A REVIEW OF MINE CLOSURE AND REHABILITATION PLANS DURING THE OPERATIONS OF LARGE-SCALE MINES IN ZAMBIA: A CASE STUDY OF NCHANGA OPEN PIT MINE

By

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Declaration

I, **Syafunko Mutinta Esther**, declare that this dissertation was written in accordance with the rules and regulations governing the award of Master of Science of the University of Zambia. I further declare that the dissertation has neither in any part nor in whole been presented as a substance for award of any degree, either to this University or any other University.

Signature: _____

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Certificate of Approval

This dissertation of **Syafunko Mutinta Esther** is approved as partial fulfilment of the requirements for the award of Master of Science in Sustainable Mineral Resource Development of the University of Zambia.

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Dedication

Firstly, to my Lord Jesus Christ and secondly to mother Pitcairn Miyanda Syafunko and my grandmother Esther Kasamba Miyanda for always believing in me and being my biggest cheerleaders.

Abstract

The world population continues to grow, with Africa projected to reach 2.4 billion people by the year 2050. This increase in population has resulted in a high demand for goods and services, which has subsequently triggered an increase in demand for mineral resources. Zambia, being a mineral rich country has seen an increase in exploration and exploitation of its mineral resources with some of the largest open pit mines in Africa being host to Zambia.

Despite the positive economic impacts that come with mining, open pit mines have an adverse environmental impact, vis a viz, loss of biodiversity, land degradation, loss of ecosystems, etc. The country does not have any large-scale open pit mines that have closed which gives an opportunity for the mines to operate and close sustainably. The aim of this study was to review the incorporation of mine closure plans and progressive rehabilitation activities into the life cycle of large scale open pit mines in Zambia. This was done by an assessment of the current mine closure plans and a review of the benefits of incorporating these closure plans and progressive rehabilitation activities into the life cycle of large-scale open pit mines.

The study focused on the Nchanga open pit mine, which is, a large-scale open pit mine in Zambia. The laws and regulations of Zambia were also examined in order to identify gaps and provide recommendations for improvement. The recommendations were drawn from an assessment of the current best practices and regulations and a review of international practices in Chile, South Africa and Western Australia. The methodology involved the use of survey questionnaires that were distributed to the local community, interviews that were conducted with key stakeholders, a site visit that was conducted at Nchanga Open Pit mine and the desktop review of the current laws and regulations on mine closure in Zambia.

The results of the research revealed that the Environmental Protection Fund is the main framework used to deal with the issues of mine closure in the country. However, due to various factors including inability of local banks to provide bank bonds or guarantees to the mines and limited resources to carry out site inspections, the framework is not implemented effectively. There is therefore the need to review the effectiveness of this framework and revise it to be an effective tool for continuous rehabilitation and mine closure.

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List of Abbreviation and Acronyms

Abbreviation	Description
BSI	British Safety Institute
COP	Chingola Open Pit
CSR	Corporate Social Responsibility
DMP	Department of Minerals and Petroleum
DMR	Department of Mineral Resources
EIA	Environmental Impact Assessments
EMP	Environmental Management Programme/Plan
EPA	Environmental Protection Authority
EPF	Environmental Protection Fund
HR	Human Resource
KCM	Konkola Copper Mines
MMA	Mines and Minerals Development Act
MMER	Mines and Minerals Environmental Regulations
MPRDA	Minerals and Petroleum Resources Development Act
MRF	Mining Rehabilitation Fund
NEMA	National Environmental Management Act
NGO	Non-Governmental Organization
NOP	Nchanga Open Pit
OB	Overburden
SHE	Safety Health and Environment
SI	Statutory Instrument
ZCCM-IH	Zambia Consolidated Copper Mines Investments Holding
ZCM	Zambia Chamber of Mines
ZDA	Zambia Development Agency
ZEMA	Zambia Environmental Management Authority

CHAPTER ONE

INTRODUCTION

1.1 Background

Zambia is one of Africa's largest producers of copper and cobalt (Zambia Development Agency, 2019). The economy of Zambia is largely dependent on mining of copper as the main commodity for its economic growth. Every year, thousands of tonnes of material (ore and waste) is extracted from the earth through open pit mining to sustain the economy. Copper production increased to 572,793 tonnes in 2007 from a low of 256,884 tonnes in 2000, representing an increase of over 100% (Zambia Development Agency, 2019). In 2018, the copper produced was 861,946 tonnes (Zambia Chamber of Mines, 2019). The increase in copper production over the past years, implies an increase in land clearance for open pit development which is an environmental concern. Figure 1.1 shows copper production trend in Zambia from 2000 to 2018.

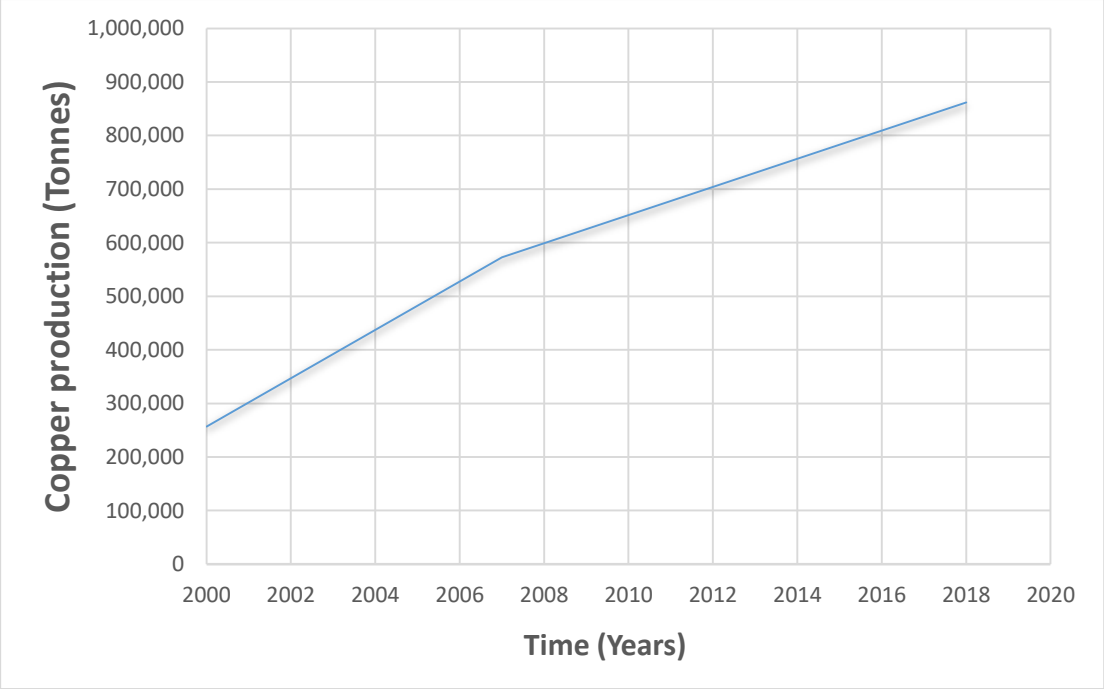

Figure 2.1: Copper production in Zambia from 2000 to 2018 (Zambia Development Agency, 2019; Zambia Chamber of Mines, 2019)

There are currently several open-pit and underground mines in the Copperbelt and North-Western Provinces of Zambia (see Figure 1.2). Some of the large-scale open-pit mines include Nchanga, Kansanshi, Lumwana and Kalumbila and the underground mines include Nchanga, Konkola, Mufulira and Nkana. Since minerals are a non-renewable resource, these mines create massive voids on the surface of the earth (see Figure 1.3). Thus, progressive rehabilitation and proper mine closure plans need to be implemented for the land to be reused for alternative purposes.

Figure 2.2: Open pit and underground mines in Copperbelt province and North Western province (Source: northernminer.com)

Figure 2.3: Nchanga Open Pit Mine (Source: DW.com)

"Mine closure is the period of time when the ore-extracting activities of a mine have ceased, and final decommissioning and mine reclamation are being completed. It is generally associated with reduced employment levels, which can have a significant negative impact on local economies." (Wikipedia, 2022). Mine closure has increasingly become a topic of focus for many countries in both the developed and developing worlds. Emphasis is now being placed on thinking about mine closure at the initial design stages of a mining project, and with increased focus on stakeholder engagement and participation in mine planning throughout the entire life of the mine. Fourie and Brent (2006) suggest that the rehabilitation process must meet the end requirements of the stakeholder groups for its objectives to be achieved. Companies need to begin looking at progressive mine closure which is the closing down of sections of the mine that have been exhausted while mining operations go on in other areas. This could work particularly well if progressive mining is integrated into a Project-based Mine Closure Model (MCM). This will allow for resources to be allocated to and utilized for closure during mining operations (Fourie and Brent, 2006).

1.2 Study area

1.2.1 Location

Chingola is a mining town on the North-Western end of Copperbelt Province of Zambia. The town lies approximately 450 km North West of Lusaka, Zambia's Capital and 51 km West of Kitwe. It lies on a latitude of 12 degrees 20 minutes South and Longitude 27 degrees 50 minutes east (PorterGeo, 2014).

1.2.2 Physical characteristics of study area

1. Climate

Chingola is generally at an elevation of 1300 meters above sea level and like the rest of Zambia enjoys two distinct seasons, the wet season (November to April) and dry season (May to October). Average rainfall ranges between 750mm to 1250mm and the temperatures, dependent season range between 6 degrees Celsius to 35 degrees Celsius (Zambia Tourism, 2019).

2. Geology

Chingola lies on the South Eastern arm of the Neoproterozoic Lufilian arc which hosts the Zambian Copperbelt mineral deposits inclusive of the Nchanga deposit. The stratigraphy of Nchanga is within the Katanga Super group with the Nchanga red granite intrusion overlain by the Lower Roan clastics and Upper Roan dolomites which contain the two major concentrations of ore. This mineralization is sediment hosted copper-cobalt mineralization including both sulphides and oxides (PorterGeo, 2014).

3. Soils and vegetation

The soils in the study area are mainly loamy-clay subsoils overlain by a sandy topsoil, these soils are generally acidic and easily leached, usually due to the high rainfall in the area. The prominent vegetation on these soils is Miombo woodlands characterized by trees that shed leaves during the dry season and produce new leaves at the onset of the wet season (Konkola Copper Mines, 2019).

4. Socio-economic characteristics

As at the 2010 census, the population of Chingola stood at 216,626 (Zamstats, 2012). The town grew from its establishment in 1943, nearly a decade after mining started, due to the growing mining activities in the area. With the increase in population came the sprouting of other economic activities including agriculture and retail trading which to date sustain the livelihoods of the population. The town also includes schools, clinics and recreational facilities among other social amenities (Konkola Copper Mines, 2021).

5. Mining operations at Nchanga mine

The mining methods at Nchanga mine consists of both underground and open pit operations. The ore body was discovered in 1923 at the time, however underground mining only started over a decade later due to the low prices of copper. Open pit mining commenced much later in the late 1950's, first with the main pit which is currently over 400m deep and subsequently with nine satellite pits totalling over 30km² of excavated area. Besides the underground and open pit mines, Nchanga mine has a processing plant which consists of the East mill, West mill, Tailing's leach plant and a smelter (Figure 1.4). It is at the mills that the mineral containing

rock (ore) is reduced in size by crushing and grinding/milling for extraction of the minerals to produce copper cathodes at the electro winning section (Konkola Copper Mines, 2020).

Figure 2.4: Nchanga Mine Smelter

Nchanga Open Pit (NOP) mine was owned by the state after nationalization in 1971 but over the years changed ownership from state-owned to private-owned. During the privatization era of the 1990's, Anglo American Corporation which was later known as Nchanga Consolidated Copper Mines (NCCM) took over operations at Nchanga, Nkana and Konkola copper mines. Vedanta Resources then took over from 2004 to 2020. Through the years, billions of US Dollars have been invested in the mine to improve operations, environmental footprint and safety standards and substantially increase in Research and Development to increase the life of mine through exploration which is currently at 15 years (Konkola Copper Mines, 2020).

1.3 Problem statement

Large scale open pit mines cause serious social-economic and environmental challenges if not closed properly. With the increase in exploration activities around Zambia, many mines are yet to be established and more ecosystems disturbed. Solving the issue of mine closure to make it more environmentally friendly will have positive domino effects and help tackle social-economic problems that would arise later like hunger due to degraded land, infertile lands and unsafe drinking water. Integration of mine closure practices into the life cycle of the mines will not only limit the extent of ecological disturbance but also manage the costs of closure as

opposed to at the end of mining. A legal framework exists through the Environmental Protection Fund to regulate mine closure and rehabilitation practices in Zambia. However, since its implementation, no reviews have been carried out to determine its effectiveness.

1.4 Research questions

(i) What is the extent of environmental damage at Nchanga Open Pit due to mining activities?

(ii) What are the main objectives of the Nchanga Open Pit's mine closure plan and how are they being achieved?

(iii) To what extent is the closure plan being incorporated into the life cycle of the mine?

(iv) What are the benefits of incorporating closure plans and progressive rehabilitation into the life cycle of the Nchanga Open Pit?

(v) What recommendations, on incorporating closure plans and progressive rehabilitation, will be beneficial for the open pit mines?

1.5 Study objectives

1.5.1 Main objective

To assess the extent to which Nchanga Open Pit Mine incorporates mine closure and continuous rehabilitation plans throughout the life of the mine and to identify its shortcomings and provide recommendations for improvement.

1.5.2 Sub-objectives

The following are the sub-objectives;

a) To determine the key socio-economic and environmental impacts due to mining activities at Nchanga Open Pit Mine.
b) To investigate the extent to which mine closure plans and rehabilitation are being incorporated into the mine life cycle of Nchanga Open Pit Mine.

c) To evaluate the benefits of incorporating mine closure and rehabilitation plans into the mine life cycle of large-scale open pit mines.

d) To identify the shortcomings of the current closure and rehabilitation practices and make recommendations for improvements.

1.6 Methodology

The study period spanned over eight months from November 2020 to July 2021. During this period, a site visit to Nchanga Open Pit Mine was undertaken where interviews were carried out and a tour of the mine was taken. Questionnaires were distributed within the town of Chingola and interviews were carried out with stakeholders from various institutions. Secondary data was collected from online libraries which was used to supplement the primary data collected.

1.7 Significance of the study

Poor mine closure practices in developing countries are of growing concern as most mines are partially or completely abandoned at closure (World Bank and International Finance Corporation, 2002). This is because they do not carry out progressive rehabilitation and incorporate closure plans into the life cycle of a mine. Incorporating such practices throughout the life of mine will ensure that the mine is properly closed and does not incur heavy costs upon closure making it environmentally and socio-economically sustainable. This has been observed for mines in developed countries such as Canada and Australia. A review of the current practices is necessary to identify the gaps. This is to inform policy makers and mining companies on the need to review legal frameworks and to incorporate sustainable mining practices.

1.8 Thesis structure

The following is the structure of the thesis:

Chapter one introduces the research topic by describing the background of the study and identifying the problem statement. It further highlights the study area, key research questions and the objectives of the study which are to be achieved through the outlined methodology.

Chapter two provides a literature review and theoretical background to the research. It gives a brief overview of the mine closure practices in Zambia, and other developing and developed countries. The review outlines the environmental and socio-economic effects of poor closure practices and possible mitigation measures to the negative effects. The nature of the research is in line with achieving the sustainable development goals and hence relevance to these is explained in the chapter.

Chapter three gives the overall methodology and the step by step procedures used to achieve the research objectives. The study population, study sample, data collection and analysis instruments and techniques are described in this chapter.

Chapter four presents the research findings of this study. The chapter presents the research findings of the data collected and analysed from Nchanga Open Pit Mine, key stakeholders, and surrounding communities. The chapter also provides findings of desk studies to establish the international practices of mine closure and rehabilitation in Zambia, Western Australia, South Africa and Chile.

Chapter five provides the conclusions drawn from the study based on the data analysis and findings of chapters four and five. These conclusions were used to deduce relevant recommendations for implementation.

1.9 Summary

The first chapter introduced the research, including the background of the study, the study area and demographics, the objectives of the research and the methodology used. The study was necessary to establish the status quo of the current rehabilitation and mine closure practices in Zambia. The chapter also provided a summary of the layout of the thesis. The next chapter provides a detailed review of literature on the socio-economic and environmental impacts of large scale mining and the local and international practices of rehabilitation and mine closure.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Mine closure planning is a relatively new development concept that begun in the 1970's and progressive rehabilitation followed much later (Mulvey et al. in March, 2017). Mine closure is a phenomenon inevitable to all mines across the globe. This closure can occur abruptly due to social, economic, political or technical circumstances. It can also be predicted with the depletion of a mineral resource overtime by using the life of mine (Inter Governmental Forum on Mining, Minerals, Metals and Sustainable Development, 2019). "In the minerals sector, it has become almost an edict that mine closure planning must start from mine inception and the plan must be reviewed and updated throughout the entire life-of-mine" (March, 2017). Prior to this, the norm was for mines to begin implementing their closure plans after operations cease. The principles of mine closure planning are a step by step approach which incorporate progressive rehabilitation. This is guided by laws and regulatory frameworks of a country. Despite this, factors surrounding these principles are international and work best for new and developing mines (March, 2017).

