ENVIRONMENTAL EFFECTS OF MINING ON LOCAL COMMUNITIES IN KITWE AND MUFULIRA IN COPPERBELT PROVINCE, ZAMBIA

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DECLARATION

I Siame Kennedy declare that this dissertation is my own work that it has not been submitted before for any degree or examination in any other university or institution of learning.

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APPROVAL

This dissertation entitled: 'Environmental effects of mining on local communities in Kitwe and Mufulira in Copperbelt province' was done under my supervision and has been submitted to the College of Education Open and Distance e-Learning of Kampala International University with my approval as the supervisor.

Signature: .....

Date.....08/12/18.....

Ass. Prof. Ijeoma, Anumaka Blessing.

DEDICATION

To my wife Hildah Siame, my daughter Tinah and my son Wizah, this comes, I give to honour you for being the source of inspiration and for your relentless support.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

CBOs	Community Based Organizations
GDP	Gross Domestic Product
GIS	Geographic information Systems
mg/Nm3	Milligrams per cubic metre
NGOs	Non-governmental Organizations
Ng/m³	Nano gram/cubic meter
Nm³/hr	Normal Meter Cubed per **Hour**. Unit used to measure gas flow rate.
pH	Potential hydrogen
Ppm	Parts per million
TCo	Total Cobalt
TCu	Total Copper
TDS	Total Dissolved Solids
Tpa	Tissue plasminogen activator
TSS	Total Suspended Solids
WHO	World Health Organization
ZCCM	Zambia consolidated Copper Mines Limited
ZEMA	Zambia Environmental Management Agency

ABSTRACT

With the focus of the mining companies remaining on profit making, environmental pollution on the surrounding communities is what has characterized mining in Zambia. It is for this reason that study aimed at determining the environmental effects of mining on local communities in the Copperbelt province of Zambia. The study was guided by three objectives which were translated into three research questions; examine the methods of mining, establish the environmental effects of mining on local communities and design a model for the mitigation of environmental effects of mining on local communities in Kitwe and Mufulira. The study used a case study design by incorporating mining sites (quadrants). The assessment was made using primary data collected from a sample of 96 key informants and 5 mining sites of $2Km^2$ from where samples of soil, water and vegetation where collected. Furthermore vegetation analysis was done basing on the 5 mining sites. The chemical species tested, took into consideration the analysis of Copper, Cobalt, Lead, Sulpher dioxide, dust, Total Dissolved Solids and Total Suspended Solids for air, soil and water pollution. The analysis was done using frequency distributions, trend surface analysis using Geographic Information Systems and laboratory tests of all chemical species was done and concentrations were compared with World Health Organization and Zambia Environmental Management Agency limits for air, soil and water. The results showed that the concentration of the elements (Pollutants) in soil and air were above the limit and water elements were below the World Health Organization and Zambia Environmental Management Agency limits. Furthermore, results reveal that the current mining methods practiced in Kitwe and Mufulira mining towns is underground and surface mining, which are yet to pose a serious risk and change to the natural resources in the mining areas /communities since there is continual clearance of forest cover, erosion, formation of sinkholes and contamination of the environment by chemicals from mining processes and products. With regards to the effects of mining environmentally, the finding reveal that the effects are localized and that at local level, the uncontrolled digging and abandoning of pits has caused destruction of land beyond economic and technical reclamation. Generally, mining contributes to environmental degradation, displacement of settlements. The finding further reveals that more needs to be done by responsible agencies and the state in order to curb environmental degradation and other problems that arise from mining activities. To this end, targeted interventions such as sensitization of the general public and formation of new environmental laws and policies that will promote sustainability of the environment are recommended. The study recommends the government should enact a legislative instrument that gives local communities adequate legal backing to fully participate in environmental decisions, management and protection that affect their lives and development.

CHAPTER ONE
INTRODUCTION

1.0 Introduction

This chapter presents the background of the study in four perspectives, historical, theoretical, conceptual and contextual perspectives or backgrounds. It also presents the statement of the problem, study objectives, research questions, and scope of the study. The arrangement of the chapter follows the outline proposed in this section.

1.1 Background of the study

Mining is a chief economic activity in many less developed countries. Operations, of any kind (small or large-scale), are naturally upsetting to the environment, generating massive amounts of waste that can have harmful effects for decades. The environmental deterioration caused by mining occurs mainly as a result of inappropriate and wasteful working practices and rehabilitation measures (Hilson, 2002; McCurdy, and Keresztes, 2012). Mining causes substantial environmental and social harm, it depletes water supplies, pollutes the air, soil and water, and destroys ecological systems. Mining also destroys arable land, leading to a decline in food security (Petkova-Timmer, Lockie, Rolfe, & Ivanova, 2009). As indicated by Noronha (2001:65), the social and environmental impacts are more persistent in regions where operations are newly established or are closing down. Albert (2015), has commented on the potentially hostile effects of mining, which include displacement of local people from ancestral lands, marginalization, and oppression of people belonging to lower economic classes.

1.1.1 Historical Perspective

Mineral exploitation contributes significantly to economic growth and development in most world economies. Globally, Zambia is the seventh largest copper producer in the world and in Africa it is ranked second (International Copper Study Group, 2014). In Zambia mining contributes the chief of the country's GDP. The mining sector in Zambia consists of both small-scale and large-scale mining, each of which has unpredictable environmental and social effects.

