conditions that they will employ only local people. And lastly, these technologies are costly, and most mines cannot afford them due to economic conditions and the prices of copper.

As far as the mining industry is concerned, the concept of the 4th Industrial Revolution can be highly contested. However, the mining industry in Zambia is slowly adopting 4IR technologies. For instance, 30 % of the mining operations in KCM are digitized. Also, in use at KCM mines are the drone technologies that replace theodolites in open cast mines.

4.4 The use of new technologies in mining operations

Findings emanating from our study reveals that the Zambian mines deploy 4IR technologies at different stages of the mining process. As depicted in Figure 3, half of the respondents indicated that they use the new technologies during the operation value chain, while 16.7 % indicated

that they also used technologies during the exploration, rehabilitation, and closure stage of the mines.

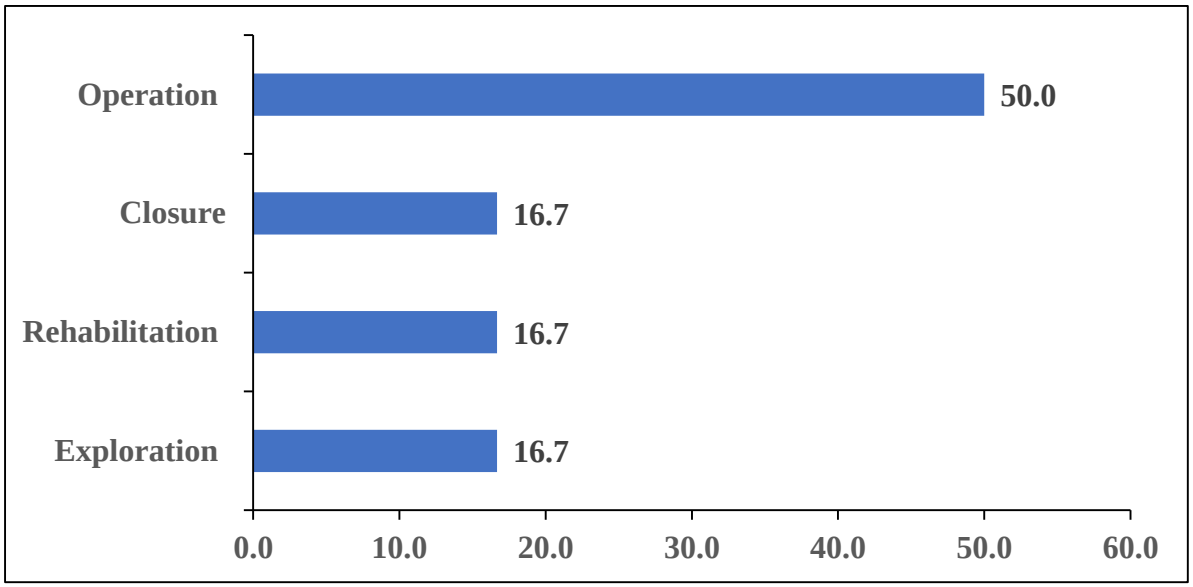


Figure 3 Technologies application at Mining Value Chain

When asked about the source of these technologies, most respondents revealed that most of the new technologies are imported. The patents for these technologies remain with the companies. These new mining technologies are imported from China, Europe, India, Australia, and the United States of America. New technologies have been used in all stages of mining in the past 3-5 years. Its only in exploration and operations that new technologies have been in use for more than 5 years. Apart from the technologies, inputs for mining are also imported from countries such as South Africa and Australia.

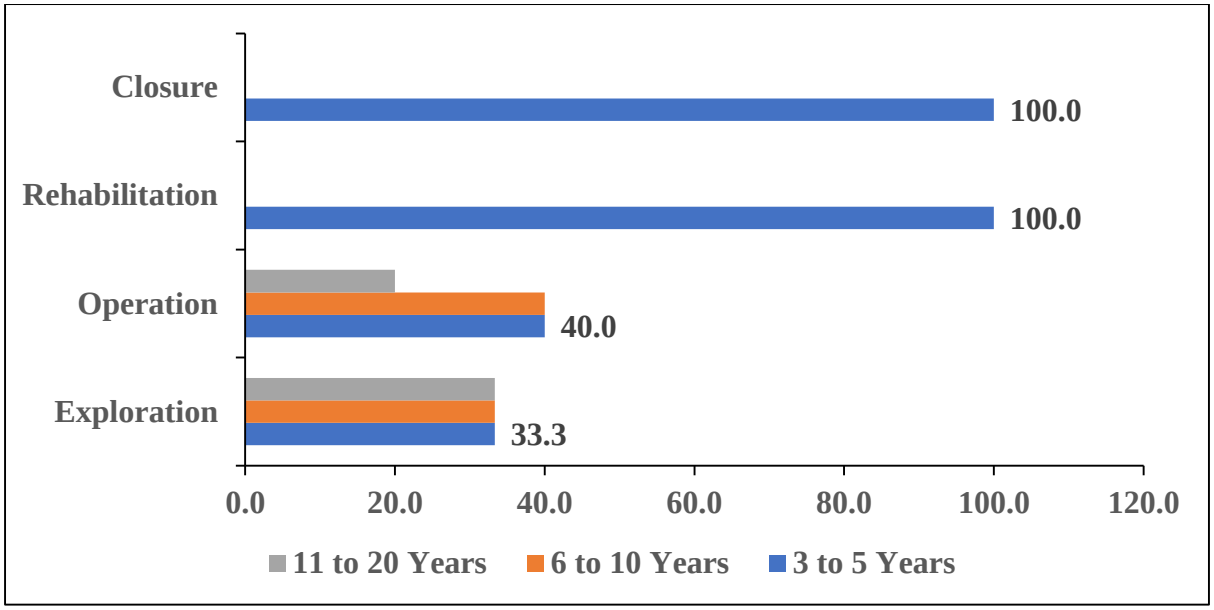


Figure 4. Period new mining technologies have been in use.

It is emerging from the study that the new technologies applied in mining have brought a change in the processes. As Figure 5 below depicts, 80 % of the respondents indicated that the new technologies have changed how mining operations and 20 % said no impact has been visible.

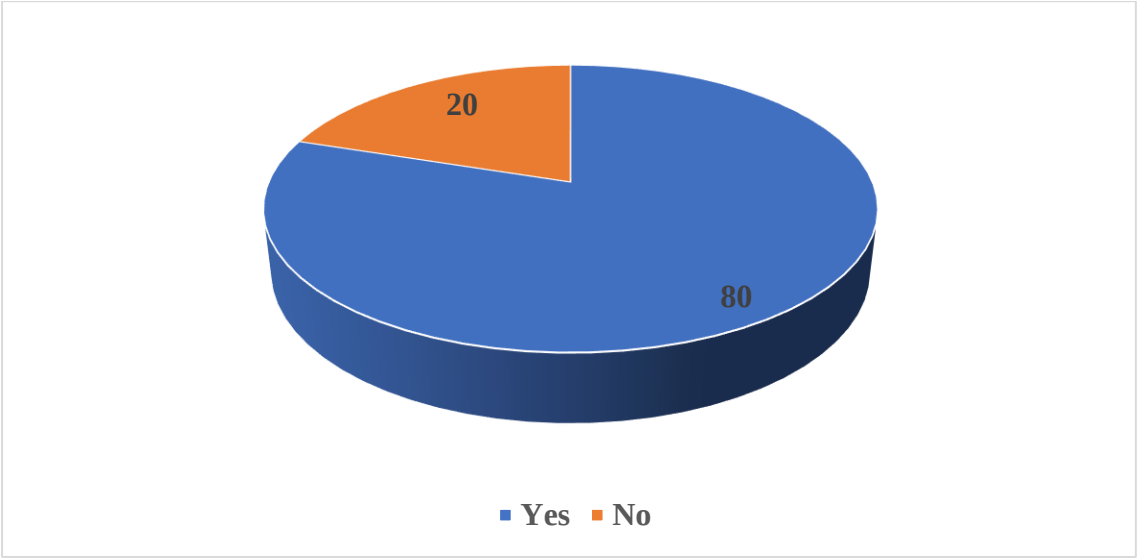


Figure 5 The impact of new mining technologies on mining operations

4.5 The impacts of new technologies on productivity

New mining technologies have brought a change in mining productivity and efficiency in Zambia. All the respondents confirm that production increased because of improved technologies (Figure 6). Although they vary in terms of the degree of increase across the mines

of the respondents. Since the deployment of new technologies, there is higher visibility and granularity on what is happening in real-time has improved the precision and accuracy of responses to changing ore physio-chemical characteristics. The life of some mines in Zambia has increased because of the introduction of new technologies. Change from conventional mining, such as the use of jack hammers has certainly enhanced efficiency at KCM. As a result of new technologies in Mopani, production cost has declined while KCM production has increased. Although the grades are not high, the quest to adopt new technologies to enhance efficiency and the investment is huge, and the output is comparable to global output. Mines at KCM are now treating more tonnage with less footprint.