Mine rehabilitation is part of the mine's obligation to the surrounding community. It is essential in mining operations and should not be considered secondary to production (Edraki, 2018). Planning for closure provides opportunities for the surrounding community to have post mine land use through ecologically sustainable rehabilitation (Blommerde et al., 2015). Therefore, production and rehabilitation should be integrated and be of equal importance. Even though mine closure practices are agreed to be essential for operations of a mine, there have been no internationally agreed multilateral and bilateral agreements through organizations such as the United Nations or Commonwealth (Blommerde et al., 2015). Decisions pertaining to closure practices are informed mainly by the mining companies in both the developed and developing world (March, 2017).

Mine closure practices have evolved with progressive discussions on environmental protection around the world. Today, public law that is regulating these practices is based on international treaties, agreements and customs that usually arose in cases of post environmental damage. The United Nations General Assembly has made several declarations and agreements which have resulted into all nations' environmental law aligning to the environmental law principles which are: (Soto, 1996)

1. Sovereignty and responsibility
2. Good neighbourliness and international cooperation
3. Preventive action
4. Precautionary principle
5. Duty to compensate for harm
6. Common but differentiated responsibility
7. Principle of sustained development.

Countries with mining activity have rendered it imperative to have legislation regulating the mine closure process for all types of mines that is, surface and underground operations. This type of law has been amended regularly to cover all aspects of mine closure to ensure that the integrity of the environment is returned to its former condition or rehabilitated to promote environmental health and prosperity (Soto, 1996).

2.2 Mine closure practices in the developed world

2.2.1 Background

As earlier stated, mine closure is inevitable in all areas of the world including developed countries. Australia is an example of a developed country that has a large number of abandoned and closed down mines (Australian Government, 2006). In developed countries, closure practices are relatively well established with adequate frameworks and regulations (March, 2017). They have national policies and legislature with a broad coverage which impact both directly and indirectly on mine closures (Clark and Clark, 2005). In North America, Canada and Australia, for example, a prerequisite to mining permit is a detailed closure plan and environmental impact assessment that is done with the community and includes both the social and environmental aspects. Despite this, "the responsibility for the enactment, implementation,

monitoring and for ensuring compliance of specific mine closure policy and legislation is largely, if not exclusively, the responsibility of the subordinate levels of government" (Clark and Clark, 2005).

In central and eastern Europe, the World Bank has provided financial aid over the past ten years to mining companies that are undertaking mine closure and restructuring. This aid was provided through governments by offering large loans and credits to finance the mitigation of both environmental and social effects (World Bank and International Finance Corporation, 2002). This has given the developed countries head start in sustainable mine closures.

2.2.2 Mine closure practices in Western Australia

Mine closure practice in Western Australia has been configured and amended regularly to promote the best sustainable reform for the environment after an activity as intense as mining. The Department of Minerals and Petroleum (DMP) oversees the regulation of all mining and mining-related activities, and with the emergence of the need for good mine practice, the Environmental Protection Authority (EPA) presides over the regulation of all environmental practices and oversees the Environmental Impact Assessments (EIA) in accordance with the provisions of the Environmental Protection Act of 1986 (Department of Mines and Petroleum and Environmental Protection Authority, 2011).

(i) Mining law

The Mining Act of 1978 contained a provision for mining companies to repair any damage caused to the environment, however, in 2010 an amendment was made to the Act, and it mandated mining companies to submit a Mine Closure Plan to the DMP as a part of the process in the mining proposal application. This plan is to be reviewed every three years after a license to mine is granted.

The Mining Act, in section 700, defines the mine closure plan as a "document that contains information about the decommissioning of each proposed mine, and the rehabilitation of the land for which a mining lease is sought or granted. It also establishes that these documents must be in the form required by guidelines approved by the Director General of Mines". Mine closure plan guidelines have been jointly prepared and published by DMP and EPA. The mine closure

plan guidelines state that: 'the Government's broad closure objectives are (physically) safe to humans and animals, (geo-technically) stable, (geo-chemically) non-polluting, and capable of sustaining an agreed post-mining land use' (Department of Mines and Petroleum and Environmental Protection Authority, 2011) and that the 'EPA's primary objective is to ensure that the mine is capable of being closed in an ecological sustainable manner' (Department of Mines and Petroleum and Environmental Protection Authority, 2011). They also state that the EPA will generally not assess mine closure as part of its EIA of mining proposals under the EPA Act when they are subject to the Mining Act. The EPA will only do so where high environmental risk is identified to minimise regulatory duplication. "The guidelines indicate that where the EPA does assess mine closure and sets a corresponding environmental approval condition, compliance monitoring of these may be delegated to DMP" (Morrison-Saunders & Pope, 2013). The mine closure plan must also include a part on the financial requirements for the complete closure of the mine, and the company must ensure that these funds are available at the time of closure and must not leave the community with an "unacceptable liability" (Department of Mines and Petroleum and Environmental Protection Authority, 2011).

A system to assure authorities of a company's commitment to mine rehabilitation was put into practice in 1985. In this system, all holders of mining licenses were required to provide bonds of an amount stated and approved by the Minister of Mines, as security to ensure that they met their obligations to mine closure, rehabilitation, and environmental sustenance. If a company abandoned a mine without full rehabilitation, the Ministry would then take over in the rehabilitation process and it would be funded by the bond. However, in 2013 the DMP argued that the bond amount did not reflect the true cost of rehabilitation and increasing the amount on the bond might end up constraining the mining company's investment capacity. The Mining Rehabilitation Fund Act of 2012 gives the provision that a 1% contribution levy based on the rehabilitation liability estimate per mining tenement is to be paid annually into the fund. The interest earned on the money is accrued within the fund and would be used to fund rehabilitation of abandoned mine sites. The interest gained would be used on legacy abandoned sites that pre-date the establishment of the fund, while the capital amount would be used to rehabilitate mine sites that the fund is based on.

In 2020, the Department of Mines in Western Australia introduced Statutory Guidelines on mine closure plans which superseded those of the 2015 Guidelines for Mine Closure Plans. This followed an outcry from the mining industry on the ambiguity of certain statements in the guidelines. The new changes are: Small-scale mines are explicitly referenced in the guidelines, inclusion of latest information on environmental protection and risk assessment, and the submission of mining proposals can include specific activities and the risk assessments, environmental outcomes, and management strategies to be applied to these activities (Government of Western Australia, 2020).

The amendments of old legislature and the creation of new regulations and/or provisions is preceded by extensive discussions among the Western Australian government, non-governmental organizations, communities, and any other relevant stakeholders.

(ii) Current state of affairs

Kragt and Manero (2021) published a report on a survey undertaken in 2018 to examine industry practice, existing barriers, and opportunities to produce viable mine closure criteria that would be satisfactory to the stakeholders in this process. The survey data set consisted of seventy-five (75) respondents who included forty-one (41) mining companies, eighteen (18) consulting businesses, and sixteen (16) government agencies in Western Australia. During the development of the closure criteria, mining companies and consulting business said they mostly engage landholders, traditional owners, local governments, and NGO's; while government agencies said half of the time, they do not engage anyone in the development of the closure criteria and the rest of the time, landholders, traditional owners, and local governments may be engaged. The information used to develop mine closure plans is mostly based on guidelines for mine closure practice, the rehabilitation team's knowledge, and mine closure plans previously used by the company from another company. The status on access to sufficient resources saw mining companies responding with the highest at 71%, followed by consulting businesses at 41% and government agencies at 14%.

The whole of Australia has an estimated 60,000 abandoned mine sites with some dating back as early as the 1800s (Callari, 2020). In Western Australia alone, 188,796 hectares of land are disturbed with only 41, 535 hectares being under rehabilitation. The Government of Western

Australia established an abandoned mine sites programme from 1st July 2019 to 30th June 2020 alongside the Mining Rehabilitation Fund (MRF - enacted in 2012), with activities being reported annually. The rehabilitation work being done through the MRF has been consistent with the mining works being done in the state. For the period 2019-2020, 3,400 ha were added to 38,135 hectares of land under rehabilitation, while 9,600 hectares were added to the 137,596 hectares currently under disturbance due to mining operations. To date, no mining company has successfully closed and rehabilitated a mine site without the post-intervention of state authorities. The 2020 MRF yearly report states that the compliance to reporting of disturbance and rehabilitation data on mining operations was at 99.1% among all mining operators with the levy contributions to the Fund for the 2019-2020 period being AU$ 33.72 million, bringing the total reported contributions to AU$ 207.3 million since 2014. This is a trend that has been steadily increasing for the past seven (7) years (Government of Western Australia, 2020).

2.3 Mine closure practices in developing world

2.3.1 Background

Mining is an important activity for a developing country as it contributes to the growth of the country and the region. As with developed countries, mines are bound to wind down operations for various reasons. However, one challenge faced by most developing countries is that mining laws, regulations and policies are not robust and further to this, are not fully implemented and enforced (Lottermoser in Fourie and Tibbett, 2012). Because of this, large mining companies located in rapidly growing mining regions of Africa and Asia mine operate without closure plans and rehabilitation practices. This is because they are not mandatory and therefore less likely to occur (Fourie and Tibbett, 2012).

2.3.2 Mine closure practices in Zambia

Mining in Zambia began in the early 1900's with the first mining operations being established in the Zambian Copperbelt. Lead and zinc deposits were first discovered in Kabwe in 1902 after which mining commenced four years later. "The modern history of the Copperbelt began in 1923 when exclusive prospecting concessions were granted to the Anglo-American Corporation for the 3000 square kilometer Rhokana Concession, and to Roan Selection Trust (RST) for the 80 000 square kilometer Rhodesia Congo Border Concession" (ZCCM-IH, 2020).

In 1970, during the first Government of the Republic of Zambia, 51% stake was acquired by the government in the Anglo-American Corporation and the Roan Selection Trust and merged the two as Zambia Consolidated Copper Mines Limited. However, there were challenges in the operations of the mines and when the Government changed, in the 1990's, majority stake of the state-owned mines was sold to private entities. The Zambian Government kept minority stake which to date it holds through Zambia Consolidated Copper Mines Investments Holding Company (ZCCM-IH) (ZCCM-IH, 2020).

(i) Mining law

In Zambia, policies and regulations exist to guide the operations of the mining sector. The Mines and Minerals Development Act of 2015 is the main legislature guiding the operations of mines in Zambia. Section 86 of the Mines and Minerals Development Act of 2015 highlights the Environmental Protection Fund of which a framework exists through Statutory Instrument 102 of 1998 on the management of the fund. Statutory Instrument 29 of 1997 in Part VIII gives detail on the implementation of this framework during mining operations. The statutory instrument states that all mines in Zambia should have a closure plan and contribute to a rehabilitation fund. This is to ensure mines are closed sustainably with minimal socio-economic and environmental impacts. Zambia being one of Africa's largest producers of copper and cobalt has a number of large-scale open pit mines located in the Copperbelt and North-western provinces that are prone to being affected by poor closure and rehabilitation practices. Some of these mines include Nchanga, Kansanshi, Lumwana and Kalumbila where towns have been built around the mining activities. These mines and others around the country have a legacy of environmental liabilities due to poor management. "Seventy years of mining operations, no formal mine closures, and a lack of concurrent rehabilitation of mining sites has resulted in a massive "environmental mortgage" resulting in ongoing environmental health liabilities and exposures to the local communities" (Ministry of Mines and Minerals Development, 2019).

The three main pieces of legislature reviewed for this research were the 'The Mines and Minerals Development Act, 2015', 'The Mines and Minerals (Environmental) Regulations (Statutory Instrument 29 of 1997)' and 'The Mines and Minerals (Environmental Protection Fund) Regulations (Statutory Instrument 102 of 1998)'. The Mines and Mineral Act, Cap 213

(MMA) is the principal piece of legislation governing the mining sector in Zambia. Its primary objectives are to maximise mineral sector investment and returns and minimise the environmental harm caused by mining. It was first established in 1995 after which it was amended in 1997 and 2015. The Act is currently under review and submissions have been received from various stakeholders. The Mines and Environmental regulations guide the operations of the mine in terms of environmental management at the onset of mining. Environmental regulations (Statutory Instrument 29 of 1997) in section 5(1) and 5(2) compel developers to submit Environmental Impact Statements (EIS) which should contain an environmental management plan, a plan for rehabilitation and management and the estimated cost of protecting the environment. However, no regulation speaks explicitly to the updating of mine closure plans throughout operations for post closure preparedness. It is within the aforementioned pieces of legislature that the aspect of continuous rehabilitation and mine closure through the establishment and management of an Environmental Protection Fund (EPF) is embedded.

An Environmental Protection Fund (EPF) is a sum of money that is collected from mining organizations and managed by the Government for the purpose of rehabilitating the mines post closure should these organizations fail to meet their post closure obligations. It is used as an assurance by the Government that the mining companies will rehabilitate after closure after which they will be refunded their money. The EPF was introduced in the Mines and Minerals Act of 1995 (amended in 1997) and the Statutory Instrument (SI)102 was instituted by the Government of the Republic of Zambia (1998) but was only operationalised in 2008, a decade later. The SI gives a detailed approach on how this fund is to be managed and by whom.

Environmental Regulations (Statutory Instrument 29 of 1997) in the eleventh schedule outline three performance categories in which a mine can be placed based on its environmental performance that is established during audits, however the frequency of these is not specified in the laws and regulations. Categorisation is based on the compliance to statutory obligations and is awarded by the Mines Safety Department under the Ministry of Mines and Minerals Development to promote responsible environmental management as stated in the submitted Environmental Impact Assessment (EIA). The three categories are as listed:

1. “Category 3 Awarded: 80%
    - For an approved EIA or Project Brief
    - Where all discharges are or will be permitted or licensed
    - Where a stable post land-use profile is possible
    - Where water management systems are in place

2. Category 2 Awarded: 90%
    - For financial capability to complete rehabilitation
    - Where rehabilitation materials are in place for complete rehabilitation
    - Where developer holds an approved EIA or Project Brief
    - Where annual environmental targets have been developed

3. Category 1 Awarded: 95%
    - For progressive rehabilitation carried out
    - Where rehabilitation has been properly monitored
    - Where annual environmental targets have been met
    - Where Environmental Management and Rehabilitation Plans have been validated by audit.” (Government of the Republic of Zambia, 1998).

An Environmental Audit Report compiled by a third party accredited by the Government certifies that the approved EIA commitments and environmental management and rehabilitation obligations are being complied with or not and report on any impact on the environment and is used for categorisation. After review and validation of the third-party audit, categorisation is done, and a demand notice is raised. Based on the category, mining firms contribute the percentage remainder of the category award i.e., 20%, 10% and 5% for category 3, 2 and 1 respectively. Companies in category 2 and 3 can be upgraded and contributions to the EPF can be reduced if the prescribed performance criteria are achieved. If the mine is contributing for the first time, then the closure cost is split over a 5-year period.

All fund contributions are calculated on final closure costs and exclude any rehabilitation costs, this being dependent on the performance of each developer. The mine closure cost is computed by calculating the quantum closure cost estimates using the master rates that have been provided for in a document called ‘Procedure for Quantum of Mine Closure Related Cost Estimates’.

The remainder of the closure cost is secured by the company as a bank guarantee or bond from approved banks and certified by the Bank of Zambia. This is in order to minimise the risk to fund the closure costs at the end of operations as is provided for under Cap 213, section 82 (1) and SI 102 of 1998 Regulation 1 (b). Notwithstanding, an interview with the Ministry of Mines and Minerals Development Mine Safety Department, revealed that Mining Companies do not acquire these bonds and guarantees because local banks do not have the capacity to provide for the huge financial obligation.

2.3.3 Mine closure practices in South Africa

Watson and Olalde (2019) explained the practices and regulations that surround mine closure in South Africa highlighting that for an entity to prospect, explore and extract a mineral resource, the Minerals and Petroleum Resources Development Act (MPRDA) requires one to apply for a prospecting right, mining right or mining permit. This application is to be partnered with an application for an environmental authorisation that contains the submission of an environmental assessment, environmental management plan, mine closure plan, and sufficient financial provision for rehabilitation and closure. The MPRDA requires that the mining company assesses the financial provision for mine closure on an annual basis and submit an audit report on whether it is adequate or not. The intrinsic impacts of mining activity on the environment are also supposed to be identified and analysed with the preparation of a complete annual rehabilitation plan. The environment is to be rehabilitated to its previous condition or an agreed standard in a practical and cost-efficient manner.