Zambia has a stretched history of mining due to its rich resources of mainly copper and cobalt. The previously state-owned mines have been privatized and for the last decade

the government has encouraged foreign investments in the mining sector as a way of advancing the country's economic activity. Mining in developing countries like Zambia can however be a treasure or a trouble depending mainly on factors like institutional stability, economic management and overall management of the sector itself (World Bank and International Finance Corporation , 2002). An often neglected fact in countries struggling against poverty is that mining has a momentous, and quite often severe, effect on its surrounding. For a developing mining nation like Zambia, it is therefore obvious that environment and development are not separate challenges; instead they are unavoidably allied.

The country's major copper fields are located on the Copperbelt province. Although records indicate that mineral exploration and exploitation in Zambia began in 1889 under the British indirect rule (Filer, 1998). There is evidence suggesting that local people, using traditional methods of mineral prospecting, produced minerals centuries before the establishment of the colonial administration. As indicated by Ghosh (2008:10), most of the deposits were discovered by the settlers with the assistance of the local scouts, who had knowledge of mineral deposits before the white settlers.

The copper industry has dominated the mining scene in Zambia for more than eight decades since the first commercial mine was opened 1928 (Simutanyi, 2008).The copper industry was gradually nationalized from 1969, and the mining operations were later run by the state through Zambia Consolidated Copper Mines Limited (ZCCM). Copper production in Zambia peaked in the early 1970s and during a short period the country saw an exceptional investment in the construction of new schools, hospitals and roads using surpluses from copper revenues. After the year 1975 the copper production declined, and the industry faced a number of challenges due to lack of investment, over-staffing, poor technology and falling copper prices. In the year 2000, the mines were privatized and ZCCM's assets were divided and sold to various investors. Zambia's government kept shares in some operations during the privatization and today still owns a minority stake in many of the mines through a holding company named ZCCM-Investment Holdings (ZCCM-IH). The government of Zambia instituted a new Mining Act in April 1999 that was conducive to foreign investment. Mineral production increased to 763 000 tons/yearly in 2013, mainly in response to the implementation of

the Trade Liberalisation Policy in 1996 and the enactment of the National Investment Act in 1999 (Simutanyi, 2008).

As indicated in the Zambia Extractive Industries Transparency Initiative, industry liberalization has been a major reason behind marketed increases in national mineral production (Stephens, 2013). Notable achievements include increased copper production reaching a peak of 769 000 tons of copper in 1969. Currently, Zambia ranks first in continental copper production ahead Congo DRC and South Africa. Whilst it is the desire of the Zambian government to diversify the economy, the Zambian copper mining industry has remained the engine that would drive this diversification for a long time to come. In the work done by International Council on Metals and Mining (ICMM), verified data from 2012 statistics show that, in that year, 86% of the foreign direct investment which came into Zambia came into the Zambian mining industry, 80% of export earnings made by the country came from the mining industry and over 25% of all revenues collected by government came from the Zambian mining industry. In terms of contribution to GDP, the mining industry contributed more than 10% and, in terms of jobs, the mining industry contributed more than 1.7% of all formal employment in the country (Roe, Dodd, Ostensson, Henstridge, Jakobsen, Haglund, Dietsche, and Slaven, 2014). Rises in mineral production has increased the contribution of the mining sector to national, Gross National Product (GDP). However, overall, mining contributes a relatively small share to national GDP, suggesting that the Zambian government, despite its successes in attracting foreign investment, it has allowed incoming mining companies to export the bulk of extracted and processed product. In fact, findings by Sardanis (2014) confirm that, "mining has provided marginal contributions to the communities surrounding operations".

However, like all other sectors, the mining sector is also grieving with its own problems and challenges. The "footprints" it usually leaves behind are terrific especially when it is not well managed because "badly managed impacts of mining on the environment or the social fabrics of society can echo negatively on economic parameters nationwide" (World Bank & International Finance Corporation, 2002: 2) and can allow many communities to become poorer with little access to resources especially when mining ventures fail (Kapelus, 2001: 1). In fact, it is observed that "to date, mining has a poor record in terms of its contribution to sustainable development, with few communities

receiving significant benefit and mining sites experiencing lasting negative ramifications" (Reed & Miranda, 2007: 15). Although in recent times most mining companies have taken giant steps in reducing or mitigating the devastation effects of their activities in the communities and areas of operation by developing comprehensive Impact Assessment studies and strategies for dealing with the effects as well as massive investment in infrastructure such as roads, hospitals, schools, electricity, water supplies etc. as a means to at least to offset some of the cost of mining activities, it is noted that most of "these communities have been victims of air and water pollution as well as other forms of environmental degradation resulting from mining operations" (Akabzaa & Darimani, 2001: 34). Mining can therefore have "decisive impact on the communities in which or near which the mines are located" (Anyemedu, 1992 cited in Akabzaa & Darimani, 2001: 34).

Though it is true that economies need these mineral resources and the profits accruing from them to satisfy their basic needs, it is also true that the continual exploitation of the mineral resources is destroys the livelihoods and environments of the communities where mining activities or operations are carried out and had been the root cause of civil unrest and wars, widespread human right abuses, environment that leads to increased pollution of the food chain, deforestation as well as forest degradation in many communities and countries (Dungan, and Murphy, 2014; Gualnam, 2008:1).