The overall mine production increased because of the deployment of new technologies. The mine deployed advanced environmentally clean technologies. In Nchanga smelter, the new technologies achieve 99.6 % sulphur capture reducing pollution to the environment. The Three new zero-discharge concentrators have replaced older concentrators and improved efficiency (Vedanta, 2021). This advanced smelter can now produce cobalt alloy because the Konkola ore body has Cobalt in the mineralogy. It emerges that there is a reduced repair fleet due to automated machines.

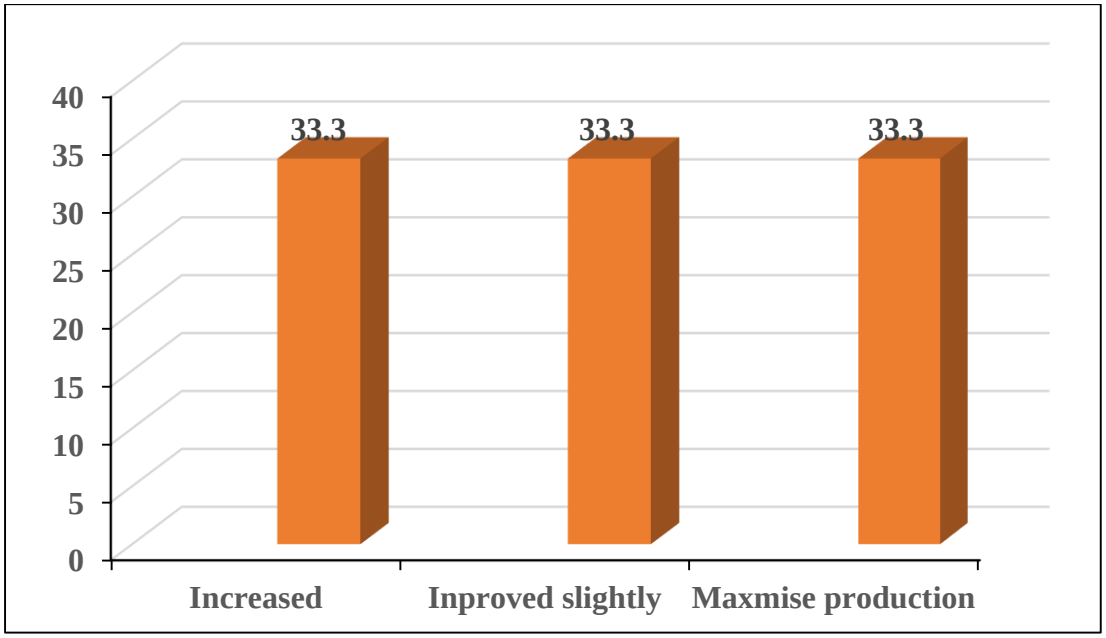


Figure 6. The impact of new technologies on production

The new technologies have brought change into the way mining is done. When asked how so, 20 % of respondents indicated that miners can now draw ore from the dangerous draw points. The other portion of respondents, constituting 10 %, specified that technologies have led to

high mineral refining, followed by 10 % of respondents confirming that more tonnage is being hosted due to more than one steel rope attached to the skips and large capacity conveyances or skips. Lastly, 10 % of respondents attest to the fact that there has been easier mineral processing. Process control philosophies are now being tailor-made on-site because the tools to study the behaviours and responses of the processing circuit are now accessible to Mine Operators, as revealed by 20 % of respondents. See figure 7 below.

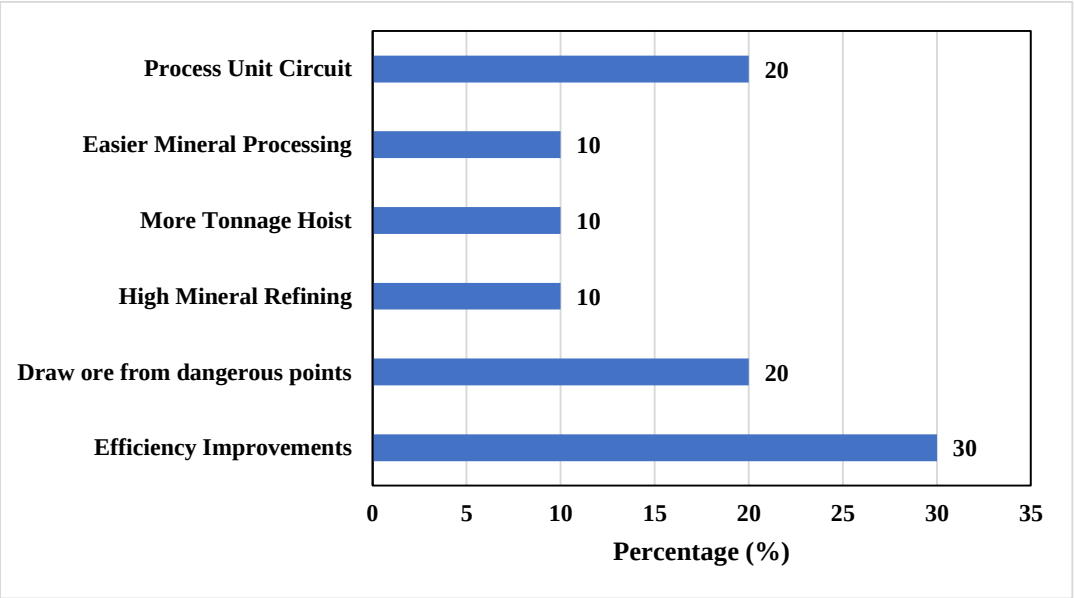


Figure 7 How mining technologies change the way mining processes operates.

When asked if the new mining technologies have rendered some aspects of the mining and mining business obsolete, most respondents (80 %) said yes, while 20 % responded no (Figure 8). An interview with the representative from the KCM revealed that the introduction of the new smelter in Nkana mine had rendered the entire mining operation obsolete. The very same smelter was the best in the world during the 80s-90s. It implies that the technology evolution is moving so fast.