(i) Mining law

The Minerals Act of 1991 introduced closure planning as a requirement for mines in South Africa (Dixon, 2003) and there has been legal reform to this Act to continually account for all aspects of mine closure and environmental protection. A mining company must submit an Environmental Management Programme (EMP) with a plan for rehabilitation and apply for a closure certificate. This process is superintended by the Department of Mineral Resources (DMR) through the Minerals and Petroleum Resources Development Act (MPRDA) and the National Environmental Management Act (NEMA).

The closure certificate is issued by the DMR and the process to obtain one involves meeting the required legislation set forth by the MPRDA and NEMA. “In terms of the MPRDA an application should be made to the Regional Manager and must be accompanied by a final rehabilitation, decommissioning, and mine closure plan, an environmental risk report, and a performance assessment of the closure plan. This should be done within 180 days of the end of mining or prospecting activities.” (Watson and Olalde, 2019).

The NEMA regulations state that an environmental authorisation involving a simple assessment should be obtained, as well as an environmental audit of the closure plan and EMP, should be submitted. “A closure certificate will be issued only if the Chief Inspector of Mines (responsible for health and safety) and other relevant government departments (particularly Water and Sanitation and Environmental Affairs) have confirmed in writing that the provisions pertaining to health and safety and management regarding pollution of water resources, the pumping and treatment of extraneous water, and compliance with the conditions of the environmental authorisation have been addressed. These authorities have 60 days in which to respond” (Watson and Olalde, 2019).

More recently in South Africa, NEMA has introduced the concept of perpetual liability (Alberts et al., 2016). This concept has allowed for the responsibility of environmental harm to be attributed to the mining company notwithstanding the issuing of a closure certificate by the Ministry assigned to manage the state’s mineral resources. A portion of the financial provision is given to the Minister in charge of the mineral resources. In South Africa there are several mines on “care and maintenance due to their inability to secure a government-issued closure certificate” (Watson and Olalde, 2019).

(ii) Current state of affairs

Krause and Snyman (2019) reported that the success rate of mines’ EMPs has been quite low due to the “inconsistency in the quality of EMPs and their rehabilitation plans (especially regarding water quality)”. Due to the inadequacies in the plans in which the financial provisions are formed, there has been insufficient financial provisions for mine rehabilitation. In 2009, the Auditor General’s report estimated that there were 5906 abandoned mines in South Africa giving rise to about six billion tonnes of mine wastewater (Schuchova and Lenart, 2020), a state

that has caused extensive damage to the country's natural resources and population leading to environmental and health issues.

2.3.4 Mine closure practices in Chile

The history of mining activity in Chile spans about 520 years where the targeted minerals have included copper, gold, lithium, silver, molybdenum, and offshore phosphorite deposits (Garcia, et al., 2020). Mining activity in the country is regulated by the Constitution and codes and regulations set forth by the Ministry of Mining, National Geology and Mining Service (locally known as Sernageomin), and the Mining Safety Regulation (Bertrand-Galindo, et al., 2021). These bodies are also in charge of monitoring the adherence to the set laws, codes, and regulations.

(i) Mining law

The 1983 Mining Law of Chile, one of the world's largest mineral producing countries did not contain the word environment nor did it have any provisions for reclamation, rehabilitation or mine closure (Clark and Clark, 2005). "Chile has, however, recently moved to deal with these issues under its environmental policy and legislation. In the majority of the older mining laws, issues pertaining to mine closure are dealt with in only the most general terms" (Clark and Clark, 2005).

The assessment of mine closure practices in Chile only started in 1994 with the Law of Environmental Bases. This law institutes the right of all citizens to live in a pollution-free environment that is perpetuated by protection, mitigation, and conservation measures (Graham Research Institute on Climate Change and the Environment, 2021). The law also requires that all the phases of mine closure be assessed as well as setting prevention and compensation measures for the environmental impact of mining activity (Curotto, 2019).

In the subsequent decade, the Sernageomin assessed and identified 461 environmental liabilities that were the result of abandoned mining ventures (Sanzana, et al., 2016). In 2004 the Mining Safety Regulation introduced the requirement of a mandatory closure plan stating measures related to the safety of the mine's facilities and obligations for the closure of tailings deposits. The Chilean government simultaneously instituted the reform of regulatory bodies and

developed new legislation to provide exhaustive control in every aspect of the mine closure process.

In November 2012, the Mine Closure Law, Statute 20.551 was enacted and led to an increase in the requirements for mine closure such as that all mining sites must have an approved closure plan before the start of operations, and mining companies must continuously assess the physical and chemical stability of their operations. The closure plan must state the mine's features, a risk evaluation, sometimes drawn from the Environmental Impact Assessment (EIA), and the commitments to environmental rehabilitation at all stages. The Sernageomin developed a framework with guidelines (Figure 2.1) for developing closure plans in collaboration with mining companies for a period of two years, and it saw the submission of plans from 140 companies representing about 90% of its target (Sanzana, et al., 2016).

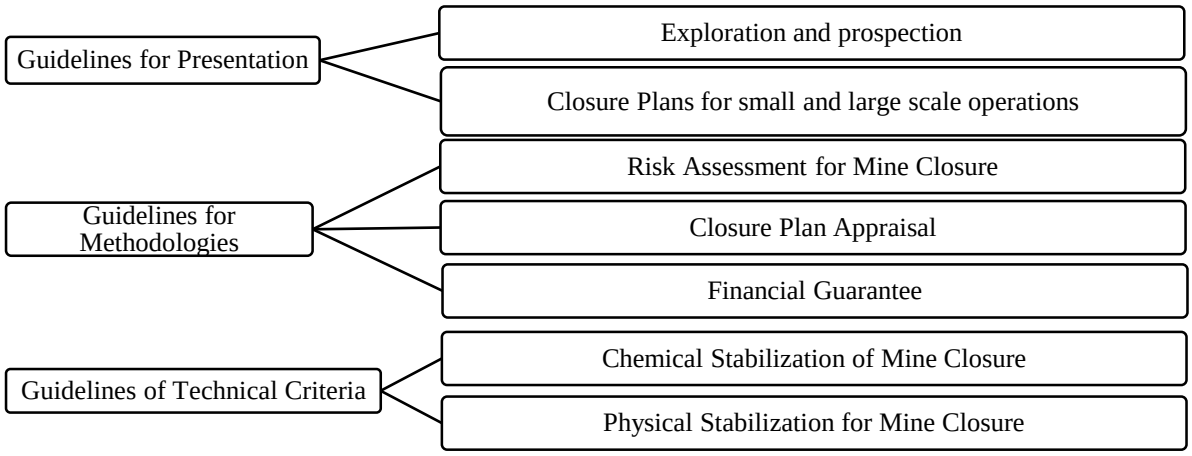

Figure 2.1: Guidelines for mine closure plans (Source: Sanzana, et al., 2016)

According to the statute regulating mine closure (Law 20.551), financial instruments to support the implementation of the closure plan are to be established from the onset of mining operations. These instruments are connected to a post-closure fund for the maintenance of closed mines by the state in case the mining company fails to execute the closure successfully.

(ii) Current state of affairs

The present regulatory laws and policies in Chile have adequately managed to mobilize the modes of operation in the mining industry and protect the environment after the cessation of

mining activity. Some challenges that have arisen in the implementation of the mine closure law is the clear description of a "Competent Person" that determines the life of the mine, guidelines of defined closure costs, and lack of competency among authorized government personnel. The SERNAGEOMIN reported in 2015 (Sanzana, et al., 2016) that the ineptitude of industry players in effectively applying the guidelines has been due to the following:

1. Incorrect application or lack of consideration of the guidelines.
2. Lack of rigorousness in identifying closure commitments.
3. Excess of international costs without detail or justification.
4. Excess of copying, lack of supervision, and involvement of consultants.

The socio-economic aspect of operating a mine in an area inhabited by people and the impacts of this on the communities has not been adequately addressed in the current regulations (Curotto, 2019). The management of stakeholders and direct or indirect employees is dependent on the mining company's policies and guidelines.

2.4 Environmental effects of poor closure practices

Environmental impacts of mining can prevail for hundreds of years after mining operations cease (Environmental Law Alliance Worldwide, 2010) entailing degradation of land fertility and original topography if not properly managed. Environmental impact of mines that are non-operational is one of the biggest concerns in the mining industry. "They may be transient (often acute, associated with accidental discharges or explosions), temporary (only during operational activities) or chronic (long-term, arising from mineral extraction and waste disposal)" (Singh and Singh, 2016). Some of the impacts may include poor water and air quality, land disturbance, waste generation and environmental pollution and biodiversity loss (Singh and Singh, 2016). Open pit mines are mines which require the stripping of overburden rock to expose the ore. Trees and natural vegetation are cut down to prepare the land for the overburden removal. This makes open pit mining one of the most environmentally destructive types of mining. Once the overburden is removed, it is dumped, causing heaps of waste rock on the surface of the earth. These waste materials are usually in very large volumes and may contain toxic and hazardous substances. If released into the environment, they may cause both water and land pollution (Environmental Law Alliance Worldwide, 2010). The other source of dumped material on or around the mine site is the extraction step of ore. The waste from the process plant called tailings

are stored in tailings dams. These tailings may contain traces of toxic chemicals which may seep and contaminate ground water or leak to the surrounding environment through dam failures. Processed tailings certified as non-toxic that are released into the natural drainage systems may begin to silt the rivers and lakes causing them to become shallow through sediment loading thereby disturbing the natural habitats of marine life. Heaps of dumped waste rock and tailings during operations and after closure cause the change to the natural topography and terrain of the environment as well as changing the natural pH of the soils. If the lands are not revegetated and rehabilitated, they will continue to erode by both water and wind causing acid mine drainage and air pollution. With continued erosion, the heaps may weaken causing landslides to occur posing a threat to the surrounding communities (Broemmea et al., 2015). Poor practices leading to the pollution of both land and water have resulted in the negative impact on plants, animals as well as human beings.

2.5 Socio-economic effects of poor mine closure

Mining has existed since the onset of human communities and has contributed vastly to the economies and civilization of modern society (Singh and Singh, 2016). This has resulted in increased infrastructure, employment and entrepreneurial opportunities. Therefore, the local communities and economies are largely dependent on mining. Despite the positive development mining has brought, there are a number of negative impacts which include human displacement and resettlement, socio-political conflicts and loss of livelihood and ecosystem services due to displacement. These impacts occur throughout mining and even after closure if no deliberate action is made to mitigate them. According to March (2017) there is a gap in research on how to handle socio-economic impacts of mine closure. It is however known that the greatest socio-economic impact of poor mine closure is loss of employment. Mining towns that are solely reliant on production to keep the economy going tend to collapse when mining ceases (March, 2017).

Australia is an example of a country known to have a lot of ‘ghost towns’ due to the shutting down of mining operations (Australian Government, 2006). When this happens, all direct, indirect and induced jobs are lost. Businesses that used to supply the mines and others that relied on sales from mine employees begin to fail as there is no source of income. People begin to leave the place in search of a livelihood to sustain themselves leaving the town desolate.

Security becomes an issue in the area as abandoned houses begin to be occupied by illegal inhabitants while others are stripped for metal and other salvageable materials causing damage to infrastructure.

Mines in Zambia have taken into account to some extent, the environmental impacts of mine closure. A gap in literature exists on how towns that are built around mines can effectively sustain themselves and prepare for post closure. Reference can be made to Kabwe where "the closed, but unrehabilitated, Kabwe lead zinc mine and smelter in Zambia led to unemployment in the town of Kabwe reaching epic proportions" (Limpitlaw, 2004). The focus on mine closure should not be inclined to only the environmental rehabilitation but to the social and economic impacts as well (Ackerman et al., 2018). "Studies indicated a strong relationship between unemployment, emotional issues, and health problems such as hypertension, insomnia and psychological maladies like depression and feelings of uncertainty" (Ackerman et al., 2018).

2.6 Mitigating negative environmental and socio-economic effects

To mitigate the negative effects of mine closure, companies should take an integrated closure approach. This should include the social, economic and environmental liabilities it would cause. The following are examples of some tools and methods to mitigate the effects of poor mine closure practices:

(i) Environmental Impact Assessment (EIA) is a document drafted before mining begins that is a product of a thorough research of the area. Investigations are carried out to assess the impact that a mine will have on the environment and surrounding communities, both in the long and short term. The main purpose of the document is to inform decision making based on the environmental and social impacts of the mine operations. This tool is essential as it can be used to prepare mine closure plans that will be able to counter-act the impacts through an informed mine closure (Singh and Singh, 2016).

(ii) Site specific closure and rehabilitation is an ongoing process that ideally should occur throughout the life of mine. It entails closing down sections of a mine as operations go on to reduce not only the cost but environmental impacts as well. As mining progresses, sections that are no longer in use are closed down, decommissioned and rehabilitated to resemble the original state of the environment (Fourie and Brent, 2006).

(iii) Socio-economic development and conservation of biodiversity tackling both the socio-economic and environmental issues. This entails coming up with programmes and projects to empower the community that will minimise the environmental footprint. An example would be educating people on the natural vegetation that reduce soil toxicity. Planting suitable trees will not only increase the soil fertility but conserve the biodiversity. These projects will therefore provide a basis of livelihood for the people and equip them with skills and knowledge of environmental protection (Ackerman et al., 2018).

(iv) Corporate Social Responsibility (CSR) is another tool that mines can use to mitigate their negative impacts and plan for closure. Mines use this as a means to "justify their performance through the disclosure of social and environmental information" (Singh and Singh, 2016). However, focusing on equipping the community with skills and creating a shared value can help prepare the people for post mine closure. This approach can be more beneficial if it is centered on environmental issues to have a more holistic and integrated application.

(v) Involvement of stakeholders through all the above initiatives is key to having an effective implementation. Dialogue will help planning in that stakeholders will give an input from different standpoints making the mitigation and closure plans all-encompassing (Ackerman et al., 2018).

2.7 Relevance to sustainable development goals

All the sustainable development goals are in one way or the other interlinked and are relevant to the research. However, the key goals that are directly linked to the study are:

(i) Sustainable cities and communities (SDG11): the main aim of this SDG according to the United Nations (2015) is to make cities and human settlements inclusive, safe, resilient and sustainable. The study was based on an approach to encompass the socio-economic and environmental aspects to inform decision making. This encourages the resilience of mining communities to be able to help them to prepare and survive even after the mine is closed. Specifically, to enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management.

(ii) Climate action (SDG13): according to the United Nations (2015) one of the targets of the SDG 13 is to integrate climate change measures into national policies, strategies and planning. Another target is to improve institutional capacity on climate change mitigation measures, early warning and reduce the environmental footprint. Incorporating closure planning into the life of mine mitigates impacts on the environment throughout operations and creates awareness to mine employees and the surrounding community on various ways of being stewards of the environment.

(iii) Life on land (SDG 15): "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" is the main theme of SDG 15 (United Nations, 2015). Incorporation of sustainable practices also helps to reduce the biodiversity loss and desertification during mine planning and development. However, the land that is disturbed during operation would through the developed framework be rehabilitated during the operations restoring ecosystems. This adds value to the land thereby increasing both flora and fauna.

2.8 Summary

This Chapter reviewed literature that highlighted mine closure practices in the developed and developing world. This included studies on mine closure in Western Australia, Zambia, South Africa and Chile and a comparative analysis is shown in Table 1.

Table 1: Comparative analysis of mine closure practices

Mine closure practice	Western Australia	Zambia	South Africa	Chile
Require environmental impact assessment	Yes	Yes	Yes	Yes
Require social impact assessment	Yes	No	No	No
Require continuous rehabilitation	Yes	Yes	Yes	Yes
Require bonding	Yes	Yes	Yes	Yes

The various environmental and socio-economic effects of poor mine closure were identified and the possible mitigation measures. An integrated closure approach was recommended as the more sustainable closure approach. This involves a more holistic approach in dealing with both the environmental and socio-economic factors. The next chapter highlights the methods used to carry out the research.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter outlines the methods used to carry out the research. It highlights the key activities undertaken during the data collection process including the research design, study population, study sample and the various data collection instruments and techniques as well as the instruments of analysis.

3.2 Research design

A mixed methods approach was used to collect data to achieve the sub-objectives of the study. To have uniformity and an objective comparison, sample size and interview schedules used were the same within a defined cluster of respondents. Questions to the respondents included both closed and open-ended questions. Quantitative data was entered and processed through Microsoft Forms. Thereafter, the data analysis of the quantitative data was done using Microsoft excel. The qualitative data was processed and analysed through visual observation and a study of literature during desk studies.

3.3 Study population

According to the 2010 national census, there are 2139 households within the residential areas around the Nchanga mine (Central Statistical Office, 2012). The study population comprised one representative of each of the 2139 households, Nchanga Mine management, Zambia Environmental Management Authority officers and the Ministry of Mines and Minerals Development officers of the Mine Safety Department.