1.1.2 Theoretical Perspective

The theoretical perspective adopted for this study was derived from the 'resource curse theory' developed and coined by Richard Auty in 1993. This theory describes the paradoxical outcome of natural resources being a curse, rather than a blessing. It holds that resource-rich countries tend to perform relatively poorly on overall economics, socially, environmentally and good governance in comparison with non-resource-rich countries (Sachs and Warner 2009). The theory is relevant because it takes a holistic view of mining as a product natural resource extraction which creates havoc social, environmental and economic development of mining activities in countries (Rachdi, 2015). Other authors have demonstrated the theory and termed it 'Local Resources Theory' (Borge, Parmer, and Torvik, 2013).

1.1.3 Conceptual Perspective

The dependent variable of the study was environment. The independent variable under this study is mining. Environment means the aggregate of social and cultural conditions that influence the life of an individual or community (webster, 2018). Douglas & Holland (2014) stated that environment is a word which describe in aggregate, all the external forces, influences and conditions which affect the life, nature, behavior and growth, development & maturation of living organism. The definition of "environment" used in this study is the sum total of all surroundings of a living organism, including natural forces and other living things, which provide conditions for development and growth as well as of danger and damage.

Hinde (2010) defines mining as an activity, occupation, and industry concerned with the extraction of minerals or other geological materials from the earth. Accordingly mining is the process of extracting of valuable minerals from the ground/earth's crust (Wambugu, Gachang'i, Ouma, and Gladys, 2001). In this study, mining includes the activities or business of processing and extracting mineral ores from a mine/ underground.

1.1.4 Contextual Perspective

In Zambia mining has been the backbone of the Zambian economy. With poor Government Investment Policies, the government has allowed the foreign investment to continue mining in order to sustain the Zambian economy though with poor mining methods and poor technology of processing (Simutanyi, 2008). Zambia being the second largest copper producing country in Africa has over 35 mines which are mainly found in the Copperbelt province of Zambia (Ministry of Mines and Mineral Development, 2015). Kitwe and Mufulira are among the big mining towns of Zambia on the Copperbelt province and the towns are blessed with abundant natural resources which have been of minimal benefit to local community and a curse at the same time. Contextually, the research provided understanding on the environmental effects that mining unleash on local mining communities.

1.2 Statement of the problem

Mining plays a vital role in the socio-economic development of any society (Walser, 2004). However, the position of mining remains controversial and true sustainable socio-economic is not just a matter of improvement of people's lifestyles through income

flows, education and skill development. With the focus of the mining companies remaining on profit making, environmental damage and land displacements on the surrounding communities is what have characterized mining in Zambia. Most communities suffer various environmental and social challenges including repeated pollution or contamination of their domestic water and land resources, unclean air causing a variety of lasting respiratory complications and damaged or run down social and economic infrastructure such as recreation facilities and roads due to heavy traffic of trucks carrying copper. This scenario has resulted in poor health conditions on both the physical environment and the residents of Kitwe and Mufulira towns (Christophe, 2009). Therefore this study captured the environmental challenges faced as a result of mining activities in the mining towns of Zambia's Copperbelt province. The study focuses its attention on determining the environmental effects of mining on local communities where mining operations are carried out with specific attention on Kitwe and Mufulira mining towns of Zambia. Few studies are available on the mining sector in Zambia and no known studies on the environmental and social impact as one theme.

1.3 Objectives of the study

1.3.1 Aim of the study

The aim of the study was to determine the environmental effects of mining on local communities in the Copperbelt province of Zambia.

1.3.2 Specific objectives

The specific objectives of this study were:

1. To find out the methods of mining in Kitwe and Mufulira.
2. To establish the environmental effects of mining on local communities in Kitwe and Mufulira.
3. To design a model for the mitigation of environmental effects of mining on local communities in Kitwe and Mufulira.

1.4 Research Questions

The following research questions guided the study;

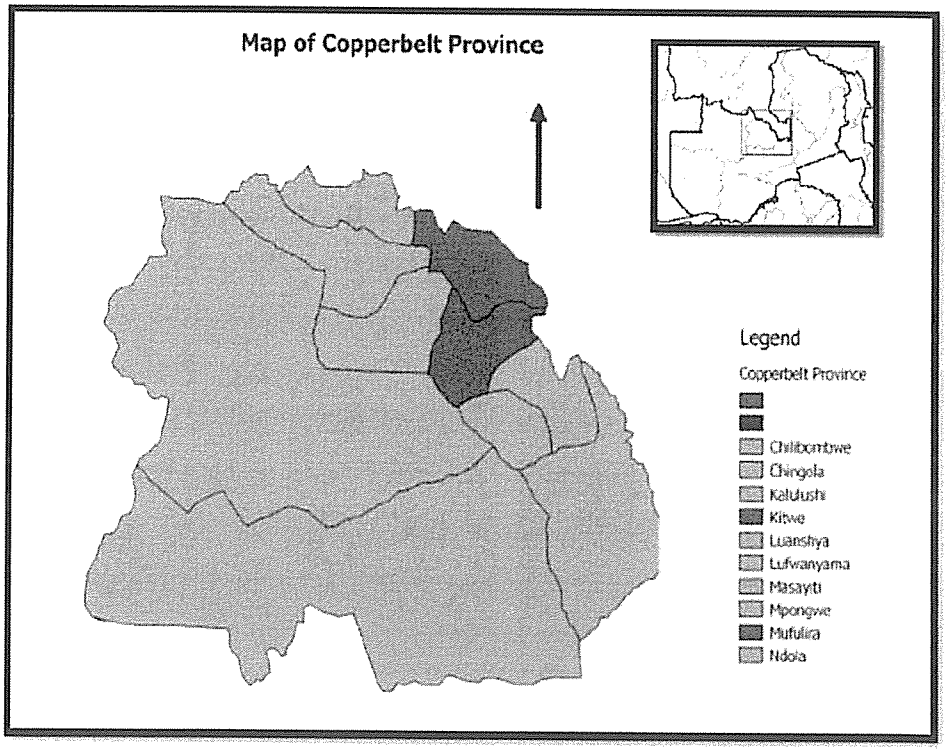
1. What are methods of mining in Kitwe and Mufulira?
2. What are the environmental effects of mining on local communities in Kitwe and Mufulira?