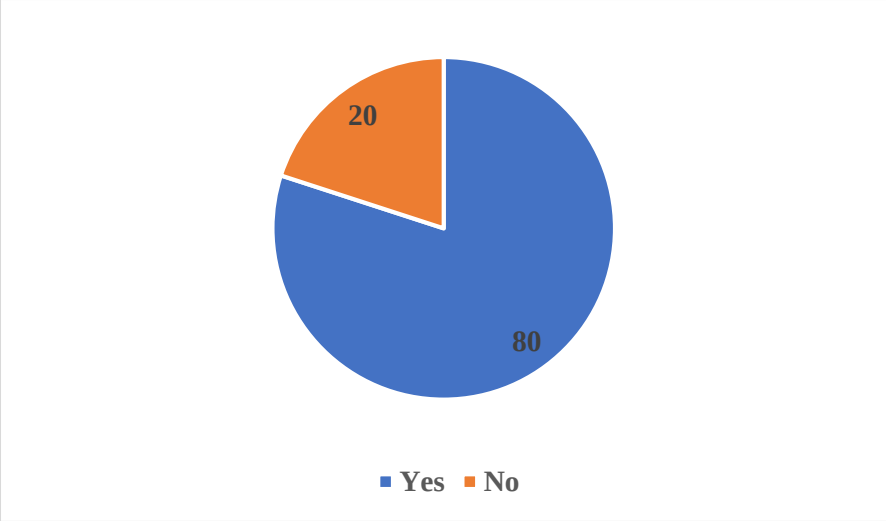


Figure 8 Respondents perceptions of new mining technologies

4.6 Impact of 4IR on labour

In Zambia, there exists many factors that may limit the full potential of the 4IR to be effectively considered as beneficial to the country. Zambia being a developing country would have challenges with convincing its citizens of the long term benefits of the fourth industrial revolution seeing that most parts of the country are still lacking electrification and people lack access to good internet connection. Zambia faces challenges in the required skills in the 4IR due to the changing nature of jobs as a result of advances in technology and mining techniques.

Mining industry experts agree that 4IR and new mining technologies will shake labour dynamics in the mining industry. The impact of 4IR on labour dynamics is inevitable and will be at the expense of jobs. Thus, hundreds of miners that would have worked are replaced by the largest machinery employed, for example, in new mines in North West Province. In 2013, KCM mines retrenched more than 1500 mines works as they moved into mechanization. The reason for retrenchment was to reduce the overheads and improve grades. This was met with resistance by workers and governments since the government-owned the largest stake at the time. The introduction of new technology saw the retrenchment of many workers from around 1400 to about 800. Kalumbila mine has the largest loader in Africa. It is easy to replace miners for the open cast, but for underground, it is not easy as machinery cannot reach certain areas. The labour component will have a negative impact if not managed well.

When looking at the categories of workers whose jobs are on the lines as new technologies are introduced, artisans and general workers are on top of the list. Highly specialized skills are required for operating highly advanced machines, and only a few Zambian locals have the

skills. Additionally, some mine reports are now being generated in a highly automated fashion; human intervention is no longer required at a data input level. With the introduction of new technologies come opportunities for water to learn new skills. For example, commissioning of the mines in Kalumbila brought highly advanced machinery, and skills were transferred to locals. The workers are now able to compete with highly skilled workers globally. Workers from Zambia trained during the commissioning of the Kalumbila mines were involved in the construction of one of the highly automated mines in the Africa in Panama. Most Zambia workers do not possess the skills required by new 4IR technologies. Part of the agreements with the local people was that the mines would employ local people for all mining operations. However, that's not the case as most workers are unskilled. For example, an agreement with chiefs was reached wherein the mines could bring highly skilled workers if they cannot find them in Zambia.

Highly skilled workers from other countries mostly come for 6 weeks to service some of the machines. Low skilled miners are now sent out to other contrite to advance their skills. The mines have now partnered with the Copperbelt University of Zambia to upskill workers with required 4IR and new technologies skills. The mining and metallurgy curriculum has remained the same despite new technological innovations. Albeit there is a need to fuse components of 4IR into the curriculum.

Our findings indicate that more than 60 % of the respondents believe that 4IR will negatively impact mining labour dynamics. About 25 % of the respondents neither agreed nor disagreed with the statement that 4IR will have a negative impact on labour. Less than 15% of the respondents did not agree that 4IR will have a negative impact on labour. Findings emanating from key informant's interview highlighted that due to negative perceptions by workers on having on new technology and 4IR, they might revolt or sabotage the machinery. Kansanshi mine in Solwezi under the Anglo Americans is a case in point where workers reportedly sabotaged the machines.

About 43.8 % of the respondents thought that the Fourth Industrial Revolution/new technology would offer the mining sector's labour component opportunities. The best to come with the implementation of new technologies in Zambia is the involvement of mineworkers using the skills learned in other countries. Around 37.5 % were neither agreed nor disagreed that the 4IR will bring about opportunities to the labour component of the mining sector. About 18. 8% of the respondents did not think that the 4IR will bring any opportunities into the mining sector's

labour component. To conclude, although 4IR will bring about changes to the labour component of the mining industry, new thinking is needed on how to manage the composite alternative livelihoods. Creating other sources of employment to complement the mining sector is thus crucial for Zambia.

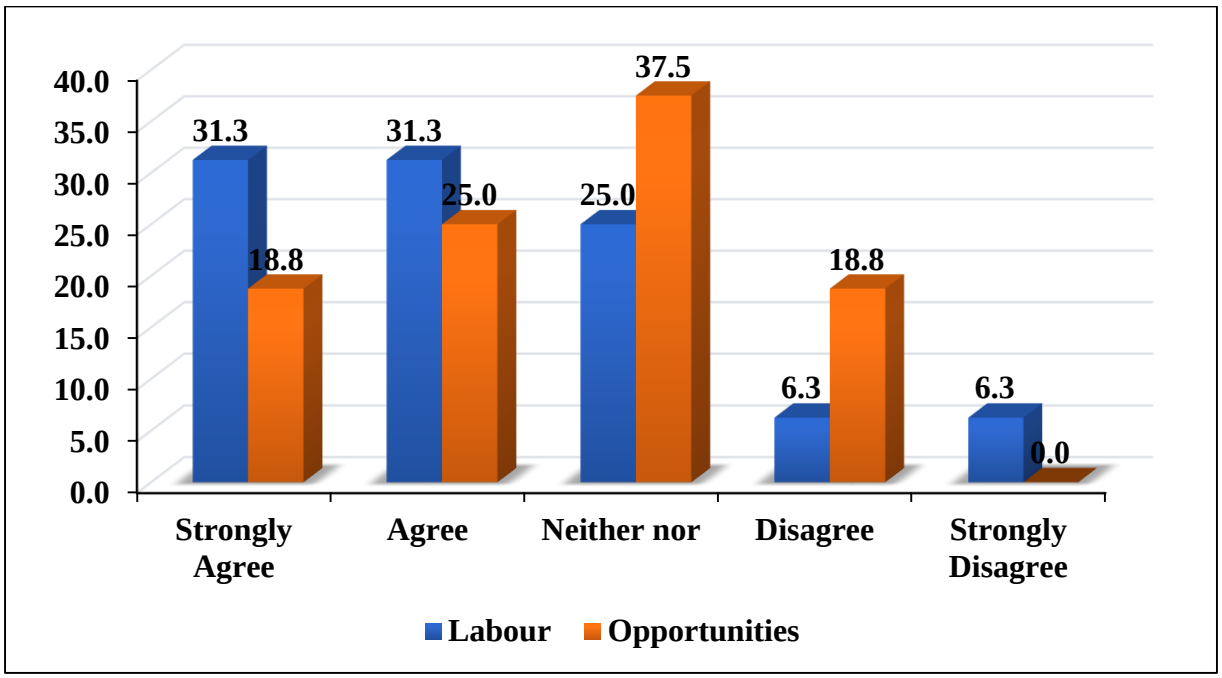


Figure 8. The impact of 4IR and new mining technologies on labour

4.7 Awareness on 4IR

Table 2 presents respondents awareness of the 4IR. The majority of the respondents who participated in this study understands the concept of 4IR and what it entails. Respondents are aware of how 4IR will change the demographics of the workforce in mining and the fact that technological innovations come with long-life learning. They also understand what drives the adoption of these new technological innovations in Zambia.