3.4 Study sample

The study sample for the interviews comprised key informants from Nchanga Mine management, Zambia Environmental Management Authority and Mine Safety Department of the Ministry of Mines and Minerals Development.

For the survey, the study sample comprised a total of 66 representatives of households (preferably the head of the house for more accurate information). This sample size was determined using Equation 3.1 (Israel, 2003) Cochran's formula.

$$\text{Sample Size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left[\frac{[z^2 \times p(1-p)]}{e^2 N}\right]} \quad [3.1]$$

Where;

N = Population size

e = Margin of error (0.1)

Z = Z-score (1.65)

p = Estimated proportion of the population that presents the characteristic (when unknown we use p = 0.5)

3.5 Data collection instruments

The data collection instruments were interview schedules, questionnaires and a camera to take pictures (Figures 4.1, 4.13, 4.15, 4.16, 4.17, 4.18, 4.19 and 4.20). Questionnaires (Appendix C) were administered to the representatives from the households. The questions asked included both open and closed ended questions. An interview schedule was preferred for the key informants from Zambia Environmental Management Authority (Appendix A), Mine Safety Department (Appendix B) and Nchanga Mine management (Appendix D) as it allowed for dialogue and understanding of the data to be collected for review and analysis. Pictures of the mine areas currently undergoing rehabilitation and those rehabilitated in the past were taken. This was necessary for the research as it gave context to the reports received from the Mine. It provided the visual needed to correlate the reports and information collected during the interviews.

3.6 Data collection techniques

For the various objectives, data was collected as outlined below;

3.6.1 Sub-objective (a)

To investigate the socio-economic and environmental impacts due to mining at Nchanga open pit mine, questionnaires were administered to the study sample (66 representatives of surrounding households). This data was analysed using graphs in Microsoft excel to generate general trends for interpretation. In addition, environmental and socio-economic reports were reviewed to qualitatively analyse using content analysis, the impacts and their mitigating measures. A tour of the decommissioned mine sites and areas of progressive rehabilitation were undertaken where pictures were taken and used to capture some of the current effects of mining on the environment and the remedial measures being carried out to mitigate the negative impacts.

3.6.2 Sub-objective (b)

To investigate the extent to which mine closure plans and rehabilitation are being incorporated into the mine life cycle of Nchanga open pit mine, interviews were carried out with key informants from Nchanga open pit mine (Appendix D), Mine Safety Department (Appendix B) and Zambia Environmental Management Authority (Appendix C). Available mine closure plans, environmental impact assessments, environmental reports, guiding laws and regulations of Zambia and other available documents at Nchanga open pit mine in form of reports on progressive rehabilitative closure were collected from both the mine and online literature. Analysis and interpretation of this data was done qualitatively through desk studies to compare and contrast the Nchanga open pit mine practices against existing legislature. Desktop studies included the collection of documents and analysis of their content and classification according to themes.

3.6.3 Sub-objective (c)

To evaluate the benefits of incorporating mine closure and rehabilitation plans into the mine life cycle of large-scale open pit mines, desktop research was carried out. This was based on current progressive rehabilitation and closure practices in Western Australia, South Africa and Chile. Desktop research included an analyses of various laws and regulations guiding mine closure and rehabilitation practices in these countries. Standard assessment criteria were set to

compare the different cases to identify their strengths that can be adapted to Nchanga open pit mine and the Zambian setup that would then feed into the recommendations in sub-objective (d).

3.6.4 Sub-objective (d)

To identify its shortcomings and provide recommendations for improvement, information obtained from the questionnaires (Appendix C), interviews (Appendix A, B and D) and case studies were analysed qualitatively. Qualitative analysis included analysis of discourse through the interviews and analysis of the content of the questionnaires by placing the responses into themes. This was to establish the strengths and shortcomings of NOP incorporation of mine closure and progressive rehabilitation plans to inform the recommendations that can be adapted for other large scale open pit mines in Zambia to enhance sustainability.

3.7 Data analysis instruments

The quantitative data collected from the questionnaires was checked in order to eliminate misleading data. The data was analysed using Microsoft excel. The qualitative data was transcribed into major themes and analysed through visual analyses (pictures), content analyses, narrative analyses, and grounded theory analyses.

3.8 Summary

This Chapter described the quantitative and qualitative methods that were used in carrying out the research. A survey was conducted on households in the surrounding mine area to gain a better understanding on the effects of the mining and the level of community engagement and awareness. Interviews were also carried out with key informants, a site visit to Nchanga Open Pit mine was undertaken and desktop research on international practices was carried out. The next chapter discusses the results obtained from the research using the methodology outlined in this chapter.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter documents the research findings from case study of Nchanga open pit mine and desktop studies. It presents the current mine closure and rehabilitation practices and key socio-economic and environmental impacts of mining at Nchanga open pit mine. The chapter further outlines the benefits of incorporating mine closure and continuous rehabilitation plans during the operation of large scale open pit mines based on an evaluation of the local and international best practices.

4.2 Impacts of mining at Nchanga open pit mine

4.2.1 Socio-economic impact

The socio-economic impacts of mining at Nchanga include job creation, improved health facilities, recreational centres, and increased education (Konkola Copper Mines, 2021). Corporate Social Responsibility is a deliberate effort made by the mine to enhance the positive impacts and mitigate the negative impacts of mining. It involves engagement with the community to assess their needs while attending to their grievances through a stakeholder management plan which has been set up. There is community sensitisation of emergencies, incident reporting and community safety.

A community's needs assessment is done every 3 years to identify the immediate needs of the community. The last assessment was done in 2018. Key stakeholders include the Government, NGO's, surrounding communities, interest groups (HR defenders). A report is generated and circulated to the chamber of mines, local council district development commission. According to an interview with the KCM Environmental management, the company practices responsible mining and builds relationship using the social investment programme in areas such as;

1. Environmental awareness - The go green initiative that feeds into the keep Zambia Clean and Green campaign. This is a joint CSR and Environmental initiative (Konkola Copper Mines, 2021), which is the USD 20 million project launched to resuscitate the Kafue

River by de-silting. The Pongamia (Pongamia pinnata (Figure 4.1) is a tree good for bio fuel) project has been launched in the community to teach locals how to rehabilitate land that is no longer suitable for agriculture. Pongamea plant is used for phytoremediation (Prasad, 2018).

Figure 8.1: Pongamia pinnata plant at Tailings Dam 2

2. Public health – The operation of Nchanga South Mine hospital that provides free medical services to mine employees and their dependants and subsidised medical services to the general population (Konkola Copper Mines, 2021).
3. Education–The building of a day care centre at Chiwempala market in Chingola to cater for children of the local marketeers and provide them with meals, uniforms and education, construction of nine classrooms and powering of a rural school to the national grid (Konkola Copper Mines, 2021).
4. Sports– The sponsorship of football (Nchanga Rangers football club) in the top Zambian leagues. Football is not only viewed as a sport but as a form of livelihood for many young footballers. The sponsored team provides employment for 40 people and provide players to the junior and senior national football teams. Other than football, USD 2 million was invested to upgrade the Nchanga golf course (Konkola Copper Mines, 2021).
5. Sustainable livelihoods–The diversification of programmes away from mining through a deliberate policy. The programmes are not all mining related and encourage

diversification such as youth programmes in leather making, health and education. KCM has invested over USD 150 million in CSR activities (Konkola Copper Mines, 2021). This is to ensure the community is self-sustained and develops even after the closure of the mine. “In 2012, KCM launched the US$ 2 million enhanced sustainable livelihood programme, which provides livestock to small scale farmers, particularly to women and youth. Beneficiaries are imparted with farming knowledge and the programmes have helped with income generation, a reduction of poverty and enhanced food security” (Konkola Copper Mines, 2021).

Demographic characteristics

A survey, using a questionnaire (Appendix C), of the community and their perspective on various aspects of mine closure was carried out during the research. This was carried out to get first-hand information on the effects mining has had on the community. The following are the characteristics and analysis of the answers received:

1. Residence in Chingola

More than half (55%) (Figure 4.2) of the sampled population cited their reasons for residing in Chingola as employment and 43% of the same population stated that they had lived in Chingola for more than 25 years (Figure 4.3). This reveals that the majority of Chingola residents are old residents (over 15 years) and relocated to Chingola due to employment opportunities.

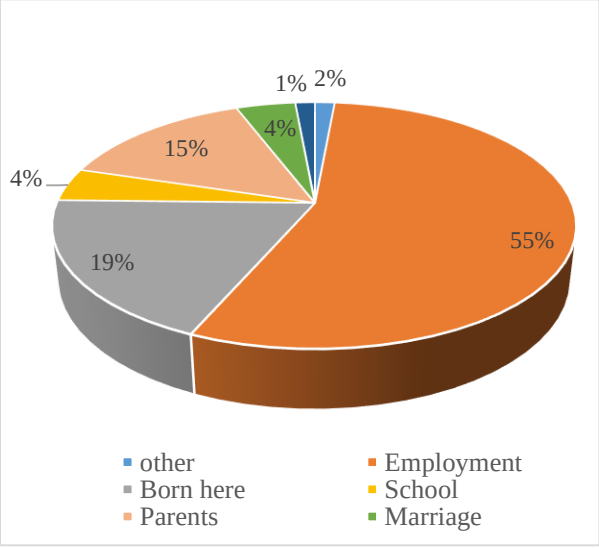

Figure 8.2: Analysis of reason for relocation of survey respondents

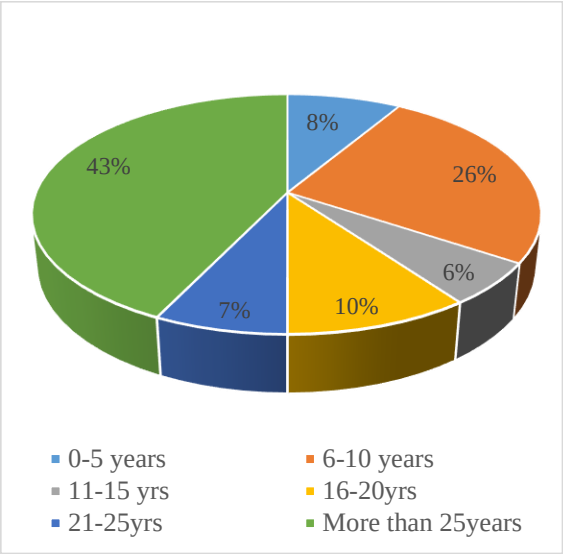

Figure 8.3: Analysis of duration of stay of survey respondents

2. Household population

On average, 49% of household's samples have six to ten occupants while 45% have one to five occupants and 6% have eleven to fifteen occupants (Figure 4.4). Of these, 55% have at least one person working for the mine while 45% do not (Figure 4.5). This reveals that over half of the population in Chingola may be affected by the closure of Nchanga open pit mine as at least one member of the household works on the mine site. This translates to over 1000 households based the 2010 statistics of the population of Chingola (2139 households).

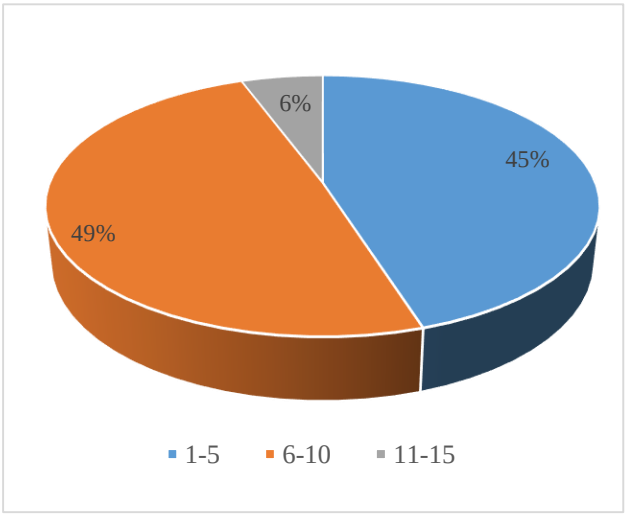

Figure 8.4: Analysis of people in household of survey respondents

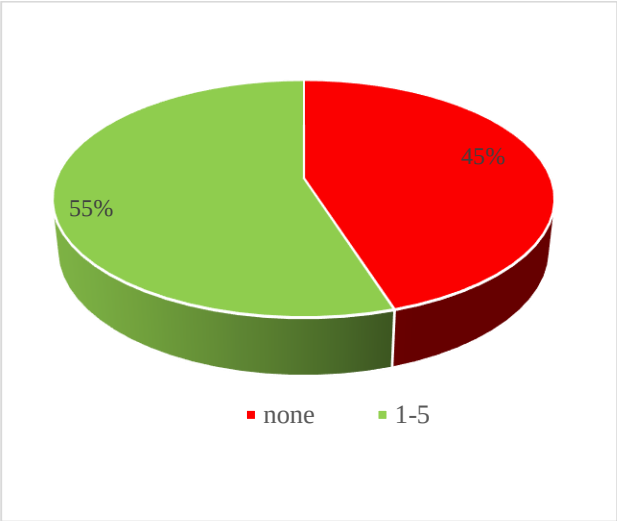

Figure 8.5: Analysis of survey respondents working on the mine site

3. Source of income

An analysis of the sources of income revealed that 57% (Figure 4.6) of the respondents are formally employed but not at the mine. The majority of these (Figure 4.7) are reliant on only one source of income, however 51% (Figure 4.8) stated that despite this, should the mine close they would be able to sustain themselves and their households. In correlating with the household analysis on the household members who work for the mine, the findings were that respondents were either not direct employees of the mine but possibly worked for a mine contractor or had a relative who is a mine employee.

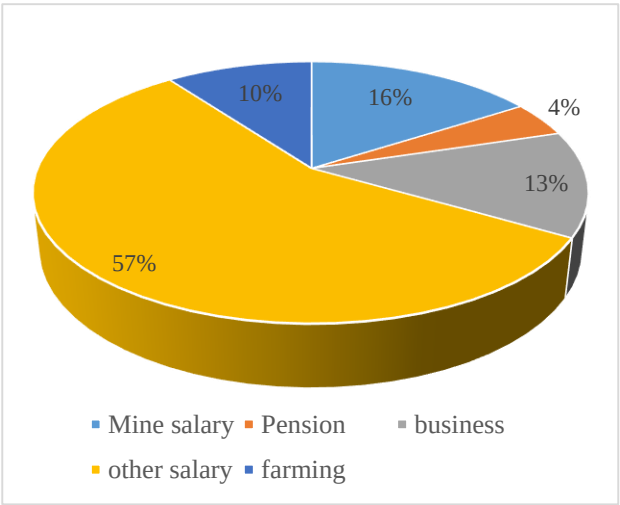

Figure 8.6: Analysis of the main source of income of survey respondents

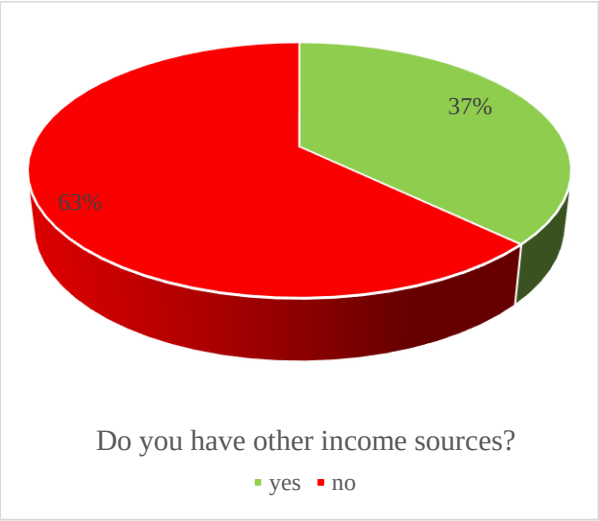

Figure 8.7: Analysis of secondary sources of income of survey respondents

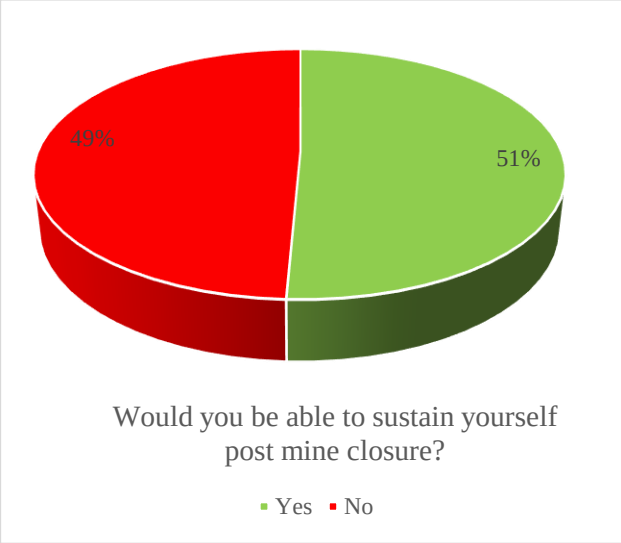

Figure 8.8: Analysis of self-sustenance of survey respondents post closure

4. Community awareness of Corporate Social Responsibility (CSR) and continuous rehabilitation

An analysis of the community awareness on CSR activities revealed that 51% (Figure 4.9) of the respondents were aware of at least one activity. Sports was the activity with the most awareness while the children's park and community empowerment which is to equip the community for post closure had the least awareness (Figure 4.10). In terms of awareness of continuous rehabilitation practices, 83% (Figure 4.11) of respondents stated that they were not aware of any current works.