3. What model could be designed for the mitigation of environmental effects of mining on local communities in Kitwe and Mufulira?

1.5 Scope of the study

1.5.1 Geographical scope

Kitwe and Mufulira ("Places of Abundance") are towns with populations of 691, 193 and 177,500 (2017) respectively in the Copperbelt Province of Zambia. The towns were established in the 1930s around the site of the Mufulira Copper Mine on its north-western edge (Central Statistical Office Zambia, 2017). The Mufulira town lies between 28°13' 49°57'' E and 12°31' 55'' S while Kitwe towns lies 28°12' 47" E and 12°48' 08" S of the Copperbelt province of Zambia (SRK Consulting, 2008). Generally, the altitude of Kitwe and Mufulira is 1288 meters and topography between elevations of 1,250 and 1,400 meters (Mopani Copper Mine, 2009). Mufulira area is drained by a number of streams such as Mufulira, Luansobe, Butondo, Mupambe and Kansuswa which eventually discharge into the Kafue River located about 15 km to the west of the Mufulira town (Mopani Copper Mine, 2008), while Kitwe is drained by Kafue river and some other streams. The geographical location of Kitwe and Mufulira towns is shown in figure 1.



Source: Developed by the researcher, 2018

Figure 1.1 Map of the Copperbelt Showing the study area

1.5.2 Content scope

The study focused on investigating the environmental effects of mining on local communities in Kitwe and Mufulira in Copperbelt province in Zambia. The major concepts investigated included: methods of mining in Kitwe and Mufulira; environmental effects of mining on local communities in Kitwe and Mufulira; and model for the mitigation of environmental effects of mining on local communities in Kitwe and Mufulira.

1.5.3 Time scope

The study was carried out for one month in July, 2018.

1.5.4 Methodological scope

The study was qualitative and conducted in July 2018 using a case study design and purposive sampling technique. A sample of 96 respondents was selected for the study. The respondents included medical doctors, community leaders, environmental health technicians, principals of colleges, communications officers of mines, spokes persons of local government and shift boss miners of Kitwe and Mufulira. The data were collected using interviews, observations and laboratory test [for primary data] and documents analysis [for secondary data].

1.6 Significance of the Study

Studies on mining in the Copperbelt of Zambia have mainly concentrated on economic benefits. Data on environmental effects of mining in the Copperbelt are sketchy and often generalized (e.g. by Simutanyi, 2008; Hinde, 2010; Nyambe, 2017; Stephens, 2013). Thus there was need to generate the specific data on the environmental effects of mining on local communities in Kitwe and Mufulira. It is hoped that this study would yield data that would be useful for proper planning and institutionalisation of a framework for action into the woes that afflict the local communities in the mining areas. The findings, conclusions and recommendations would hopefully benefit city planners, economic policy makers, service providers, campaigners against poverty, politicians, non-governmental organisations, environmentalist, activists, investors and opinion leaders to base their decisions and actions on concrete knowledge of issues supported by research other than subjective judgements. The researcher also hopes that the study would form the basis for further research on environmental effects of mining.