Table 2. Awareness of the 4IR technologies and their impacts on mining

	Responses	Percentages
Fourth Industrial Revolution	Yes	64.7
	No	35.3
Demographic shifts are in the workforce	Yes	86.7
	No	13.3
How 4IR will impact health and safety	Yes	75.0
	No	25.0
What is meant with lifelong learning	Yes	75.0
	No	25.0
What the strategic drivers are for new business models	Yes	75.0
	No	25.0

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5 SOUTH AFRICAN CASE OF 4IR IMPLICATIONS ON MINING

5.1 Introduction of participating mines

This section presets an introduction of all mines that participated in this study. The section will focus on these mines relationships or lack of with the Fourth Industrial Revolution or new technology. These two concepts will be used interchangeably as they refer to same or similar developments. The use of these technology will be traced across what we have termed a 'generic mining value chain', which is exploration, operation, closure and rehabilitation.

Sasol integrated chemicals and Energy Company. The company was formed in 1950 in Sasolburg, South Africa and built on processes that were first developed by German chemists and engineers in the early 1900s. **AngloGold Ashanti** Limited is a global gold mining company. It was formed in 2004 by the merger of AngloGold and the Ashanti Goldfields Corporation. It is now a global gold producer with 21 operations on four continents. **South32** is a mining and metals company headquartered in Perth, Western Australia. It was spun out of BHP Billiton on 25 May 2015. The company has colliery mines in Gauteng Roodepoort and Mpumalnga, Emalahleni area, both in South Africa. 0128463000

Koffiefontein Mine is a diamond mine situated in the Free State province, about 80 km from Kimberley, South Africa. **Natal Portland cement company (Pty)** is located in Durban, KwaZulu-Natal, South Africa and is part of the cement & concrete product manufacturing industry. The company has 465 total employees across all of its locations. **Bosjespruit coal mine** is an underground mine based in Mpumalanga and it is owned by Sasol. The mine was opened in 1977 and has produced more than 250 million tons of coal in the last 40 years. Current coal production takes place at Irenedale with a 17.9km underground conveyor running past the South shaft to the Bosjesspruit Main shaft. Bosjesspruit mines between six and 6.5 million Mtpa and has a life of mine to 2031.

5.2 Demographics

This section presents demographic data of respondents who took part in this study.

Figure 1 shows the mineworkers' gender, figure 2 shows the respondents' position in the workplace, figure 3 shows the race representation of the respondents and figure 4 shows the number of years that respondents were employed in their respective mines.

Most of the South African data was collected through interviews with those in managerial positions in the mines. The mines that participated in the study include; Sasol integrated, Anglo Gold Ashante, South 32, Koffiefontein mine, Natal Portlant and Bosjespruit coal mine.

Figure 1: Gender

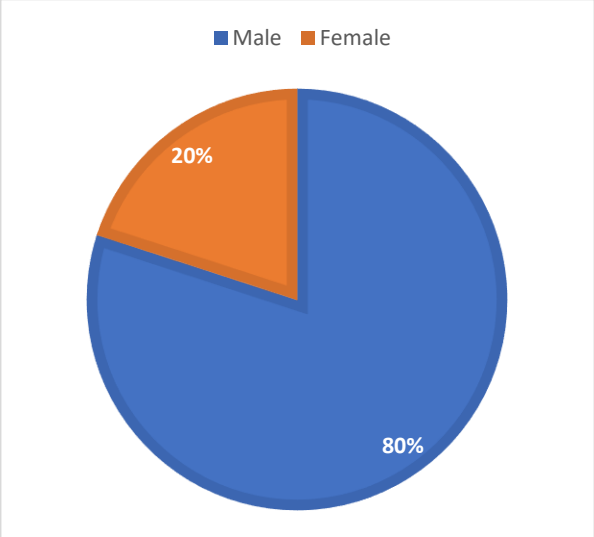
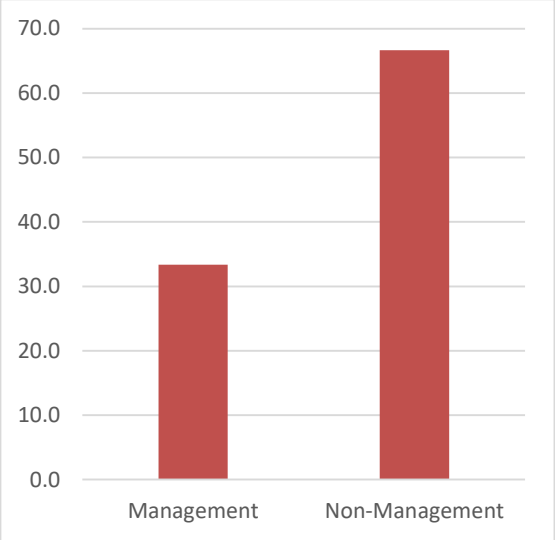


Figure 2: Position

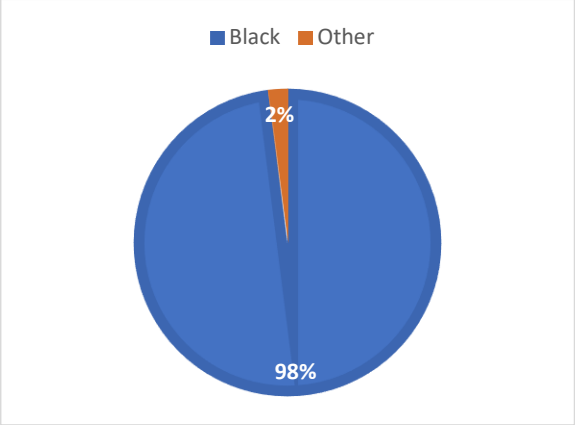


20% of the respondents were male and 80% of them were female. In regards with position, only about 33% of the respondents were from management while 66% of them were non-management. This is based on the number of people who responded to the online survey.

The management from Sasol reported that with an overall workforce of 12 000 employees, only 13% of the employees are female. They further stated that one of their major goals is strioving to hire more females in their mines.

Figure 3: Race represenation in the mines

Figure 4: Years of employment in mine



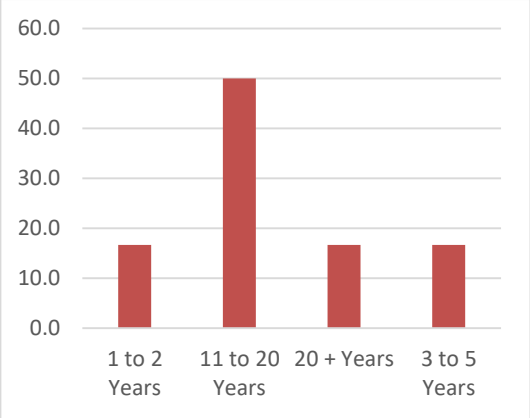


Figure 3 indicates that 98% of the respondents while only 2% of the respondents were from other races. Figure 4 shows the number of years that respondents have been employed, 50% of the respondents indicated that they have worked for between 11 to 20 years. About 16% of the respondents worked for between 1 to 2 years.

5.3 Current Status quo of Mining Technology

Section 3 presents the status quo of the mines that were interviewed in regards with the 4IR technologies.

Figure 1 represents new technologies being used in the mining value chain as indicated by respondents. Figure 2 shows how long mines have been using new technology. Figure 3 shows the key attributes of new technology on exploration, figure 4 shows the key attributes of new technology in mine rehabilitation. Figure 5 shows the key attributes of new technology on operations, figure 6 shows the key attributes of new technology on mine closure. Figure 7 shows any other key attributes of new technology in mining, and table 1 shows how long each technology has been used in the value chain.

The results on the status quo indicates that new technologies have been introduced and implemented in the mines that participated in the study. Respondents have to a large extent indicated a lack of knowledge in the functionality of the technology in the mining value chain. Although respondents are aware of the new technology, they were unable to report on the key attributes of the technology in the mining space.

However, mine mangers have indicated that technologies have been introduced and implemented since at least 20 years ago. This has been a gradually slow process, but with time

the technology has really aided their mines in terms of productivity and efficiency although automation definitely meant that labour would experience some shedding.