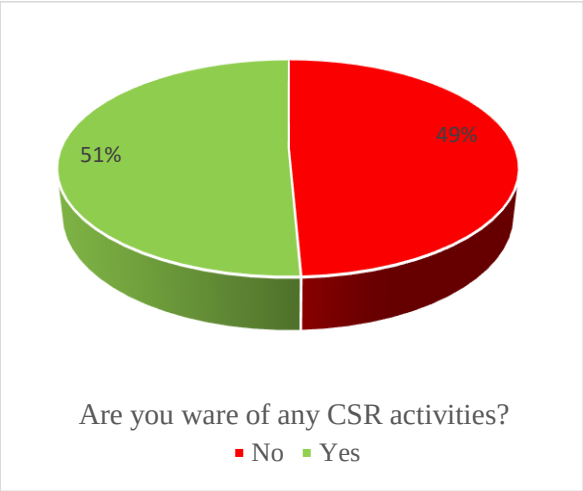

Figure 8.9: Analysis of survey respondents' awareness of CSR

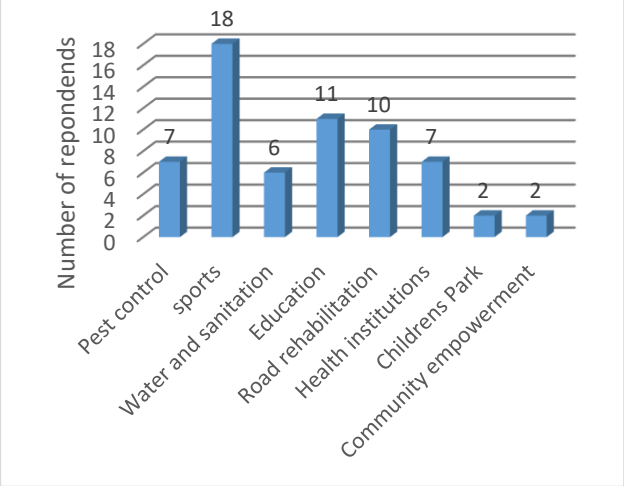

Figure 8.10: Breakdown of analysis of CSR awareness

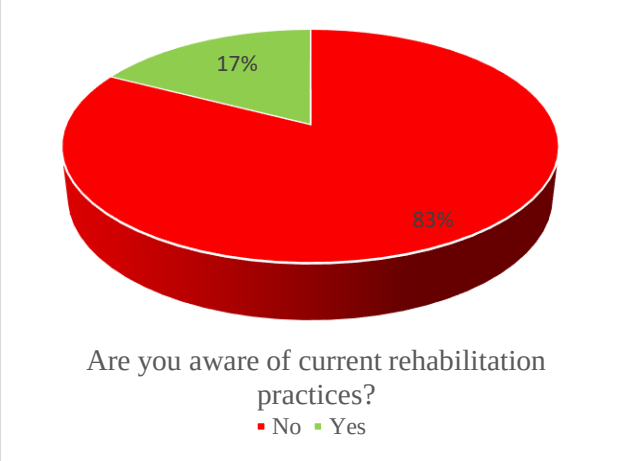

Figure 8.11: Analysis of survey respondents' awareness of rehabilitation practices

4.2.2 Environmental Impact

A review of the 2001 Environmental Management Plan of Nchanga mine revealed that open pit mining causes destruction to the environment; not only has it deforested the area, it has also left wildlife homeless, and eroded the soil which upland communities and lowland farmers depended on for their livelihoods (Konkola Copper Mines, 2001). The Nchanga Ground failure which has recently been recorded on the NOP footwall has led to nearby communities being relocated. There is air and water pollution, subsidence and soil erosion (Konkola Copper Mines, 2020).

It was also found that the key environmental challenges included mine effluent with total dissolved solids >35ppm discharged into the ambient water courses (Figure 4.12), mine emissions affecting ambient air quality and loss of biodiversity as a result of displacement of wildlife, resource use and pollution (Konkola Copper Mines, 2020).

Figure 8.12: Mine effluent discharged into ambient water courses prior to 2018 with total dissolved solids >35ppm (Source: Konkola Copper Mines, 2020)

4.3 Incorporation of closure plans and continuous rehabilitation during pperations at Nchanga open pit mine

4.3.1 Desktop analyses

Nchanga Open Pit mine has been compliant to the laws and regulations of the land including contributing to the Environmental Protection Fund. To attain and maintain ‘Category 1’ status, the mine has complied to the Environmental Impact Assessment by ensuring the water and air

quality are maintained to acceptable standards and dumps are revegetated to reduce soil erosion. The mine has embarked on journey to decommission and demolish facilities that are no longer in use such as the old concentrator, west mill, screening plant, crushing plant, old tank house and pink Pachuca at the tailings leach plant. This reduces closure costs whose incorporation in the mine's operational budget also minimises contribution to the fund. However, legacy issues of old and decommissioned facilities pose a challenge as they are costly to rehabilitate hence creating a burden. In terms of socio-economic preparation for closure, this case study of Nchanga Open Pit mine revealed the minimal involvement of the community and a lack of awareness of the measures being implemented as evidenced by the community survey that was carried out. This is despite the efforts being made by Nchanga mine to sensitize the community and involve them in the rehabilitation activities.

A review of NOP reports showed that in 2001, the Environmental Management Plan (EMP) was developed creating a paradigm shift in the environmental operations at NOP. Despite this initiative, the plan was not as robust until the Safety Health and Environment (SHE) office was created that revised the EMP and introduced the SHE policy which was the guiding document from the year 2000. By 2007, Nchanga had achieved ISO 14001 certification which stipulates the standards for an environmental management system. In 2008 the Nchanga smelter (Figure 4.13) was established with new technology in which 99.9% of the Sulphur emissions are captured. Operations have since improved with <35ppm of total dissolved solids in the water being released into the environment (Figure 4.14 (b)) from greater than 35ppm (Figure 4.14 (a)) (Konkola Copper Mines, 2020). The EMP was reviewed in 2011 and in 2012, in which the sustainability principles were introduced, and 9 more policies namely Water Management, Social, Biodiversity, Supplier and Contractor Management, Energy and Carbon, Human Rights, Security, Health, Safety and Environment and HIV/AIDS anchored on the EMP were developed.

Figure 8.13: High grade leach plant replaced by a new plant

Figure 8.14: Improvement in clarity of waste water as result of reduction in total dissolved solids (Source: Konkola Copper Mines, 2020)

The mine closure plan was developed in 2001 and reviewed in 2009. Since then annual audits of the mine are carried out by the British Safety Institute (BSI). It was established that audits of the current premises revealed that the cost of closure of the mine is approximately USD100 million (Konkola Copper Mines, 2018). This value was arrived at by calculations guided by the "Procedure for Evaluation of Quantum for Mine-Site Decommissioning and Closure" developed by the Mine Safety Department of the Ministry of Mines and Minerals Development. The procedure for evaluation takes into account the progressive rehabilitation and mitigation measures being carried out. Nchanga has from 2008 been compliant and contributed to the

Environmental Protection Fund (EPF) of which the contribution is calculated based on the closure costs as stated in Section 2.3.2.

Budget is a key aspect of setting up an Environmental Management System and Nchanga strives to incorporate this as part of the mitigation measures of environmental harm. As a result, the controls of environment are pushed into the operations. “A comprehensive and well-funded programme was designed to address legacy environmental issues. Particular focus has been placed on the areas that most affected the surrounding communities when modernising infrastructure to local and global industrial standards. As part of KCM’s US$ 2.9 billion investment programme, several environmental management projects were completed, including commissioning of a new smelter, commissioning of a new concentrator, revamping the piping and dam catchment for hydrometallurgical processing and underground rehabilitation for water handling and pumping” (Konkola Copper Mines, 2021).

4.3.2 Environmental management plan and mitigation measures at Nchanga open pit mine

The main objective of the Environmental Management Plan (EMP) is to support effective management of the environment that will in turn enhance safety, health and socio-economic impacts of the operations. To promote and support environmental stewardship, the mine has made deliberate efforts to rehabilitate areas of the mine as operations are in progress. Areas of active rehabilitation on the site include:

1. The new smelter where sulphur dioxide emissions are captured with the newly installed smelter (Figure 1.4)
2. In pit filling of Chingola Open Pit (COP) B open pit (Figure 4.15). Waste material from active mining area is dumped in COP B where mining is no longer viable thereby filling the pit but also avoiding dumping of the material on undisturbed land.
3. Silt that is controlled and restricted from entering streams through releasing of waste water into the stream with reduced total dissolved solids (<35ppm) (Figure 4.14).
4. Overburden (OB) dump 1, OB dump 2 and OB dump 22 (Figure 4.16 and Figure 4.17) where dumps were revegetated by planting of 2000 native trees (eucalyptus, pine and neem) in 2020 from the nursery (Figure 4.18) within the mine. The seedlings are started

up in the dry season so that the trees are ready for planting at the onset of the rain season. It is mine policy that prior to cutting down of trees, approval needs to be obtained and for every tree cut, three more trees are planted.

Figure 8.15: Top of Chingola B open pit backfill

Figure 8.16: OB22 vegetation (large trees)

Figure 8.17: OB 22 vegetation (shrubs)

Figure 8.18: Plant nursery

Of the already rehabilitated areas, the old power plant was decommissioned and demolished, and a new, environmentally friendly acid plant (Figure 4.19) was installed. Future rehabilitation is planned for two concentrators which have been decommissioned and replaced. They are scheduled for demolition and plans are to green the area afterwards.

Figure 8.19: New acid plant that replaced the demolished old power plant

Through interviews with Nchanga mine management the following challenges faced during the continuous rehabilitation practices were highlighted:

1. Illegal miners uprooting trees that are being planted on dumps and backfilled areas.
2. Changes in rainfall patterns affecting the growth of reforested areas.
3. Legacy issues of mine closure where decommissioned sites were not rehabilitated. Old sites that were not in use were left idle for years increasing the financial cost of operations now to bring down the infrastructure and rehabilitate the site.
4. Efforts to carry out rehabilitation are not as efficient as not all employees including part of management are not aware of the need for continuous rehabilitation or the site closure procedures and policies. Sensitising employees would make rehabilitation all-inclusive by bringing everyone on board.
5. High cost of site decommissioning and closure (e.g. backfilling of the open pits which requires a high financial investment with little to no financial return).

4.4 Evaluation of local and international mine closure and continuous rehabilitation practices

Desktop studies of mine closure practices in Western Australia, South Africa and Chile were carried out to compare a high, middle and low income country respectively. The study revealed that the three countries have similar frameworks with Western Australia having the longest experience and the most advanced financial framework for mine closure. The Western

Australian regulations stipulate that mine closure plans must incorporate the financial requirements for the complete closure of the mine, and the company must ensure that these funds are available at the time of closure through a bond. However, since the implementation of this law in 1985, it came to be seen that the bond amount did not reflect the true cost of mine closure, which was evidenced by the lack of successfully closed and/or rehabilitated mines in the region. The post-intervention of the state resulted in the formation of a Mine Rehabilitation Fund in 2013 which has been used to close and rehabilitate abandoned mine sites (Government of Western Australia, 2020).

Zambia, South Africa and Chile, have minimal experience with mine closure, and their mine closure and continuous rehabilitation frameworks are not robust. Additionally, the prevalent constraints in resources have resulted in intermittent audits and reviews. However, South Africa has taken deliberate measures in their policies to ensure application for licenses is supported by an environmental management plan, environmental impact assessment and an elaborate mine closure plan with sufficient provision for finances to rehabilitate and sustainably close the mine. In Zambia there is a challenge of finances to monitor compliance, therefore it is likely that mining companies can operate without incorporating the required post closure land use due to the lack of elaborate laws on mine closure.

Among the three countries, Western Australia has advanced the farthest in implementing a working solution to source funds for adequate mine rehabilitation, evidenced by the increasing number of closed mines year-on-year. Zambia, South Africa and Chile have made efforts to find solutions on closure for operating and non-operating mines, there is still work to be done on mine legislature and establishment of a fund to finance closure works and hold mine owners accountable.

4.5 Inadequacies of the current closure and rehabilitation practices in Zambia

From desk studies, it has been established that Zambia has laws and regulations that support mine closure and to some degree, the incorporation of continuous rehabilitation during the mining operations. Environmental regulations (Statutory Instrument 29 of 1997) in section 5(1) and 5(2) compel developers to submit Environmental Impact Statements (EIS) which should contain an environmental management plan, a plan for rehabilitation and management and the

estimated cost of protecting the environment. The Statutory Instrument also highlights the framework of the Environmental Protection Fund (EPF) which is the main tool to implement mine closure practices. The EPF framework encourages compliance to the Environmental Impact Assessment (EIA) and continuous rehabilitation. However, there are no well-defined guidelines in place that outline the contents of a mine closure plan or how the rehabilitation should be incorporated during the actual mining operations.

Contributions to the fund are based on closure costs whereby a mine makes a percentage contribution of the total cost based on environmental performance. The remainder of the cost is to be secured as a bank bond. The continuous rehabilitation of the mine reduces the closure costs and thus reduces the mining company's contribution to the fund. Conversely, due to the high costs of incorporation of continuous rehabilitation during the operations, most mining companies are reluctant to practice this as it erodes profit. This poses a challenge in the restoration of the environment. Mining companies would rather contribute to the fund than spend money on closing off areas of the mine that have been decommissioned. In the past, this has caused legacy issues on decommissioned sites (Figure 4.20) that have not been demolished and rehabilitated. A shortcoming of the EPF framework is that none of the approved banks in the regulation nor any other bank in Zambia are able to guarantee the remainder of the cost thereby presenting a loophole in the system and rendering it inefficient. This may cause challenges in financing the closure of mines as the funds will not be secured to sustainably close the mine.

Figure 8.20: Old milling plant at Nchanga mine to be demolished

The desktop study of the Zambian laws and regulations also revealed that the socio-economic impact of mine closure has not been addressed. This presents a business continuity risk to the community whose business activities are linked to the mining activity and would be crippled in the event of unforeseen closure.

4.6 Analysis of benefits of incorporating mine closure and continuous rehabilitation plans into mining operations

The analyses have revealed the effects of poor mine closure and rehabilitation practices. Some examples include the creation of abandoned towns also known as 'ghost towns' in countries like Australia and also the legacy burdens imposed on mines in Zambia today. The survey carried out on residents of Chingola (Section 4.2.1) revealed this is a challenge the town may face should the socio-economic issues not be addressed. As a result, the following benefits of incorporating mine closure and continuous rehabilitation plans into mining operations were identified:

1. Community preparedness – equipping the community with resources and skills not dependent on the mining activity may deal with the effects of the town being abandoned post closure. Residents will be able to sustain themselves through economic activities which ultimately benefits the nation.
2. Managed cost of rehabilitation – legacy burden of rehabilitating decommissioned sites has proven to be a huge financial burden. The cost of rehabilitating these old sites has proven to be profit-eroding. Being able to rehabilitate old sites by annual budgetary allocation manages this financial burden as closure is done using a phased approach.
3. Minimal environmental damage – being able to continuously rehabilitate reduces the impact of mining on the environment. Case in point is the reduction in total dissolved solids of waste water and planting of trees which endeavours to keep the environment in its natural state and preserves the local ecosystem thereby combating climate change.
4. Maximum use of land – an added benefit to minimizing environmental damage is maximizing the use of land. Renovation of infrastructure or bringing down of old sites to their natural state allows for the reuse of land that was once occupied for other purposes rather than clearing out 'virgin' land.