CHAPTER TWO

LITERATURE REVIEW

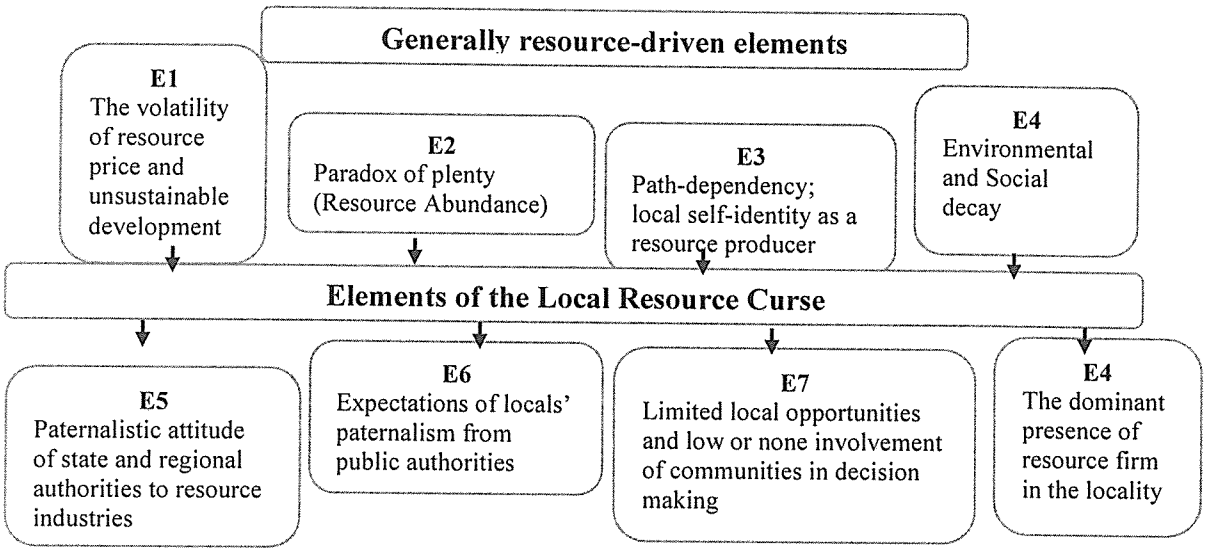
2.0 Introduction

This chapter contains a review of literature that relates to the topic of study and the theoretical framework which influenced the direction which the discussion of the findings took. The literature review is divided into six major sections namely, theoretical framework, conceptual framework, methods of mining, environmental effects of mining, mitigation of environmental effects of mining and gaps identified

2.1 Theoretical Framework

The theoretical framework adopted for this study is derived from the 'Resource Curse Theory' developed and coined by Richard Auty in 1993. This theory describes the paradoxical outcome of natural resources being a curse, rather than a blessing. It holds that resource-rich countries tend to perform relatively poorly on overall economics, socially, environmentally and good governance in comparison with non-resource-rich countries (Zuo, and Schieffer, 2014). Hence, the resource curse does not necessarily refer to countries being cursed as a result of their resources, but cursed as a result of the leadership (Duruigbo, 2005). The Resource Curse Theory has to be approached from a different viewpoint as one has to explain how the current way of resource extraction represents a challenge for sustainable socio-economic and environmental local development. This idea encouraged the researcher to hypothesize that local level obstacles to sustainable socio-economic development, which could benefit from the comprehensive use of the human, natural resource and environmental potential of the community, can be explained by a modified version of the Resource Curse Theory known as 'Local Resource Curse Theory'.

Local Resource Curse Theory serves as a tool to identify the elements that describe the incomplete nature of local development, which could be improved by changes in the interrelations between policies and practices of the state, the region, resource firms and local actors in the community (Suutarinen, 2015). Basing on the modified version of 'Local Resource Curse Theory', the theory has eight elements which are grouped into two, namely; general resource-driven elements and elements of the Local Resource Rurse as show in the figure 2.1 below.



Source: Suutarinen, 2015

Figure 2.1 General resource-driven elements and elements of the local resource curse

For this study the researcher only opted to adopt the E4 and E7. With reference to E4, Environmental degradation and social decay is an obvious local level consequence of extensive resource extraction. It has a direct influence on the quality of life in resource communities. Moreover, environmental degradation hampers other land use activities around the resource extraction areas, such as the traditional land use of indigenous people. This is evident especially in the oil and gas regions of the Russian North where the reindeer herding of indigenous people often collides with resource industries (Stammler, & Peskov, 2008). However, the consequences of environmental degradation for sustainable socio-economic development vary between different resource communities. In resource communities with obvious diversification potential, for example, into tourism, environmental degradation can hamper these opportunities. However, if there was no settlement before resource extraction began, the community would be created because people came to work in the local industry, and they get used to the fact of a certain level of environmental degradation in their community. Environmental degradation is to a certain extent tolerated and taken as 'normality', that is, as an inevitable consequence of the resource industry (Bolotova 2012: 667).