Figure 5: New technologies being used in the mining value chain

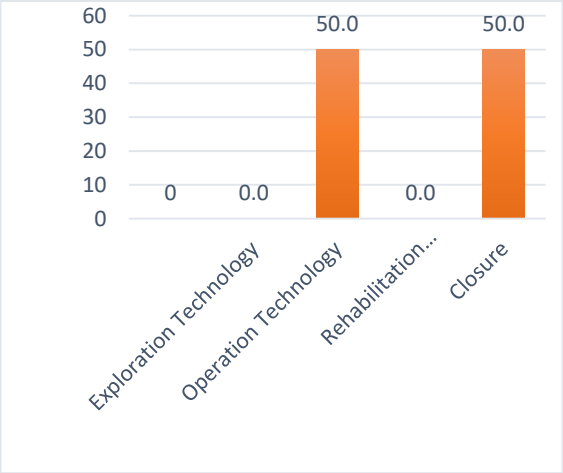


Figure 6: How long have you been using new technology

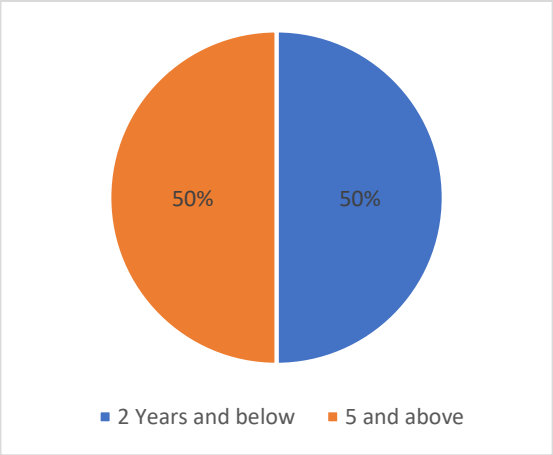


Figure 5 indicates the technology that has been used in the various mining value chain areas. 50% of the respondents indicated that the technology that is being used is the operations and another 50% reported that there was technology being used in closure. However, respondents did not report on any technologies being used in exploration and rehabilitation.

In figure 6, 50% of the respondents indicated that they had been using new technologies 2 years and more. Similarly, 50% of the respondents also indicated that they had been using new technologies for 5 years and more.

Figure 7: Key attributes of new technology in the mine

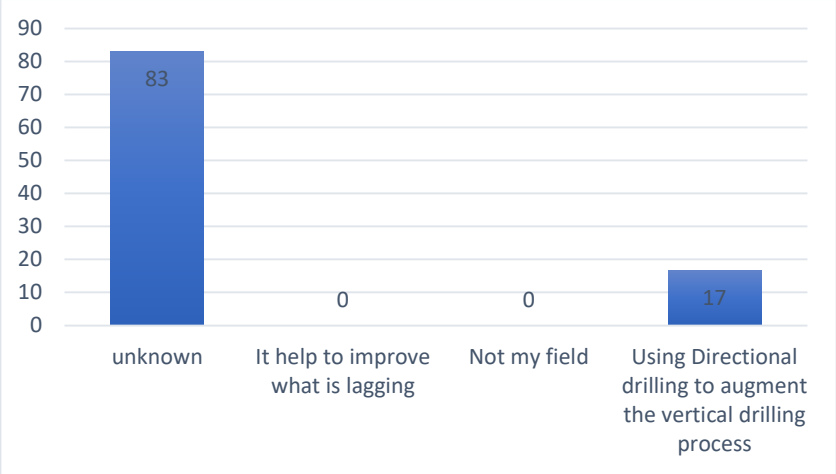


Figure 7 indicates that of the total respondents, 83% of them, could not indicate what the attributes of new technology were. However, at least 17% of the respondents indicated that using directional drilling to augment the vertical drilling process was a key attribute for some of the technology. This indicates that the respondents who took part in the study may not be fully knowledged on what the specifications of the technologies are.

However, one of the participating mines indicated that one of the key attributes of the technology was that it allowed for them to get real time information in the mine. Which meant that mining activities could be more efficient.

Table 1: How long has each technology been used in the value chain?

Value chain technology	**Number of years**	**Number of respondents**
For how long have you been using these new technologies? [Exploration]	20 + Years	20%
For how long have you been using these new technologies? [Operation]	11 to 20 Years	40%
	20 + Years	10%
For how long have you been using these new technologies? [Rehabilitation]	20 + Years	10%
Closure	20 + Years	20%

Table 1 indicates how long technologies have been used across the mining value chain. Of the total respondents across the participating mines, 20% of them indicated that the technologies have been used for 20+ years in closure, similarly 20% of the respondents indicated that the technologies is being used for exploration all over a period of 20 + years.

In operations, technology has been used for about 20+ years as well as indicated by the participants. In terms of whether the technology was locally manufactured or imported, respondents indicated that the technology was all imported from European countries. This transaction was reported to have been done in such a way that different parts of the technologies would have to be imported from different countries for one machine. Thus one machine does not necessarily come from one country per se.

5.4 The impact of 4IR on productivity

Figure 9 represents impact that the 4IR has had on productivity in the mining sector. Responses are presented as per the interviews conducted with mine mangers and an online survey that was sent out to both workers and managers.

Figure 9: The impact of labour on productivity

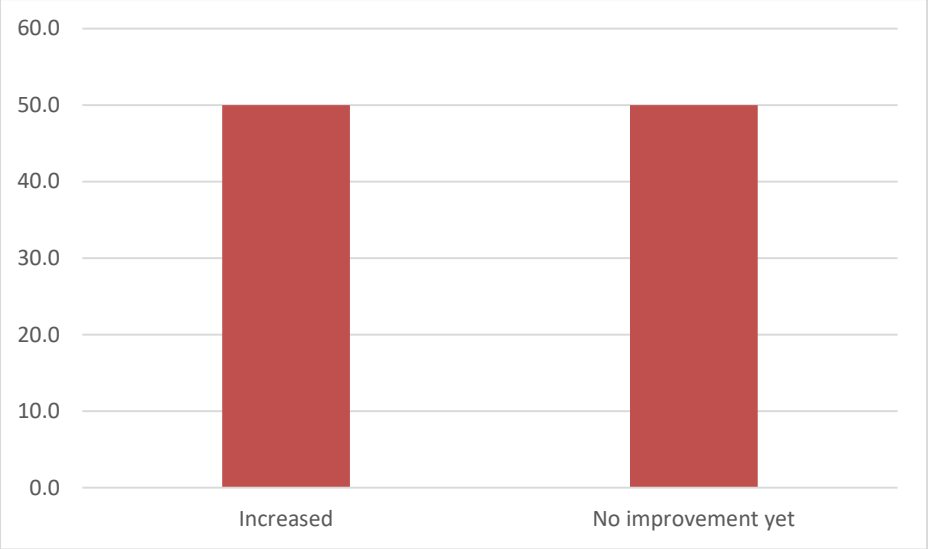


Figure 9 above is an indication of how the 4IR has impacted productivity in mining. The general outcome as indicated in the graph is that 50% of the respondents expressed that productivity has increased while 5% of them expressed that productivity had not increased yet.

One of the interviewees indicated that if they were to quantify productivity, they would say that with the new technologies, productivity has increased by 15 – 20% all in all. It is also more efficient as they are able to receive more real time information, and as a result are able to reach much faster in emergency situations in the mines.

Another mine reported that they have a machine called "the continuous miner" which essentially manages to conduct most of the work needed in production. In this case most tasks and areas of mining have then been integrated which means that work is much more effective at a lower cost, taking out the manual worker expense.

5.5 Impact of 4IR on labor

Figure 8 presents the impact of the 4IR on labour. On the one side it shows the responses of those who felt that the 4IR has a negative impact on labor. On the other side, it shows the responses of those who expressed that the 4IR has presented new opportunities in the mining sector.