4.7 Summary

This chapter outlined the research findings and discussed the results. An analysis of the mine closure and continuous rehabilitation practices on and around Nchanga mine was carried out. In addition, a desktop study of the current laws and regulations guiding mine closure and rehabilitation of Zambia, Western Australia, South Africa and Chile was carried out. The results demonstrated the shortfalls of the existing framework and demonstrated the benefits of incorporating mine closure and continuous rehabilitation practices during mining operations. The next chapter seeks to conclude the report and provide recommendations based on the research.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main objective of this study was to 'Evaluate the extent to which Nchanga Open Pit Mine incorporates mine closure and continuous rehabilitation plans throughout the life of mine and to identify its shortcomings and provide recommendations for improvement'. The following conclusions were made on the sub objectives:

a) To investigate the socio-economic and environmental impacts of mining at Nchanga Open Pit Mine: It was observed that Nchanga mine faces challenges in dealing with legacy issues of decommissioned and abandoned sites. The mine also lacks community awareness and involvement in the closure and rehabilitation processes. This, coupled with the high dependence of the community on the mine pauses a challenge in the community preparedness for closure. The key negative impacts identified were displacement of settlers due to land disturbances, disruption to the ecosystem (change in quality of air and water), land subsidence and soil erosion. The key positive impacts included job creation, improved health facilities, recreational centres and increased education

b) To investigate the extent to which mine closure plans and rehabilitation are being incorporated into the mine life cycle of Nchanga Open Pit Mine: It was established that Nchanga mine was compliant to the law guiding this framework and onsite visitations verified the efforts to practice continuous rehabilitation. The old mills are yet to be rehabilitated but the facilities that have undergone rehabilitation include the acid plant, overburden dumps, the leach plant, Chingola B open pit and the old power plant. However, based on the survey analysis there is little community involvement in closure and continuous rehabilitation activities including post closure community preparedness. There have nonetheless, been positive socio-economic impacts through various Corporate Social Responsibility (CSR) efforts and presence of the mining activity within Chingola influencing growth of local businesses.

c) To evaluate the benefits of incorporating mine closure and rehabilitation into the mine life cycle of large-scale open pit mines: The Environmental Protection Fund was identified as the framework used to ensure the sustainable closure of mines in Zambia. This framework encourages the continuous rehabilitation and incorporation of closure plan throughout the life of mine, subsequently reducing the cost burden of closure. Other benefits, as identified at Nchanga open pit mine, include community preparedness, minimised environmental damage and maximised use of land.

d) To identify the shortcomings of the current closure and rehabilitation practices and make recommendations for improvement: The EPF framework is not efficient in that none of the approved banks in the regulation nor any other bank in Zambia are able to provide bank guarantees or bonds for the majority of the closure costs. In addition, the laws of Zambia do not highlight the need for an integrated approach to mine closure i.e. it is not statutory to take into account the socio-economic aspect of closure. Emphasis lies on the environmental aspect.

5.2 Recommendations

Based on the research findings, the following recommendations are being proposed:

1. Regular reviews and updates of the Zambian laws on mine closure which will be aimed at improving relevancy and efficiency in the regulations for the mine closure and rehabilitation processes.
2. Formulation of a comprehensive and integrated mine closure and sustainable development (social, economic, and environmental sustainability) framework that includes the requirement of all mines to have an integrated Mine Closure Plan.
3. Review and revise the regulations in the Environmental Protection Fund (EPF) restricting mining companies to secure bank bonds and guarantees from local banks.
4. Nchanga Open Pit Mine to increase annual budget allocation for rehabilitation activities to cater for legacy concerns and also increase investment in skills development programmes for post closure preparedness, involve the community in the planning for closure and create more awareness on various CSR and environmental remediation activities.

5. Further research to be carried out on the limitations of local banks to provide guarantees and bonds for mineclosure, and a review on the practicality of the calculation of closure costs and if the calculations are reflective of actual closure costs.

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APPENDICES

Appendix A: Interview schedule - Zambia Environmental Management Authority

Name of Organization:

Core Business:

Name of Employee:

Position:

Date:

Opening

My name is Mutinta Syafunko, a student from the University of Zambia doing my Masters of Science in Sustainable Mineral Resource Development. I am currently carrying out my research to review the incorporation of mine closure plans and rehabilitation in the life cycle of large-scale open pit mines and my case study is Nchanga Open Pit (NOP) mine.

I would like to ask you some questions about your background, your experience with the organization, your observations and expertise on the matter to input into my report. I hope to use this information to identify loopholes in the current practices and provide feasible recommendations.

The interview should take about 40 minutes. Are you available to respond to some questions at this time?

Interview questions

1. What does the organization do?

2. How long have you worked here?

3. What exactly do you do?

4. Is there information at ZEMA on the current life of mine of Nchanga Open Pit (NOP) mine?

5. Are you aware of the current active pits and the non-active pits?

6. To the knowledge of ZEMA, what is the state of the current pits and mine structures and what are the long term plans?

7. Do you have any policies and procedures that guide in relation to the mine operations and incorporation of closure and rehabilitation plans?

8. How do you monitor and implement these policies?

9. To the knowledge of your organization, what are the closure and rehabilitation plans of NOP mine?

10. To what extent are closure plans and rehabilitation being incorporated into the mine life cycle of the open pit mines.

11. What are some of the advantages of continuous rehabilitation?

12. What are some of the challenges of continuous rehabilitation?

13. What can be done better to improve the rehabilitation process?

14. Is there any law or regulation that guides on the socio-economic rehabilitation?

15. Which government agency or ministry is in charge of this in question 14?

16. Do you think the initiatives currently being carried out are sufficient enough to equip the town to continue operating after closure?

17. Which stakeholders were part of the consultation process for the post mine closure plan?

18. How often does the government monitor and evaluate the implementation of the closure plan?

19. Are the measures put in place for the mines not implementing the plans accordingly sufficient and effective?

20. Other than the current regulations around the EPF and the ZMERIP project, what do you think could be done by both the mine and government in terms of closure and rehabilitation of the mines?

Closing

A. I appreciate the time you took for this interview. Is there anything else you think would be helpful for my review of mine closure and rehabilitation practices on large scale open pit mines?

B. Would you have any information either in soft or hard copy that you are able to share with me on the mine closure or rehabilitation practices?

C. I should have all the information I need. Would it be alright to contact you in future should I need further information?

D. Would you mind sharing your details? (If the answer to C is a yes)

Thank you for your time and assistance.

Appendix B: Interview schedule - Mine Safety Department

Name of Organization:

Core Business:

Name of Employee:

Position:

Date:

Opening

My name is Mutinta Syafunko, a student from the University of Zambia doing my Masters of Science in Sustainable Mineral Resource Development. I am currently carrying out my research to review the incorporation of mine closure plans and rehabilitation in the life cycle of large-scale open pit mines and my case study is Nchanga Open Pit (NOP) mine.

I would like to ask you some questions about your background, your experience with the organization, your observations and expertise on the matter to input into my report. I hope to use this information to identify loopholes in the current practices and provide feasible recommendations.

Interview questions

1. What does the organization do?

2. How long have you worked here?

3. What exactly do you do?

4. Is there information at MSD on the current life of mine of NOP mine?

5. Are you aware of the current active pits and the non-active pits?

6. To the knowledge of MSD, what is the state of the current pits and mine structures and what are the long-term plans?

7. Do you have any policies and procedures that guide in relation to the mine operations and incorporation of closure and rehabilitation plans?

8. How do you monitor and implement these policies?

9. To the knowledge of your organization, what are the closure and rehabilitation plans of Nchanga Open Pit Mine?

10. To what extent are closure plans and rehabilitation being incorporated into the mine life cycle of the open pit mines.

11. What are some of the advantages of continuous rehabilitation?

12. What are some of the challenges of continuous rehabilitation?

13. What can be done better to improve the rehabilitation process?

14. Is there any law or regulation that guides on the socio-economic rehabilitation?

15. Which government agency or ministry is in charge of this in question 14?

16. Do you think the initiatives currently being carried out are sufficient enough to equip the town to continue operating after closure both socio-economically and environmentally?

17. Which stakeholders were part of the consultation process for the post mine closure plan?

18. How often does the government monitor and evaluate the implementation of the closure plan?

19. Are the measures put in place for the mines not implementing the plans accordingly sufficient and effective?

20. Other than the current regulations around the EPF and the ZMERIP project, what do you think could be done by both the mine and government in terms of closure and rehabilitation of the mines?

Closing

A. I appreciate the time you took for this interview. Is there anything else you think would be helpful for my review of mine closure and rehabilitation practices on large scale open pit mines?

B. Would you have any information either in soft or hard copy that you are able to share with me on the mine closure or rehabilitation practices?

C. I should have all the information I need. Would it be alright to contact you in future should I need further information?

D. Would you mind sharing your details? (If the answer to C is a yes)

Thank you for your time and assistance.

Appendix C: Representative of household questionnaire

Dear Participant,

The overall objective of this research is to obtain data to review the incorporation of closure plans and progressive rehabilitation into the life cycle of Nchanga Open Pit (NOP) mine both socio-economically and environmentally. The questionnaire aims at establishing the strengths and shortcomings of NOP in the incorporation of mine closure and progressive rehabilitation plans from the community perspective to inform relevant recommendations.

(To ensure objectivity and anonymity, you are not required to indicate your name when responding to the survey).

1. (a) Which part of Chingola do you live?

……..……..……

(b) How long have you lived in Chingola for?

……..……..……

2. What brought you to Chingola?

……..……..……

3. (a) How many people live in your household?

……..……..……

(b) How many people in your household work on the mine site?

……..……..……

4. What is your main source of income?

……..……..……

5. What are your secondary sources of income?

a) ……..

b) ……..

c) ……..

6. Which current and passed CSR activities of mine are you aware of?

a) ……..

b) ……..

c) ……..

7. How are they beneficial to the community?

……..……..……

……..……..……

……..……..……

8. What can the mine do better to empower the local community?

……..……..……

……..……..……

……..……..……

9. (a) If the mine were to close down, would you be able to sustain yourself and your household? ☐

Yes No ☐

(b) If your answer to question (a) is yes, briefly explain how.

……..……..……

……..……..……

……..……..……

10. What are some of the challenges you may have faced due to the mining operation?

……..……..……

……..……..……

……..……..……

11. How have you resolved the challenges you may have faced due to the mining operation?

……..……..……

……..……..……

……..……..……

12. Which past or present rehabilitation measures by the mine on the environment are you aware of?

……..……..……

……..……..……

……..……..……

13. How involved or informed is the community on such practices in question 12?

……..……..……

……..……..……

14. What are your recommendation to ensure that the mining town of Chingola continues to operate even after the mine closes?

……..……..……

……..……..……

Appendix D: Interview schedule - Mine Management

Name of Organization:

Core Business:

Name of Employee:

Position:

Date:

Opening

My name is Mutinta Syafunko, a student from the University of Zambia doing my Masters of Science in Sustainable Mineral Resource Development. I am currently carrying out my research to review the incorporation of mine closure plans and rehabilitation in the life cycle of large-scale open pit mines and my case study is Nchanga Open Pit (NOP) mine.

I would like to ask you some questions about your background, your experience with the organization, your observations and expertise on the matter to input into my report. The interview aims at establishing the strengths and shortcomings of NOP in the incorporation of mine closure and progressive rehabilitation plans from the management perspective to inform relevant recommendations. I hope to use this information to identify loopholes in the current practices and provide feasible recommendations.

The interview should take about an hour. Are you available to respond to some questions at this time?

Interview questions

1. How long have you worked for Nchanga Open Pit (NOP) mine?

2. What exactly is your role at the mine?

3. Do you have any source of income other than your salary?

4. If yes to question 3, what are your other sources of income?

5. Are you aware of the current life of mine?

6. How many pits are currently inactive?

7. Are you aware of the long-term plans for NOP?

8. What are some of the environmental challenges that come with open pit mining at NOP?

9. How are the environmental challenges in question (8) above being mitigated?

10. Are you aware of the current policies and procedures on mine rehabilitation and closure?

11. How do you incorporate these policies and procedures in question (10) into your tasks?

12. Which areas of NOP are currently being rehabilitated/closed off?

13. What are some of the advantages of the rehabilitation in question (12)?

14. What are some of the challenges of the rehabilitation in question (12)?

15. What is the plan for the mine after all the economic minerals are mined?

16. Was there stakeholder involvement in the post mine closure plan?

17. What are some of the CSR the mine is currently engaging in?

18. Do you think these initiatives are sufficient for the town to continue operating after closure and why?

19. What can be done better to improve the rehabilitation and closure process both environmentally and economically?

Closing

A. I appreciate the time you took for this interview. Is there anything else you think would be helpful for my review of mine closure and rehabilitation practices on Large Scale Open Pit mines?

B. Would you have any information either in soft or hard copy that you are able to share with me on the mine closure or rehabilitation practices?

C. I should have all the information I need. Would it be alright to contact you in future should I need further information?

D. Would you mind sharing your details? (If the answer to C is a yes)

Thank you for your time and assistance.

Appendix E: Nchanga mine Environmental department interview notes

· Waste management, water, energy, documentation of systems.
Budget is key for environmental management.
- controls of environmental should be pushed into operations. Environmental role is thrived to
- BSI auditors (British Safety Institute). Annually.
- contributors to Environmental Protection Fund
from 2008 audits have be done
- Audit of current premises ($ 100 m) and cost to close.
5% for 5, 10%, 20%
· 3 categories of EPF (Excellent, Very good, Good) Insurance period of 5yrs.
· Citizen for better environment auditors, quatom audit and Environmental performance audit.
· MSD has no resources to renew documents for EPF audits
· Law does not stipulate how often renews are done.
KCM compliant to cash payment. $

- Secure bank gaurantee with 95% is a challenge.
Requirement by law to get a gaurantee, but challenge due to huge sums of money
Need to revise regulations to secure.

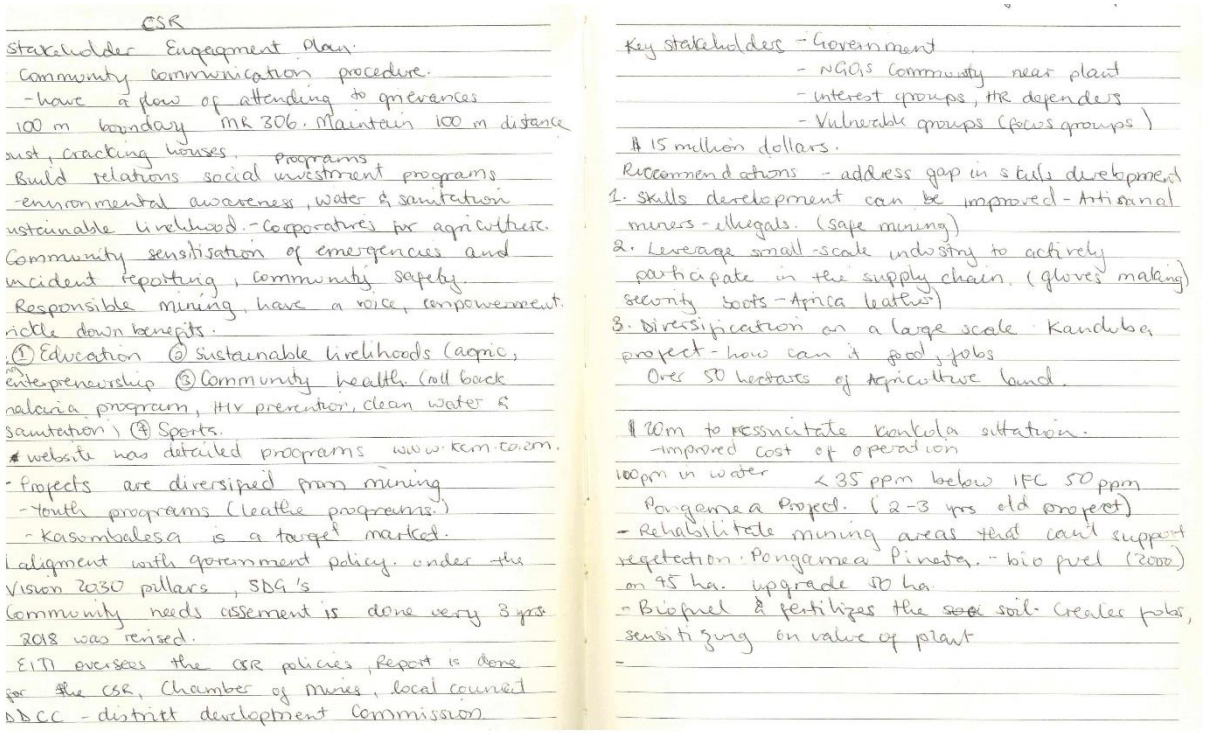
· ERM consultant to renew EMP and consolide, including Mine closure plan and all documents.
- 2009, plan was renewd (EMP)
EM act (2011).