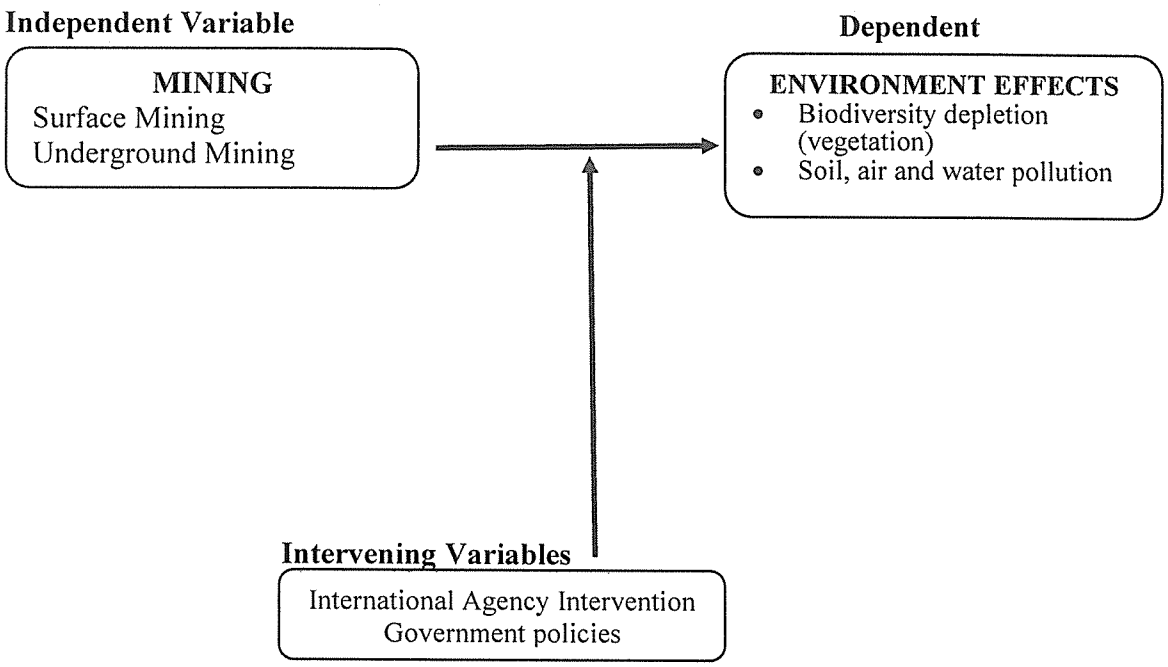
Under E7 the state prolongs this domination because it relies on the exports of materials produced by resource regions and communities. Moreover, also the dominance of external resource corporations and their policies in the resource communities restrict local opportunities to influence local development. Local firms usually operate at the beginning of the production chain and their products are processed in other regions (Carson & Carson 2011: 374). This has resulted in only minor benefits which do not translate the resources abundance to high economic benefit of the local communities as they are not engaged in decision making process by the state.

2.2 Conceptual Framework

Under this section, the researcher adopted conceptual framework on the environmental effects of mining on local communities. Within the framework of environmental sustainability, which emerged from the concept of sustainable development. Environmental sustainability in development has become a cardinal principle in developmental processes all over the world. The need to plan, organise, control, regulate and manage the available natural resources is vital if development and growth are to be achieved in a sustainable way. The concept of sustainable development came into prominence in 1980, when the International Union for the Conservation of Nature and Natural Resources (IUCN) presented the World Conservation Strategy (WCS) with the overall aim of "achieving sustainable development through the conservation of living resources". It became a global tool in 1987, after publication of the report of the World Commission on Environment and Development (WCED). The popularly accepted definition of sustainable development is "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development. , 1987). The implication of this definition is that development must not endanger the natural systems that support life on earth (the atmosphere, water, soils and the living beings). The concept has been put forward as a framework within which we can balance immediate and long-term human demands and the health of the environment, both now and in the future. This concept is particularly important in developing countries such as Zambia as it stresses that renewable natural resources should be treated as production factors which need to be used and maintained in a sustainable manner. There is a strong emphasis on intergenerational equity. Thus, exploitation of resources, investment patterns,

technological development and institutional changes must all incorporate environmental concerns and balance resource use and prevention of destruction. The most important characteristic of sustainable development is the emphasis on the interdependence between development and resource conservation. This paradigm constitutes a clear departure from the old ways of thinking, when natural resources only attracted attention once problems such as pollution and land degradation emerged (Colby, 1990).

Mining methods such as underground and surface mining affects the natural environments of the mining areas and beyond. The major impacts are environmental degradation such as biodiversity depletion (vegetation and wildlife), soil, air and water pollution. However, the effects of mining activities on the environment depends on international Agency Interventions and government policies. Figure 2.2 Effects of mining activities on the environment.



Source: (Aragon, Punam, and Bryan, 2015)

***Figure 2.2* Effect of mining activities on the environmental and social conditions**

2.3 Mining Methods

Mining methods are divided into two common excavation types; Surface and Sub-surface (underground) mining. Some mining, including much of the rare earth elements

and uranium mining, is done by less common methods, such as in-situ leaching; this technique involves digging neither at the surface nor underground (Kotsadam, 2015). The extraction of target minerals by this technique requires that they be soluble e.g. potassium chloride, sodium chloride etc, which dissolve in water. Other minerals such as copper minerals and uranium oxides, require acid or carbonate solution to dissolve (Stephens, 2013).

2.3.1 Surface Mining

Surface mining is done by removing (stripping) surface vegetation, dirt and layers of the bedrock in order to reach buried ore deposits. The techniques of surface mining includes; open pit, strip and mountaintop removal mining (Mopani Copper Mine, 2009). "Opencast mines are dug on an angle less vertical, to prevent and minimize damage and danger from rock fall, large scale surface mining have a haul road". Haul Road is situated at the sides of the pit forming a ramp which trucks can drive carrying ore and waste rock.

2.3.2 Underground Mining

Underground or Sub-surface mining consists of digging tunnels or shafts into the earth to reach buried ore deposits. Ore, for processing and waste rock for disposal are brought to the surface through the tunnels and shafts. Subsurface mining can be classified by the type of access shafts used, the extraction method or the technique used to reach the mineral deposit (Graff-Zivin, Joshua, and Matthew Neidell, 2012). Drift mining utilizes horizontal access tunnels, slope mining uses diagonally sloping access shaft and shaft mining utilizes vertical access shafts. Other methods includes; shrinkage slope mining, long wall mining, room and pillar mining (International Copper Study Group, 2014).