Figure 8: The new technology has changed the way mining is being done

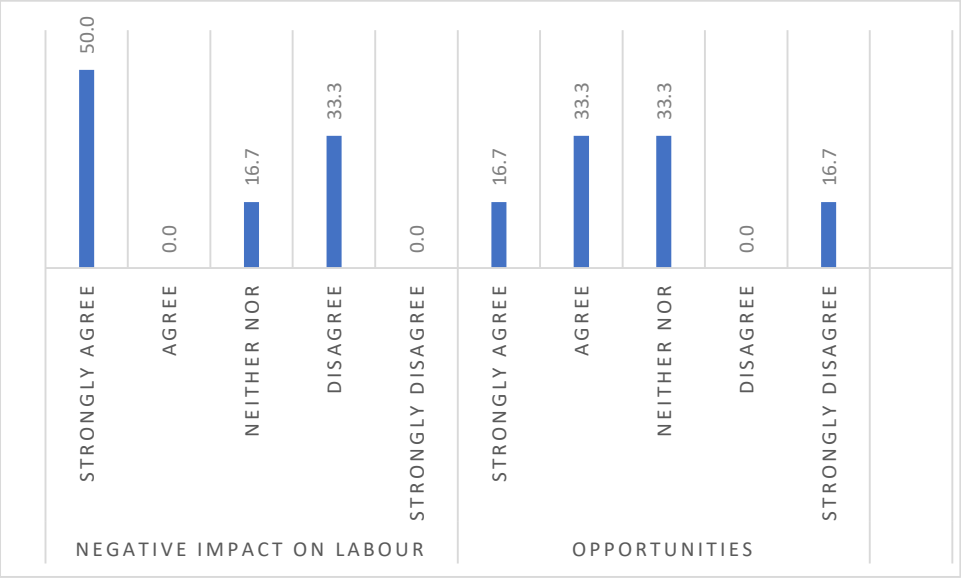


Figure 8 is a presentation of the perceptions of respondents in regards with how technology has changed the way in which mining is done. The perceptions were divided into two groups; where one group sought to answer the question of whether technologies have brought about a negative impact on labour and the second group discusses whether the new technologies brought about opportunities. 50% of the respondents reported that they strongly agreed that the new

technology had a negative impact on employment. 33% of the respondents indicated that disagree that the mining technology has a negative impact on labour and only 16, 7% of the respondents indicated that they neither agree nor disagree.

The other side of figure 8 presents the perceptions of respondents on whether the 4IR has brought opportunities in labour for workers. The data corresponds quite well with the other group of data. 16,7% of the respondents indicated that they strongly agree that mining technologies will present opportunities which is of course a small amount. Another 16,7 % of the respondents indicated that they strongly disagree that mining technologies will present opportunities. Based on the data, there might be some uncertainties among respondents on the actual impact of the 4IR on labour. 33% percent of the respondents indicated that it is neither nor from their point of view.

In the interviews, one of the mines indicated that a lot of jobs had been cut down on since the automation. The justification for this notion is that automation allows for safer, more effective and efficient mining.

5.6 Awareness of 4IR

Table 2 shows the extent to which mineworkers are aware of the 4IR. Respondents answered questions with a 'yes' or 'no'.

Table 2: Awareness of the 4IR

Area of awareness	Yes/No	%
I am aware of the Fourth Industrial Revolution	Yes	83,3
	No	16,7
I am aware of Demographic shifts are in the work force	Yes	16,7
	No	83,3
I am aware of how the 4IR will impact my health and safety	Yes	66,7
	No	33,3
I am aware of main transformative technologies	Yes	66,7
	No	33,3
I am aware of what is meant with lifelong learning	Yes	50,0
	No	50,0
I am aware of what the strategic drivers are for new business models	Yes	50,0
	No	50,0

As indicated in table 2, mineworkers are mostly aware of the 4IR. 83.3%v of the respondents indicated that they were aware of the 4IR, while only 16.7% of the respondents reported to not have been aware of the 4IR. Although the responses vary, a large amount of respondents reported to have some knowledge of the 4IR.In terms of the demographic shifts, 16,7% of the respondents indicated that they are aware or had knowledge. This is a very small percentage and indicates that respondents might need some education around the changes that will take place. 50% of the respondents indicated that they are aware of is meant by lifelong learning which means that they are aware that systems will continually change and they have to be prepared in some way.

From a management point of view, interviewees indicated that they have been aware of the technology and have been embracing it over the past 20 years. They reported that the dynamics of how operations were done definitely meant that their mines would have to undergo massive changes, of which they also embraced. However, the process of adaptation has been slow for some mines.

5.7 References

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6 THE VOICE OF THE UNIONS IN ZAMBIA ON THE 4IR

6.1 Introduction

This section focus on the union's responses to 4IR and examines awareness of the concept by the unions. The note is made on the future of work. Unions' arguments to adapt to the technological and environmental change need to be heard and be part of policy responses for mining management and the state and other stakeholders such as universities as knowledge creators. Thus, this section takes a look at the disruptions on labour dynamics and how unions are preparing for the future of work under 4IR era.

6.2 Trade Union Movement in Zambia

Zambia trade unions were formed to fight for the interest of the working class. In Zambia, the earliest piece of legislation to regulate the activities of trade unions was the Trade Unions and Trade Disputes Act of 1964 (Zambia Daily Mail Limited, 2015). Mineworkers Union structure was opened 1974. The MUZ union comprises of 10 board members: 4 members are full time and the rest are part time. The union is the largest mine workers union with 80 Branches across the country. Other unions include (National Union of Mine and Allied Workers (NUMAU) United Mine Workers Union (UMUZ), Mine Contractors, ZUNO, Consolidated Mine Workers, and TAU). The increasing union's concentration is in the North West Zambia's, where two biggest mining unions, the Mineworkers Union of Zambia (MUZ) and the National Union of Mine and Allied Workers (NUMAW) organise. Mutually these two unions are headquartered in Kitwe, where union leadership and professional staff are housed (Kapesea & McNamara, 2020).

Trade unions are a distinctive voice in society meant to highlight the plight of workers and also to raise awareness on various ills. MUZ is a biggest mining union though it has witnessed drop in membership. Accordingly, the number of unionized miners fell to below 20,000 in the early and mid-2000s (from a peak of 65,000 before privatization), it has reached about 30,000 across the mining unions (McNamara & Musonds, 2019).

6.3 Zambia mining Unions Evolution

Zambia has come through a serious transition–From State Owned Mines to Privatisation. During the time when the mines were state owned government provided free accommodation, basic services such as water, electricity, housing and Sporting services. Organized labour has been a significant factor in progressive social, political, cultural and constitutional change in Zambia (Wild, 2012).

Privatisation was a game changer which saw most of the benefits for workers being eroded. This brought up social despondent in most mining towns. Investors have been more on the profiteering than ploughing back to the community. Trade unions note carefully that the world of work is undergoing rapid changes conveyed about by the 4IR. The overall membership of trade union also seems to be on declining. This a point of concern for organised labour.

The sector has experienced strikes back dated to 1934 and 1948: Strikes. Another recent case in point was in Sinazongwe district at Maamba Collieries Limited where a Chinese National

was killed. The key highlights on the findings of the field are discussed below from mining trade unions in Kitwe.

6.4 Unions Awareness of 4IR

The 4IR or new mining technologies is an emerging concern for trade unions in Zambia and it has transformed the workplace remarkably. Trade unions are aware that the new venture mines in the North West province have been employing new technologies, new methods of mining, to enhance productivity as output is the major goal. These technologies are bringing large scale in the mining industry and everyone has to be ready for the new era. With massive investment on these new technologies, a need arise to shed some workers as their positions get redundant. Unions are aware that in other areas, new technologies have contributed to safety of workers in the mines and increased lifespan of the mines. There is a consensus that workers will also have to improve their skills to match the need of automated workforce.