Kunsongai 2004

operations. Co-designed an implemented program.
- Feeds into Keep Zambia Clean (Make Chingola clean) Joint CSR & Environmental initiative.
- Started from Abandoning Nkana smelter (under demolishon) 2007.
- technology of smelting was changed. Nchanga smelter was established. 99.9% capture of Sulphur. Commissioned in 2008

Areas of Active Rehab.
= Smelter is site for continuous rehabilitation.
- Sulpur plant was demolished a new plant was developed.
- Konkola: New concentrator, replaced convetional concentrator (huge footprint). ← zero discharge.
- 2 New concentrators which have replaced, old concentrator has been demolished. Plans to uproot & green the area
* - In-pit filling, pits have been burned (near blocks, COP C. Originally pits were not burned.
- control silt from entering streams
- siltation, land degradation, dumps, hydro-carbons from equipment, dust

Appendix F: Nchanga mine Corporate Social Responsibility department interview notes



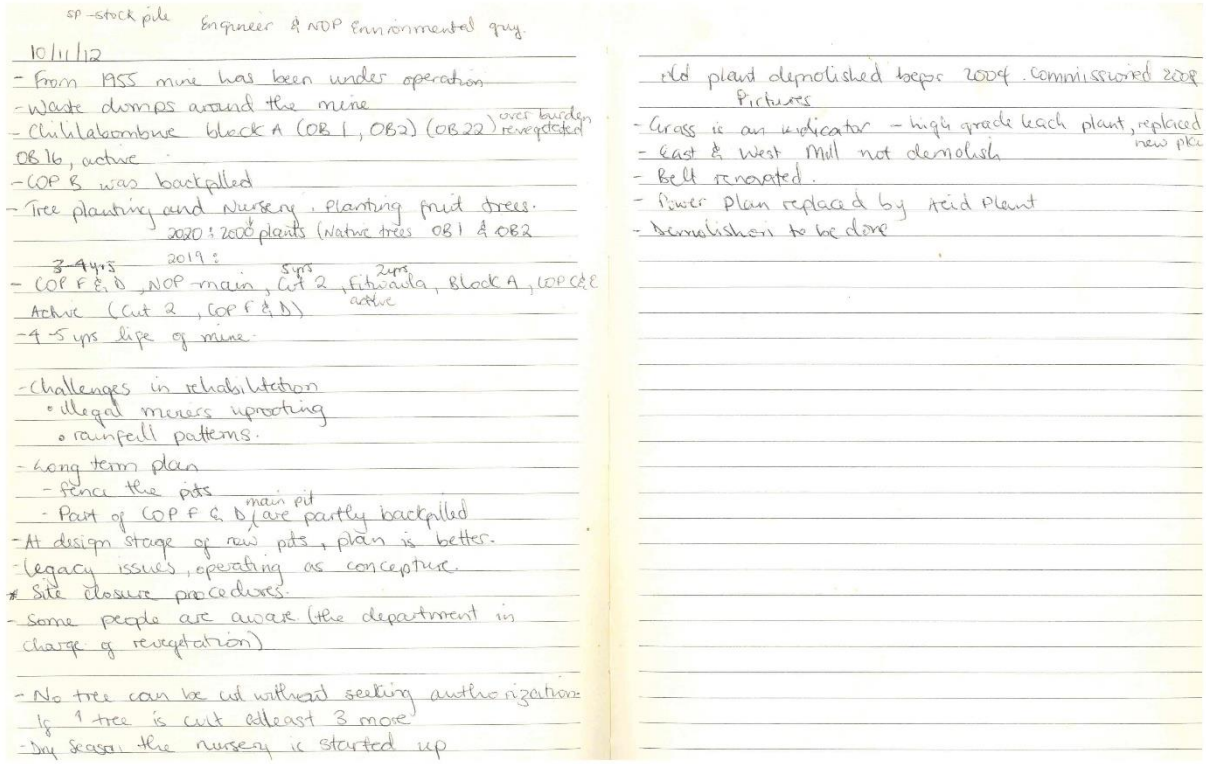
CSR

Stakeholder Engagement Plan:
Community communication procedure.
- have a flow of attending to grievances
100 m boundary MR 306. Maintain 100 m distance rust, cracking houses.
Build relations social investment programs (Programs)
-environmental awareness, water & sanitation
sustainable livelihood - Corporatives for agriculture.
Community sensitisation of emergencies and incident reporting, community safety.
Responsible mining, have a voice, empowerment.
ripple down benefits.
① Education ② Sustainable livelihoods (agric, entrepreneurship ③ Community health (roll back malaria program, HIV prevention, clean water & sanitation) ④ Sports.
* website has detailed programs www.kcm.co.zm.
- Projects are diversified from mining
- Youth programs (leather programs.)
- Kasombalesa is a target market.
Alignment with government policy. under the Vision 2030 pillars, SDG's
Community needs assesment is done very 3 yrs 2018 was revised.
EITI oversees the CSR policies, Report is done for the CSR, Chamber of mines, local council DDCC - district development commission.

Key stakeholders - Government
- NGOs Community near plant
- interest groups, HR dependers
- Vulnerable groups (focus groups)
15 million dollars.
Recommendations - address gap in skills development
1. Skills development can be improved - Artisanal miners - illegals. (safe mining)
2. Leverage small-scale industry to actively participate in the supply chain. (gloves making) security boots - Africa leather)
3. Diversification on a large scale Kansuba project - how can it good, jobs
Over 50 hectares of agriculture land.

20m to resuscitate Konkola sittation.
-improved cost of operation
100pm in water < 35 ppm below IFC 50 ppm
Pongamea Project. (2-3 yrs old project)
- Rehabilitate mining areas that can't support vegetation. Pongamea Pinata. - bio fuel (2000 on 95 ha. upgrade 50 ha.
- Biofuel & fertilizes the ~~soil~~ soil. Creates jobs, sensitizing on value of plant

Appendix G: Nchanga mine Open Pit department interview notes



SP - stock pile Engineer & NDP Environmental guy.

10/11/12
- From 1955 mine has been under operation
- Waste dumps around the mine
- Chilulabombwe block A (OB 1, OB2) (OB 22) over burden revegetated
OB 16, active
- COP B was backpilled
- Tree planting and Nursery. Planting fruit trees.
2020: 2000 plants (Native trees OB1 & OB2
3-4 yrs 2019:
- COP F & D, NDP main, 5yrs Cut 2, 2yrs Fitwaula, Block A, COP C&E
Active (Cut 2, COP F & D) active
- 4-5 yrs life of mine.

- Challenges in rehabilitation
  - illegal miners uprooting
  - rainfall patterns.
- Long term plan
  - Fence the pits
  - Part of COP F & D main pit are partly backpilled
- At design stage of new pits, plan is better.
- Legacy issues, operating as conceptual.
* Site closure procedures.
- Some people are aware (the department in charge of revegetation)

- No tree can be cut without seeking authorization
If 1 tree is cut atleast 3 more
- Dry season the nursery is started up

old plant demolished before 2004. commissioned 2008
Pictures
- Grass is an indicator - high grade leach plant, replaced new plant
- East & West Mill not demolish
- Belt renovated.
- Power plan replaced by Acid Plant
- Demolishion to be done

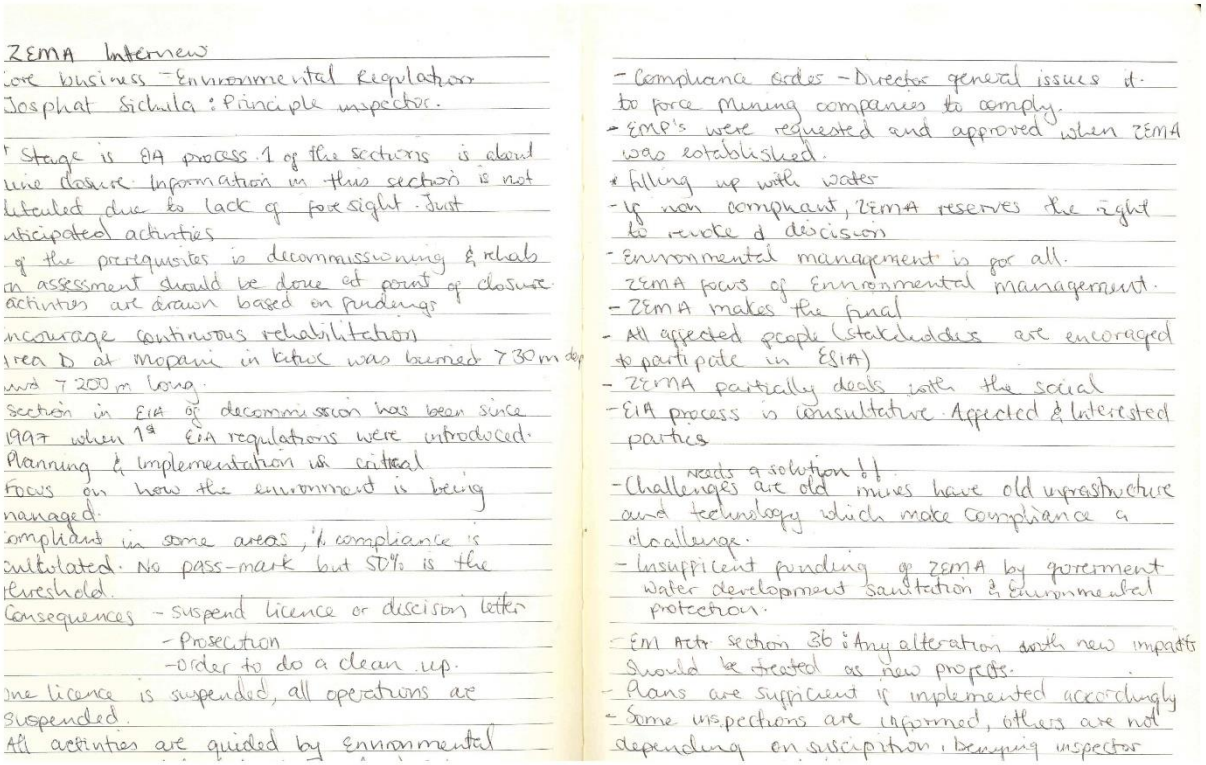
Appendix H: Mine Safety department interview notes

Name of Organization: Mines Safety Department (MSD)
Core business: To deal with matters pertaining to safety, health and environment in exploration, mining and mineral processing operations throughout Zambia in line with the provisions of the mines and minerals development act No. 11 of 2015. To facilitate sustainable development of the mining sector in order to increase investment and job creation
Name of Employee: Kantonga Kelly
Position: Inspector of Environment
Date: 27th November 2020
Answers

1. **What does the organization do?**
   ANS: Our department regulates all exploration, mining and mineral processing operations in Zambia in line with safety, health and environment standards in accordance with the provisions of the Mines and Minerals Development Act of 2015 and its subsidiary regulations.
2. **How long have you worked here?**
   ANS: 2 years and 6 months
3. **What exactly do you do?**
   ANS: I Work as an Inspector of Environment whose mandate is to undertake regular inspections, sampling and certifications relating to occupational health, environmental impact assessment reports associated to environmental management and rehabilitation plans and periodic environmental audit reports in proposed and existing prospecting, exploration and mining operations and projects.
4. **Is there information at MSD on the current life of mine of Nchanga Open Pit Mine?**
   ANS: Yes the information is there. If you are interested or want to know more about this you can get in touch with our Mining Unit here at MSD.
5. **Are you aware of the current active pits and the non-active pits?**
   ANS: Yes
6. **To the knowledge of MSD, what is the state of the current pits and mine structures and what are the long-term plans?**
   ANS: My colleagues from Mining Unit can help to answer this question well
7. **Do you have any policies and procedures that guide in relation to the mine operations and incorporation of closure and rehabilitation plans?**
   ANS: There are regulations in place that guide mine operations and also closure and rehabilitation of mines although they need reviews and updates because mining and mineral processing are dynamic and keep advancing with time. The other challenge is that there are so many gaps in the legislation governing mine closure and rehabilitation in Zambia. Mostly the legislation currently focuses more on the mines assurance to rehabilite and manage the environment at closure by contributing funds towards the Environmental Protection Fund. This is done by calculating the quantum closure cost estimates using the master rates that have been provided for in a document called ***Procedure for Quantum of Mine Closure Related Cost Estimates***. Find attached the mentioned document. Closure plan is not strongly pronounced in the current legislation hence is it very common to find that mines operate without incorporating the required mine closure and post closure land use plans. There are no well-defined guidelines in place that outline the contents of a mine closure plan or how the progressive rehabilitation should be incorporated in the actual mining operations and other requirements that should be included in it. All this brings about a challenge on the regulating Agencies to monitor and evaluate the Mining houses in terms of Mine closure and rehabilitation plans.
8. **How do you monitor and implement these policies?**
   ANS: By means of carrying out inspections, investigations, conducting audits and reviewing different types of documents that are submitted to our offices as per statutory requirements then subsequently conducting validation exercises.
9. **To the knowledge of your organisation, what are the closure and rehabilitation plans of Nchanga Open Pit Mine?**
   ANS: This information can be better obtained from Nchanga Mine.
10. **To what extent are closure plans and rehabilitation being incorporated into the mine life cycle of the Open Pit mines.**
    ANS: Refer to 7 above.
11. **What are some of the advantages of continuous rehabilitation?**
    ANS
    - ✓ Continuous Environmental rehabilitation ensures continuous environmental management improvements and compliance in managing the impacts that arise as a result of mining activities.
    - ✓ It also lessens the burden of incurring huge costs of rehabilitation at official mine closure or emergency closure.
    - ✓ Continuous rehabilitation also fully puts the rehabilitation responsibility on the Current Mine owners which would leave less environmental liabilities to be handled by the government if the mine was to be abandoned or orphaned.
12. **What are some of the challenges of continuous rehabilitation?**
    ANS: The challenge of continuous rehabilitation would be on the mining houses to incorporate the rehabilitation costs in the actual mining operation costs as most people are likely to deem it as a non-beneficial programme to the mines existence and operations.
13. **What can be done better to improve the rehabilitation process?**
    ANS: There is need to review our legislation and close up the gaps in order to put up effective policies safeguarding mine closure and rehabilitation processes.
14. **Is there any law or regulation that guides on the socio-economic rehabilitation?**
15. **Which Government Agency or Ministry is in charge of this in question 14?**
16. **Do you think the initiatives currently being carried out are sufficient enough to equip the town to continue operating after closure both socio-economically and environmentally?**
    ANS: The initiatives are not very efficient.
17. **Which stakeholders were part of the consultation process for the post mine closure plan?**
18. **How often does the government monitor and evaluate the implementation of the closure plan?**
    ANS: It is not easy to monitor the implementation of mine closure plans because some mines do not even have preliminary closure plans in place. The best time to monitor the implementation of closure plans is around the same time when the review and validation of the EPF audits are conducted.
19. **Are the measures put in place for the mines not implementing the plans accordingly sufficient and effective?**
    ANS: The measures in place are likely not sufficient and effective.
20. **Other than the current regulations around the EPF and the ZMERIP project, what do you think could be done by both the mine and government in terms of closure and rehabilitation of the mines?**
    ANS: First of all the best thing to do around the EPF in order to strengthen our regulations is to first find out how developed countries are handling these matters so that the best practices could be adopted. Secondly there is need to review and update the legislation, considering all the gaps that would be highlighted and then put in place better policies with close engagement from the stakeholders.

Note: In the current legislation regulating the operations and environmental management in the mining sector, a closure plan is not strongly pronounced hence is it very common to find that mining houses operate without incorporating the required mine closure and post closure land use in the operations because it is likely that it proves a challenge to prepare an extensive closure and rehabilitation plan.

Appendix I: Zambia Environmental Management Authority interview notes



ZEMA Interview
core business - Environmental Regulation
Josphat Sichula : Principle inspector.