2.4 Environmental effects of mining

The environmental impact of mining makes headline news far too often and is one of the main drivers of the general negative perception towards mining. Mining and mineral processing can generate several types of negative externalities impacting local community welfare. For instance, these activities can generate significant amounts of air pollutants from dust from blasting and earth-moving operations, fumes from smelters and refineries, and exhaust of gasoline engines of heavy machinery. If toxic emissions are relatively large, they can deposit on the ground as acid rain, which contributes to soil

degradation and can have cumulative negative effects (Menz, Fredric C., and Hans M. Seip, 2004). Mining activities can also release industry-specific pollutants, such as cyanide, sulfuric acid, mercury, heavy metals, and acidic drainages (Dudka and Adriano 1997; Salomons 1995). These pollutants can have negative, cumulative effects, on quality of soil and water sources. Similarly, small-scale and artisanal mining operations can pollute air and water. The most notorious example is pollution from mercury used in gold amalgamation. The common environmental impacts from mining operations are summarized in Table 1 below.

Table 2.1 Common environmental impacts from mining operations

Activity	**Environmental Impacts**
Mineral Extraction	Vegetation and habitat destruction
	Erosion
	Landform changes
	Alteration of water tables
	Dust
	Aesthetics
Water Discharge	Heavy metals overloading
	Acid Mine Drainage
Dewatering	Sediment runoff
	Effluent contamination
	Ecological impacts
	Impacts on water resources
Smelting	Acid deposition
	Air pollution
	Heavy metals contamination
Transportation	Dust and sediment pollution
	Noise pollution
	Gaseous emissions
	Oil and fuel spills
	Soil contamination
	Gaseous emissions

(Hilson & Murck, 2000: 229)

From the research conducted in Tanzania by Kitula (2006) who posits that, environmental pollution is a major problem in the mining areas of Geita District. Continuous disposal of mine wastes contributes to air and water contamination, which are detrimental to human health, livestock and wildlife biodiversity, and have serious effects on the welfare of the mining communities, especially groups of women and children. The health and safety of miners and the nearby communities are at risk from a variety of factors, ranging from the inhalation of mercury fumes and dust, to water contamination and poor safety procedures. Unprotected pits, for instance, during the rainy seasons, form breeding grounds for disease vectors such as mosquitoes and housefly the agents that spread malaria and water borne diseases. In the study from the Bowen Basin in Queensland, Australia stakeholders indicated various physical forms of negative impacts from mining activities such as coal dust, vibrations from blasting and the noise from trains (Ivanova *et al*, 2007: 219).

According to Akabzaa and Darimani (2001) in their study points out that, extensive areas of land and vegetation in Tarkwa have been cleared to make way for surface mining activities. Currently, open pit mining concessions have taken over 70% of the total land area of Tarkwa. It is estimated that at the close of mining a company would have utilized 40-60% of its total concession space for activities such as siting of mines, heap leach facilities, tailings dump and open pits, mine camps, roads, and resettlement for displaced communities (Akabzaa and Darimani, 2001). This has momentous adverse impact on the land and vegetation, the main sources of livelihood of the people. There is already a scramble for farmlands in Atuabo and Dumasi. In most parts of Tarkwa, the environment is undergoing rapid dreadful conditions and its immense economic value is dwindling from year to year, due mainly to the heavy concentration of mining activities in the area. Agricultural lands are not only generally degraded, but the loss of land for agricultural production has also led to a shortening of the fallow period from 10-15 years to 2-3 years. The traditional bush fallow system, which sufficiently recycled substantial amounts of nutrients and made the next cycle productive, can no longer be practised due to insufficiency of land. Large-scale mining activities generally continue to diminish the vegetation of the area to levels that are vicious to biological diversity (Akabzaa and Darimani, 2001).

Furthermore another study conducted in Ghana on the impact of mining on the environment shows that agricultural production could be affected by mining activities in several ways (Aragon, F. M, Punam, C. P and Bryan, C. L, 2015). Mining could lead to a rise in local wages, reduce profit margins in agriculture, and lead to the exit of many families from farming something akin to a localized Dutch disease problem. Negative environmental spillovers such as pollution (as found by Aragon, F. M, Punam, C. P and Bryan, C. L 2015) or local health problems could also dampen productivity of the land and of the farmers, and thereby reduce the viability of farming. Alternatively, mining could create a mini-boom in the local economy through higher employment and higher wages that can lead to an increase in local area aggregate demand, including for regional food crops. Rud (2015) in his research further asserts that, "another possible important pollution externality is the loss of agricultural productivity" One is through directly affecting crop health and growth, which translates into lower yields. Another is through degrading the quality of key agricultural inputs, such as soil and water (Menz and Seip 2004; U.S. Environmental Protection Agency 2012). For instance, deposition of air pollutants in the form of acid rain can lead to soil degradation. The increased acidity leaches nutrients from the soil, reduces plants' ability to absorb remaining nutrients, and releases toxic metals, like aluminum. Finally, air pollution can reduce labor productivity (Chang et al. 2014; Graff-Zivin and Neidell 2012). The loss of agricultural productivity can have a negative impact on agricultural output, and, through that channel, affect income of farmers and rural populations. This externality can be particularly relevant.