Trade unions are keeping an eye on the ongoing trend towards modernization of mining which include growing demand for automation, adoption of wireless technologies, and the use of the latest technologies such as IOT and AI are supporting countries worldwide to strengthen their mining markets (OGAnalysis, 2019). However, the impact of these technologies and machinery on labour and local communities has not being clearly defined. This give rise to antagonism between labour and the mining employers.

6.5 Unions' Perception on Technology Innovation

Organised labour in Zambia have a perception that mechanisation and automation is replacing most labour. Members forced to move from mining to agriculture for livelihood. This has had serious ripple effects particularly to the workers and also the labour movements. A case in point was the shutdown of Mopani Copper Mine under the guise of investigative exploration. Specific technologies such as the concentrators and smelter saw scaling down in number from: 1500 to 150 employees. This has had serious impact to the mine workers' and this remain a threat. The Chinese are using robots as such that led to boom operators losing their jobs.

6.6 Impact of 4IR Labor Dynamics

Zambia mining industry is undergoing rapid shifts with companies focusing on increased productivity, efficient mineral processing, and cost-efficient methods (OGAnalysis, 2019). The use of these advanced machines- first world technology threatens the labour force. Thus, hundreds of miners that would have worked are replaced by the largest machinery employed

for example in new mines in North West Province. Unions argue that in some countries the largescale application of technologies in mines have led to destruction of livelihoods. Kansanshi mine in Solwezi under the Anglo Americans is a case in point where workers reportedly sabotaged the machines and revolted. Introduction of new technology saw the retrenchment of many workers from around 1400 to about 800. (Kalumbila mine have largest loader in Africa). For open cast, it is easy to replace miners but for underground it is not easy as machinery cannot reach certain areas. The labour component will have negative impact if not managed well. Workers will lose jobs, sabotage the machinery used or revolt.

The trade unions generally understand the significance of technologies and their role for productivity in mining. To reach ore at deeper levels, automation need to be applied to ensure occupational health and safety of workers. Under privatisation era, the new mine owners invested massively in the mines and there was a sudden economic upturn due to advanced productivity. Investments went into new machinery, new mining methods, and new mineral processing and metal extraction technologies. The massive greenfield projects at Kansanshi and Lumwana, both in the North West Province of Zambia brought newer technologies into the industry and mines remained operational and jobs saved (Sikamo, Mwanza & Mweemba, 2016)

Occupational health and safety of workers has also being bone of contention. Amongst the reasons for primary technological innovations, was necessitated by two main factors namely occupational health and safety and production. Mining today, is faced depth with extreme geo-stress uncertainties, geomechanics and cost, demanding sophisticated design and site-specific planning (Ali et.al, 2021). With global emphasis on decent work and zero harm mining, mines are now obliged to install automated digital systems to monitor the real-time well-being of workforce. Introduction of smart mine, digital systems, and real time ground behaviour monitoring, proximity detectors enhances safety in mining operations.

6.7 Casualization of labour

Mining companies in Zambia are increasingly employing workers through contractors instead of offering direct employment. It was discovered through a study that the new jobs have tended to be fixed-term contracts or outsourced to independent contractors (LIZ, 2016). Unions are recruiting and organizing to fight back this promotion of precarious work (IndustriAll, 2019). This casualization of labour is regarded as a new slavery and subject workers to poverty as it denies them of full benefits. Chief among major concerns is that of the country's 65,000

mineworkers, nearly half, 30,000, are employed through contracting (IndustriAll, 2019). Mineworkers Union of Zambia (MUZ), has been opposing plans by Konkola Copper Mines (KCM), to outsourcing of operations, and transfer of workers to contractors. Unions argue that some mine companies continue with disregarding the health and safety standards. Nonetheless, when injuries and death occur, employers shift the responsibility to the contractors.

6.8 Trends and Challenges envisaged

What is emerging from the union's voice in Zambia is that technological applications and new mining methods post a threat to sustainability of jobs. It is highlighted that some existing jobs are decreasing. The Levels of remuneration are also very poor and it is concerning that machines may do most of the work and even lower levels on pay for the workers and could further affect the sector minimum wages. Koyi (2016) emphasizes that the current wages for lowly paid unionised workers in the Zambian mining sector are insufficient to cover the minimum requirement for decent living in Zambia. Given the changes, particularly regarding modern machinery and technology and lack of clarity, this may cause revolt by labour. There has to be a political will to enforce the laws and regulations which will safeguard the interest of the populace.

6.9 Looking into the Future for MUZ and other trade unions

MUZ has faced the dwindling trend in membership. The Mineworkers Union have developed and boosted the liquidity ability of most mines to meet needed outreach demands of the current members. Union believe that there are opportunities to be expected as well. Youth have a great potential to swim along with the transformation. Thus, the skills transfer is much easier to the youth workforce. Retraining and training is key and the new young emerging scholars can fit into this space to lead research and development (R&D). Trade unions call for Government support to enact the compelling laws and rules to enhance value addition in the sector. Furthermore, the union's strategic focus is to work towards positioning itself and other unions to bring forth a collective voice that propel the interest of the workers. This resonates with international labour voices which calls for preparation for future of work (ILO, 2019).

6.10 General Reflection

Trade unions in Zambia concede that data and information from cutting edge research is critical for informed decision making in building a transformative society. This research in particularly is important as it feeds into the Strategic vision and mission of MUZ. Union's call for a compact

and collaborative planning and research to ensure that workers are not the casualties of new 4IR technologies. At the centre of 4IR is the extensive use of artificial intelligence and other technologies and these technologies will have impact on relevancy of trade unions (Kaggwa, 2018).

It is further opined that what is not contestable is that the 4IR will reduce the number of people employed in work places. At the extreme, it will eliminate the human element in many production systems across African continent at large (Kaggwa, 2018). It is pertinent that with low trade union membership, it will be perplexing for workers to organise and that will weaken their voice in fighting for their interests. Organized labour can help ensure that those marginalized voices are authentically heard at the policy-making table around new mining technologies. The voice of trade unions shouldn't be subdued. Unions further argue that research to focus more on novel and economically viable new Technologies needs to be commissioned by the stakeholders. Due to the long term history of mining on the Zambian Copperbelt, there has to be a clear plan to safeguard livelihoods.

The attitude of organised labour in Zambia towards technological change is not well documented. Nevertheless, the evidence suggests trade unions are not fully opposed to new technological innovations at mines, they are only concerned about workers welfare. They insist technologies shouldn't destroy livelihoods. Cooperation and consensus is what is needed between mining management and organised labour to reduce negative effect on workers. Union's calls for "up-skilling" of workers from now henceforth to help them attain employment. For the foreseeable future, the 4IR, will indeed bring disruptions in the mining sector in Zambia and labour must be ready to adapt to avoid labour being casualties. Although the new technologies have disruptive power, trade unions must also work on strategies to counter and ensure impact on workers is minimal.

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7 THE VOICE OF THE UNION IN SOUTH AFRICA

7.1 Introduction

Trade unions are mainly concerned about protecting the interests of workers and ensuring that workers do not lose their jobs. The 4IR will bring about massive changes in numerous economic sectors including the mining sector. With these changes, come threats to the employment status of workers, and on the other hand, safer and more effective production on the side of mining companies (Mpafa, 2018). Thus the 4IR can in many ways benefit the employer more than it would benefit the employee. As a result, trade unions only have one major concern and that is: how will the role of trade unions be affected in the 4IR? This food for thought was discussed by (Kaggwa, 2018) in his article which sought to bring forth a response for organised labour on 4IR related issues. The lifeblood of trade unions is in fact employees, who are in essence trade union members. In his study (Mpafa, 2018) argued that the 4IR is most likely to undermine the bargaining power of trade unions. This notion immediately births a lot of uncertainty and anxiety among trade unions, particularly around the topic of their sustainability in the 4IR.