* Stage is EIA process 1 of the sections is about mine closure. Information in this section is not detailed due to lack of foresight. Just anticipated activities
of the prerequisites is decommissioning & rehab an assessment should be done at point of closure activities are drawn based on findings
encourage continuous rehabilitation
area D at Mopani in Kitwe was burned 730m deep and 7 200 m long.
section in EIA of decommission has been since 1997 when 1st EIA regulations were introduced.
Planning & implementation is critical
Focus on how the environment is being managed.
omplaints in some areas, % compliance is calculated. No pass-mark but 50% is the threshold.
Consequences - suspend licence or discision letter
- Prosecution
-order to do a clean up.
ine licence is suspended, all operations are suspended.
All activities are guided by environmental

- Compliance orders - Director general issues it. to force Mining companies to comply.
- EMP's were requested and approved when ZEMA was established.
* filling up with water
- If non compliant, ZEMA reserves the right to revoke d decision
- Environmental management is for all.
ZEMA pows of Environmental management.
- ZEMA makes the final
- All affected people (stakeholders are encouraged to participate in ESIA)
- ZEMA partially deals with the social
- EIA process is consultative. Affected & interested parties
- Challenges are old mines have old infrastructure and technology which make compliance a challenge. needs a solution b/c
- Insufficient funding of ZEMA by government Water development Sanitation & Environmental protection.
- EM Act section 36 ; Any alteration with new impacts should be treated as new projects.
- Plans are sufficient if implemented accordingly
- Some inspections are informed, others are not depending on suscription ; Bringing inspector

Appendix J: Demographics raw data

Residence	Duration	Reason for residence	# in household	# with mine job	Main income source	Other income source	CSR activities aware of?	Beneficial	More to empower community	Post closure sustainance	How?	Challenges faced due to mining	Resolutions	Awareness of rehabilitation	Involvement in rehab	Post closure ecommendations
Nchanga North	16-20yrs	other	6-10	1-5	Mine salary	none	Water and Sanitation;Childrens park;	Yes	Marketeer empowerment;farming corperatives;Promote small scale and artisan miners;	Yes	Farming and transportation business but this would be dependent on miners	Cracks in buildings;Human danger ;	Community engagement;	No	No	The mine and government to come together to establish other sources of income
Chingola Central	6-10 years	Employment	6-10	none	other salary	farming	None;		Improve wages and conditions of service;	No		Air pollution;land degradation;	Engaging the mines;	No	No	To sell the mine to serious investors
Nchanga North	More than 25years	Born here	1-5	1-5	other salary	Transportation;Research and Tax consultancy;	Sponsorship of sports;Health institutions;Road rehabilitation;	Yes	Increase employment;	No		Air pollution;land degradation;water pollution;Noise pollution;	Nil;	Yes	No	New investment to tackle income challenges
Nchanga South	6-10 years	School	1-5	none	business	none;	None;		Increase employment;	No		Air pollution;water pollution;	Control of gases emitted in the atmosphere;	No	No	Holistic approach to post mine closure
Chingola Central	0-5 years	Employment	1-5	1-5	other salary	none;	Sponsorship of sports;Pest control;	Yes	Increase employment;Marketeer empowerment;	No		Air pollution;	Nil;	No	No	Government to create industries
Kabundi South	More than 25years		11-15	1-5	Pension	farming;	None;		farming corperatives;	No		water pollution;Air pollution;	Nil;	No	No	Get involved in intensive farming
Chingola Central	More than 25years	Parents	6-10	1-5	other salary	none;	Sponsorship of sports;Pest control;	Yes	Awarding contracts to locals and road maintenance;	No		water pollution;Air pollution;	Nil;	No	No	Provide land for farming and farming inputs
Nchanga South	6-10 years	Employment	6-10	1-5	other salary	farming;	Education sponsership;Road rehabilitation;Sponsorship of sports;	Yes	Increase employment;	No		Air pollution;water pollution;	Nil;	No	No	Community should be involved in farming
Chabanyama	16-20yrs	Employment	6-10	1-5	other salary	business;	None;		Increase employment;	No		water pollution;Air pollution;	Nil;	No	No	Avoid releasing of gases into the atmoshere
Nchanga South	More than 25years	Parents	6-10	1-5	other salary	none;	Sponsorship of sports;Pest control;	Yes	Increase employment;Provide entrepreneurship and training and maintaining roads;	No		land degradation;Air pollution;water pollution;	Nil;	No	No	Provide farm land and farm inputs
Nchanga North	More than 25years	Employment	6-10	1-5	Mine salary	none;	Sponsorship of sports;	Yes	Increase employment;	No		Air pollution;	Nil;	No	No	Start farming
Kabundi South	More than 25years		11-15	1-5	farming	Piece work;	None;	No	Increase employment;	Yes	By farming and other projects			No	No	Bring community empowerment
Nchanga South	More than 25years	Parents	6-10	none	other salary	none;	None;		Increase employment;	Yes	Through the transport business	water pollution;Noise pollution;	Nil;	No	No	
Kabundi South	More than 25years	Parent employment	6-10	1-5	other salary	none;	Road rehabilitation;Sponsorship of sports;	Yes	Increase employment;Improve wages and conditions of service;Improve on payment to contractors;	No		Noise pollution;Air pollution;land degradation;water pollution;	Nil;	No	No	Empower the youth to go into agriculture
Nchanga South	6-10 years	Employment	6-10	none	other salary	none;	None;		Increase employment;	Yes	I don't work for the mine	water pollution;	Nil;	No	No	Start farming
Nchanga North	More than 25years	Employment	6-10	1-5	other salary	farming;	None;		Increase employment;	No		Cracks in buildings;	Nil;	No	No	Empower people to farm
Nchanga North	More than 25years	Born here	6-10	1-5	business	none;	Water and Sanitation;	Yes	Increase employment;	No		Lowering of water table and water accumulation in older pits;	Nil;	No	No	Look for other sources of income
Nchanga North	More than 25years	Employment	6-10	1-5	other salary	none;	None;		Promoting local contractors;	No		Air pollution;	Nil;	No	No	
Chikola loop area	21-25yrs	Born here	1-5	1-5	business	none;			Increase employment;	No		Slow business;	Nil;			
Nchanga North	16-20yrs	Parents employment in Chingola	1-5	none	other salary	none;	None;	No	Promote local contractors;	Yes	I dont depend on the mine, most of our contracts are in Lumwana and Kalumbila	land degradation;Air pollution;	Dust suppression by water;	No	No	Venture into other forms of business other than mining

Kabundi South	21-25yrs	A better life	6-10	1-5	Mine salary	none;	None;		Improve wages and conditions of service;Increase employment;Marketeer empowerment;	Yes	Venture into farming	Air pollution;water pollution;Noise pollution;land degradation;	Live in houses away from the mine;	No	No	Diversify into farming and non mining related businesses
Kabundi South	More than 25years	a better life	6-10	1-5	farming	none;	None;		Increase employment;	No				No	No	
Kabundi South	More than 25years	Employment	6-10	1-5	farming	farming;Dependent on the person who works;	None;		Increase employment;better roads, clean enviroment;	No				Yes	Yes	Encourage people to leave Chingola because industries will close down when the mines close
Nchanga South	21-25yrs	Employment	1-5	none	other salary	none;	None;			Yes	through farming	water pollution;	Nil;	No	No	more industries
Kabundi South		Employment	11-15	1-5	pension	farming;	Road rehabilitation;Water and Sanitation;Education sponsership;	No	Marketeer empowerment;Increase employment;Road repair;	No		Air pollution;Noise pollution;water pollution;	Use of borehole water;	No	No	Diversify , go green and agriculture is the answer
Kamba	6-10 years	Employment	6-10	none	other salary	none;	None;		Increase employment;	Yes	No one works for the mine	Air pollution;	Nil;	No	No	People involve themselves in other things
Kasompe	6-10 years	School	6-10	1-5	business	Brick making;	None;			Yes	Conntinuing to make artifacts and farming		Nil;	No	No	
Kasompe	16-20yrs	School	1-5	1-5	farming	business;			Increase employment;	Yes	Because the work is not related to the mines	Air pollution;water pollution;Noise pollution;	Boiling water;	No	No	
Nchanga South	More than 25years	Employment	1-5	none	other salary	none;	None;		Promote small scale and artisan miners;	Yes	Through farming	water pollution;		No	No	Need for more industries
Riverside	6-10 years	Employment	6-10	none	other salary	business;	None;		Provide well equipped health facilities to support government ones;	Yes		Air pollution;	Nil;	No	No	People should invest in other sources of income like farming and other viable businesses
Nchanga North	6-10 years	Employment	1-5	1-5	other salary	none;	Education sponsership;	Yes	Increase employment;	Yes	Through farming	Noise pollution;Air pollution;	Nil;	No	No	Introduce industries like manufacturing
Chingola east	More than 25years	Parents	6-10	1-5	other salary	none;	None;		Put policies in place;	No		Displacement and desertion of potential people to develop Chingola;	Nil;	No	No	It is catastrophy, i feel scared to recommend
Nchanga North	More than 25years	Born here	6-10	1-5	other salary	none;	Sponsorship of sports;Education sponsership;Pest control;	Yes	Giving contracts to locals;	Yes	I am a teacher	Air pollution;	Nil;	No	No	Diversification into agriculture and other sectors
Kabundi North	6-10 years	Employment	6-10	none	other salary	none;	None;	No	Increase employment;awarding contracts to local investors;	Yes	Non of the household members works on the mine	Air pollution;	Nil;	No	No	Involvement in ventures other than mining
Nchanga South	6-10 years	Employment	6-10	none	other salary	none;	None;	No	Increase employment;	Yes	I do not work in the mine	Land slides;	Nil;	No	No	People should involve themselves in other ventures
Kabundi East	6-10 years	Marriage	1-5	none	other salary	business;	Water and Sanitation;	Yes	Provide soft loans for the community to start up businesses;	Yes	I have my own source of income	Air pollution;Noise pollution;water pollution;	Nil;	No	No	Empower the community and rehabilitate roads
Nchanga North	16-20yrs	Employment	1-5	1-5	Mine salary	none;	Education sponsership;Road rehabilitation;			No	That is the only source of income	Air pollution;water pollution;Noise pollution;		No	No	People should find other sources of income
Kabundi North	11-15 yrs	Employment	1-5	1-5	Mine salary	none;	None;	No	Come up with a program to help develop the area;	No		People are faced with lay offs and business is very difficult as business reduces;	Nil;	Yes	No	Empower the youths as many are involved in crime
Old airport	More than 25years	Born here	6-10	none	business	none;	Sponsorship of sports;	Yes	Being more involved in community programs;	Yes	my work has nothing to do with the mines	Air pollution;	Nil;	No	No	People should start farming

Nchanga South	More than 25years	Parents	1-5	none	other salary	none;	Education sponsership;Road rehabilitation;Educational loans;	Yes	To be consistent in their support and on a large scale;	No			Only the mines can resolve the challenges faced;	Yes	No	Introduce many non-mine industries
Kabundi North	More than 25years	Born here	1-5	1-5	Mine salary	none;	Education sponsership;Sponsorship of sports;Pest Control;	Yes	Improve wages and conditions of service;Marketeer empowerment;Maintaining road networks;	No		Air pollution;water pollution;Land slides;	Nil;	Yes	No	Give land to every KCM employee and contracting employees so that everyone is empowered
Nchanga mine police camp	16-20yrs	Employment	1-5	1-5	other salary	none;	Sponsorship of sports;	Yes	Increase employment;	No		water pollution;Air pollution;Land slides;	Nil;	No	No	Land should be given to people so that they can start farming
Lulamba	6-10 years	Employment	6-10	none	other salary	none;	None;		Increase employment;Awarding contracts to locals;	Yes	Non of my household members works in the mine	Air pollution;	Nil;	No	No	Major in different fields other than mining
Nchanga South	More than 25years	Employment	1-5	1-5	Mine salary	business;farming;Transportation;	None;	No	Marketeer empowerment;Increase employment;	Yes	I have other sources of income other than mining	Most of the investors bring in their own labour and hence locals do not benefit;	Community engagement;	No	No	Train people of Chingola in various sectors and put programs that will empower them financially
SQ	0-5 years	Employment	1-5	1-5	Mine salary	none;	None;	No	Increase employment;	Yes	Utilise other skills i possess	Noise pollution;	Nil;	No	No	Ensure mining does not harm the environment
Mporokoso flats	More than 25years	Born here	1-5	1-5	other salary	farming;	Road rehabilitation;Sponsorship of sports;	Yes	Increase employment;	No		Air pollution;Noise pollution;water pollution;	Nil;	Yes	No	Introducing new industries like manufacturing
Kabundi East	6-10 years	Employment	1-5	none	other salary	none;	Pest control;	Yes	Through co-operatives local communities can supply materials to the mines;	Yes	Not employed by the mines	Air pollution;	Nil;	No	No	Diversification into agriculture with a ready market at Kasumbalesa
Nchanga North	More than 25years	Born here	6-10	1-5	other salary	none;	None;		Increase employment;	Yes	I would be able to invest my money into business and help my husband who is employed by the mines	Air pollution;	Nil;	Yes	No	Form groups that can do something profitable to help the mining town so that it can be maintained
Kabundi South	11-15 yrs	Family	6-10	none	business	none;	Education sponsership;Health institutions;	Yes	Award more contracts to local contractors;	Yes	My income is not dependent on the mines and has no connection to it whatsoever	water pollution;Air pollution;	The mines are taking better methods of dumping the waste;	No	No	More contracts need to be awarded to the locals
Chingola Central	0-5 years	Employment	6-10	none	other salary	business;farming;	None;		Increase employment;	Yes	It is not good to depend on the mines	Air pollution;	Nil;	No	No	
Nchanga South	0-5 years	Employment	1-5	none	other salary	none;	Education sponsership;	Yes	Increase employment;	No		Flying rocks hitting nearby houses;	Blasting pattern was revised to improve flying rocks;	No	No	
Nchanga North	More than 25years	Born here	6-10	1-5	other salary	business;	Pest control, restocking of Kafue river with fish, empowering local farmers;	Yes	farming corperatives;Help youths access loans;	Yes	I would venture full time into farming	water pollution;	Nil;	No	No	People should be educated on venturing into entrepreneurship while employed
Kabundi East	6-10 years	Employment	1-5	none	other salary	business;	None;		Start cleaning the community;	Yes	By engaging in entrepreneurship activities	Prostitution;	Calling for workshops and sensitization;	No	No	The mines should develop the area by empowering members of the public
Kabundi East	More than 25years	Born here	1-5	1-5	business	none;	None;		Increase employment;	No		Low business;	Nil;	No	No	
Nchanga North	More than 25years	Born here	1-5	none	other salary	none;	Road rehabilitation;	Yes	Increase employment;	No		Lack of water in houses;	People have resorted to boreholes ;	No	No	We need not only depend on farming but other activities such as farming
kabundi East	21-25yrs	Parents	6-10	none		none;	None;		Reduce air and water pollution;	Yes	My family has diverted into agriculture			Yes	No	Keeping the open pit and other machinery in operation
Nchanga South	6-10 years	Employment	6-10	none			None;			Yes	Because we dont work in the mine	Nothing;		No	No	

Nchanga North	16-20yrs	Parents	11-15	none	farming	business;	Cleaning the market, provision of food in hospitals;	Yes	Increase employment;Supply food and medicines to hospitals;Community empowerment;	No		Lack of employment by retrenched employees, business is affected;	Educating people on farming and business;Community engagement;	Yes	No	Mines to continue educating the community on farming and other businesses to sustain living
Riverside	More than 25years	Employment	6-10	1-5	other salary	business;	Sponsorship of sports;Road rehabilitation;Health institutions;	Yes	Give the mine to Zambians to operate and control;	No		Poor salary, lack of medicine in hospitals, poor infrastructure;	Nil;	No	No	Change the investors
Kabundi South	11-15 yrs	Employment	1-5	1-5	Mine salary	business;farming;	Childrens park;Community Empowerment;	Yes	Community empowerment;	Yes	Involved in entrepreneurship as an alternative	Low and unimproved salaries, limited time for other social responsibilities;	Community engagement;	No	No	Shouldnt just depend on mining but involve themselves in other activities
Nchanga North	6-10 years	Marriage	1-5	1-5	other salary	none;	Education sponsership;	Yes	Increase employment;	No		Human danger ;	Engaging the mines;	No	No	
Nchanga North	6-10 years	Employment	1-5	1-5	Mine salary	business;	Health institutions;	Yes	Increase employment;	No		Air pollution;Noise pollution;	Engaging the mines;	No	No	Mining of industrial minerals that can be used to build roads and infrastructure
Nchanga South	6-10 years	Employment	6-10	none	other salary	none;	Water and Sanitation;	Yes	Increase employment;	No		water pollution;	Community engagement;	No	No	Investing in real estate
Nchanga South	0-5 years	Business	1-5	none	business	farming;	Sponsorship of sports;Education sponsership;	Yes	Community empowerment;	Yes	My business and farming sustains my family	Air pollution;Human danger ;	Engaging the mines;	Yes	No	People should look for other sources of income
Nchanga North	0-5 years	Employment	1-5	1-5	Mine salary	business;	Sponsorship of sports;	Yes	Increase employment;Create recreational centres;	No		Noise pollution;water pollution;	Nil;	Yes	No	The government to create industries like manufacturing so that Chingola is not made into a ghost town
Nchanga North	21-25yrs	Family	6-10	none	farming	none;	Health institutions;Sponsorship of sports;	Yes	Increase employment;	Yes	Because i am a farmer not a miner	Air pollution;	Nil;	No	No	People should go back to farming
Kabundi South	More than 25years	Born here	1-5	none	business	farming;	Sponsorship of sports;Health institutions;	Yes	Increase employment;	Yes	My work has nothing to do with mining	land degradation;Noise pollution;Air pollution;	Nil;	No	No	People should consider farming as an alternative
Nchanga South	More than 25years	Born here	1-5	none	Retirement income	farming;	Health institutions;Sponsorship of sports;	Yes	Community empowerment;	Yes	I no longer work for the mine	Air pollution;Noise pollution;water pollution;	Nil;	Yes	No	Creation of more industries
Nchanga North	More than 25years	Employment	6-10	none	farming	none;	None;		Increase employment;	No		Cracks in buildings;Air pollution;	Nil;	No	No	
Kabundi East	11-15 yrs	Employment	1-5	none	other salary	none;	None;	No	Increase employment;	Yes	I am a teacher	water pollution;Children not coming to school due to illegal mining activities;	Nil;	No	No	People should go back to school and change careers
Lulamba	More than 25years	Marriage	1-5	none	other salary	none;	Road rehabilitation;	Yes	Community empowerment;	No		Air pollution;				