There are three main unions that organise in the mining space namely: The National Union of Mineworkers **(NUM),** Association of Mineworkers and Construction Union **(AMCU),** National Union of Metalworkers of South Africa **(NUMSA)**. All these unions have voiced out their concerns which pertain to how they will bargain for workers with the 4IR in place as evidenced in Mpafa's (2018) study. Further, issues raised in this regard, have been regarding the skilling and re-skilling of workers with the purpose of avoiding retrenchments and instead, keeping workers relevant and secure even with the 4IR enforcing new measures. Additionally, unions have indicated their concern around how they can retain workers after skilling them for the use of technology (Mpafa, 2018). This is especially relevant because trade unions are more likely to attract unskilled workers.

This section therefore seeks to answer questions around the relevance and role of the trade union in the 4IR. What does atomisation mean for workers in the mining sector? Will the union still be sustained post mechanisation?

7.2 Awareness of the 4IR

The topic of whether workers are aware of the 4IR is only the tip of an iceberg. The union should be concerned about whether workers are well-knowledgeable; especially more so about

the implications of the 4IR on their jobs and how they can still not be left behind. Moreover, as much as workers must be informed, it is imperative that they are constantly educated about new job roles in the 4IR. In a study conducted by (Koziol, et al., 2018), it was highlighted that lifelong education could be the key to ensuring 4IR awareness among employers and employees. The same applies for trade unions, and this could be a service for members.

More awareness can be created for workers in the following ways:

- Educating workers and potential workers on how to perceive the 4IR based on its possible opportunities and not more as a threat to jobs
- What changes must take place and how they should take place to ensure that companies, unions and workers are aligning with the 4IR
- How to ensure that the youth is included in the 4IR

These are questions that can be answered through initiatives of intentionally pushing educational programmes that could possibly instil hope for workers, employers and trade unions.

7.3 Impact of the 4IR on labour

This section discusses the impact that the 4IR is most likely to have on various factors from the perspective of a trade union. In essence, whatever the impact, it will directly affect the union in one way or another. As evidenced through research, the 4IR is very likely to bring about large declines in employment

Labour has been such a large area of concern in regards with the 4IR more especially with countries such as South Africa which are highly dependent on the mining sector. The country's dependence on the mining sector is a clear indication that, the sector also contributes largely to employment for the lives of individuals. The concern then becomes what happens when all these individuals are out of employment?

South Africa has a population of 59.62 million, and a total workforce of 451, 427 employees in the mining sector (StatsSA, 2020). This essentially makes up a large number of people who are employed in the mining sector, as they are just about half a million. In this case, the 4IR is likely to have a different kind of impact on three major groups which would be: **employees, employers** and **trade unions**.

In terms of employment, jobs will definitely be lost. In situations where ten people could be employed only one person will be employed. A study on the impact of 4IR on the mining sector

by (NSTF, 2019) indicated that the 4IR will bring about massive changes in the mining industry and listed out the following future technologies in the mining sector:

- Digital capturing of information
- Autonomous equipment such as driverless trucks
- Wearables for capturing real time data
- Drones for surveying temperatures
- Diverse mobile workforce with integrated remote operations
- A digital mine nerve centre with controlled, safe and healthy conditions

Source: (NSTF, 2019)

All these changes that are highly likely to be brought forward by the 4IR are a clear indication of a total wipe-out of the workforce. From a trade union's perspective, this is a complete threat to their sustainability or even their total existence. Employers on the other hand, are more concerned about running efficient and effective production and no so much the lives of employees. Those who will be in the red, are mostly employees and trade unions.

It is also highly important to note what level of development South Africa lies in. Asking questions such as; is South Africa ready for the 4IR? If so, in which particular compartments of the mining sector? Also, in which provinces? Which mines in particular? And lastly, which mines are still able to provide employment for all those manual workers.

The **NUM, NUMSA** and **AMCU** have indicated how they would keep trade unions relevant in the 4IR. In so doing, they kept in mind the some mines are still stuck in the second revolution. Further, they indicated that some for some mines, they would not need to defend the interests of workers but respond to the technological changes instead (Mpafa, 2018). In responding to these changes, the unions have highlighted the following:

- Skilling and re-skilling workers with the aim of retaining them in the union as members
- Coming up with approaches on how they can source more skilled workers into the union
- Unions diligently providing quality services

Source: (Mpafa, 2018).

7.4 Conclusion

In summary, the 4IR might not be ideal for trade unions, but this is how systems work. Systems evolve and institutions must adapt, the trade union will have to adapt in this case as well. Trade unions have to make sure that the right measures are taken in order for them not to be left

behind. Continuous research and development must be invested in as much as trade unions must invest in their members as a means to retain them.

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8 CROSS-CUTTING ISSUES

The impact of 4IR in the mining sector both in terms of its scope and severity is dependent on many factors which may vary or be similar across countries. The two country case studies provide useful insights into what seems common and different across them.

8.1. Awareness: The study showed that the general level of awareness across the mines respondents in both countries is well over 60% although South Africa had more respondents (83%) conversant with the 4IR (Table 1). Most the mine workers in both countries acknowledge the impact on health and safety across the mines, with more respondents from Zambia indicating that latest technologies has improved their health and safety in the mines.

Table 1: Awareness and Perceptions on 4IR.

Awareness	**South African Respondents**	**Zambian Respondents**
4IR awareness	83	64
Impact on health and Safety	66	86
Demographic shifts in workforce	57%	87%

Evidence also show that there is a huge demographic shift in workforce particularly in the Zambian case where 87% of the respondents have reported such. This corroborates the labour decline in Mines such as KCM of Zambia which shed nearly 1500 workers particularly the artisans and general workers. Similarly quoted from the voice of NUM leader in South Africa, retrenchments are the order of the day. While no specific numbers could be provided in the situation seems more dire in Zambia than in South Africa. Important to note is that apart from 4IR deployment other mines are shedding off employees primarily due to inherent factors such as liquidation, privatisation or change of ownership of the mines as is the case in Zambia.

8.2. *COVID-19:* Both Zambia and South Africa could not be spared from COVID-19. This heavily impacted the research activities and outputs thereof. Travel restrictions have stalled research activities. Access to mines and obtaining authorisation and consent for information gathering has been a huge set back. Equally the mining sector has been affected by the travel restrictions particularly in so far as the transfer or transportation of goods in the two respective countries.

Coupled to COVID challenges has been the reluctance of most mining companies to share or disclose information. The mining sector is a very sensitive environment which most mine owner guard jealously to protect their privacy. Contrary to the profiteering notion since March, the mining industry has been declared ‘essential’ in many countries worldwide, including the two case countries in this study enabling them to operate amid government lockdowns with devastating results, i.e COVID reported cases, failure of some of the mines to provide enough preventative measure.

8.3. *Technology Deployment*: Applications of new technologies is being experienced in both countries the mining processes including exploration, operation, closure and rehabilitation for both open and underground mine ventures. Source of these technologies vary with indications

that the advanced technologies in sync with 4IR are imported abroad from countries such as China, Europe, India, Australia and USA.

8.4. *Production*: Increased productivity and efficiency due to the new 4IR technology has been reported in both countries. While production cost are said to have declined in some cases it has also increased in some of the mines. It has also been observed that some of the operations and sections of the mining value chain have been rendered obsolete following the introduction of mining activities as discussed in the preceding chapters.

8.5. *The voice of the union*: The unions are key players in the 4IR. Union's voice for both Zambia and South Africa attest that technological applications and new mining methods pause a threat to the sustainability of jobs. According to MUZ of Zambia, continued decline in members is primarily due to retrenchments in the mining sector majority of which is coming with new technology deployment. In South Africa NUM, NUMSA and AMCU have also indicated how retrenchments pose a huge threat and remain an unjust phenomenon in the country. For both countries' union skilling and re-skilling workers with the aim of retaining them in the union as members remains a key priority.

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