Akabzaa (2009) in his study also embraces that, "deforestation that has emanated from surface mining has long-term effects even when the soil is replaced and trees are planted after mine decommissioning". The new species that might be introduced have the potential to influence the composition of the topsoil and then determine soil fertility and fallow period for certain crops. In addition to erosion when surface vegetation is depleted, there is deterioration in the viability of the land for agricultural activities and loss of habitat for wildlife. This has degenerated into destruction of the luxuriant plant life, biodiversity, cultural sites and water bodies, as strongly supported by (Akabzaa and Darimani, 2001).

A similar research was conducted in Botswana by Kwesi (2015) also populates that, "the physical environment suffers severely in terms of the destruction of vegetation, soil and

water pollution, displacement of wildlife from their natural habitat. The more recent environmental issues associated with mining include use of toxic chemicals, disposal of hazardous waste, accidents, and release of ozone depleting substances and greenhouse gasses". This is in line with the findings of the researchers Akabzaa and Darimani, 2001; Kitula, 2006; Hilson and Murck, 2000; Opoku-Ware, 2010; Aragon e'tal, 2015 and Akabzaa 2009. The environmental effects of mining are very complex in nature; mining does not only destroy the existing vegetation on the ground but it also affects the air quality, surface water and ground water, land resources, noise and vibration and socio-economic status (Simutanyi, 2008). With regards to Simutanyi (2008), the findings from the study conducted by Albert etal (2015) in Ghana also showed that mining activities, especially that resulting from illegal small-scale mining (popularly known as *'galamsey'*) deplete environmental resources such as water, soil, the landscape, vegetation, the ecosystem, among others.

2.5 Mitigation of environmental effects of mining

Protection of environmental quality with respect of pure air, water and soil is important for environmental sustainability. A reduced carbon foot print initiative with plants could help reducing the impacts of mining to environmental components. Tripathi et al. (2011, 2014) studied the role of revegetated mine spoils as a sink of carbon dioxide which improves the aesthetic environment and ecology.

Environmental Impact Assessment (EIA) is a tool applied primarily to prevent or minimise the adverse effects, and maximise the positive effects, of mining activities from the inception to closure stage (ERM, 2003).

Mitigation for soil impacts includes the use of best management practices during operational phases and a reclamation plan for re-establishment of viable soils and vegetation at closure. To conserve the soil sustainably, top soil has to be removed and kept separately for its use in reclamation and revegetation.

In addition, the effective soil treatment approaches depend upon better understanding of the risks associated with metals in mine wastes. Organic amendments and biofertiliser accelerates the revegetation with native plant species, biological and chemical

stabilisation of overburden dumps. Recent studies have also shown that the application of chitosan to contaminated soil can remediate the heavy metal contamination and reduce the bioavailability of metals to plants (Tripathi et al., 2016).

For dust attenuation, role of native plant species was studied and it was delineated that the broad leaved native dry deciduous tree species such as Albizzia lebbeck, Tectona grandis, Dalbergia sissoo have great potential to reduce dust in mining areas (Singh 2005). Chaulya et al (2002) indicated that maximum dust is generated from the haul road. Effective green belt development has to be developed in different tiers for preventing the dust out of core and buffer zone of mine area. Alstonia scholaris and Tectona grandis have been found to remove 21.50 and 12.34 g/m_2 of dust from the mine area site of BCCL (Singh and Tripathi, 2005).

Recent study of revegetated mine spoil indicated that mine spoil acts as sink of carbon dioxide offset rate by 9.4 Mg ha-1 yr-1 by carbon sequestration from the atmosphere, after 19 years of revegetation (Tripathi et al 2014). It is a substantial amount to clean the air environment of mining areas.

Mitigation measures to reduce the effects to water include: Staged development of the tailings storage facility so that the amount of water sent to the processing plant is minimized. Return of disturbed areas to natural runoff conditions as soon as possible (Singh, Srinivas, and Naik, 2015).

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter outlines the methodology that was used in this study. It constitutes the following: research design, target population, sample size, sampling techniques, types and sources of data, data collection methods, data analysis and ethical considerations.

3.1 Research design

The study adopted a case study design whereby Kitwe and Mufulira were considered as case studies for an intensive, descriptive and holistic analysis in order to gain an insight into larger cases about environmental effects of mining on local communities.

3.2 Target population

The target population includes all the mining sites in Kitwe and Mufulira in which the respondents would comprise of medical doctors, environmental health technicians, community leaders, shift boss miners, teacher education college principals, communications officers of mines and spokes persons of local governments.

3.3 Sampling techniques and Sample size

Non-probability sampling techniques involving purposive sampling was used to select the mining sites and respondents. The respondent were purposively selected based on their presumed knowledge on the subject of study. The aim was to collect only focused and useful data given the limited time and financial constraints. Thus the researcher deliberately decided whom to include in the sample. A sample of 96 was purposively selected and it included 23 Medical doctors, 31 Community Leaders, 13 Environmental Health Technicians, 16 Shift Boss Miners, two Principals of Colleges, six Communications Officers of Mines, two Spokes persons of Local Governments). In this case, the sample size was determined by the data saturation point instead of being fixed in advance

3.4 Data collection methods

The study used a combination of data collection techniques which were both primary and secondary.

3.4.1 Primary data

Primary data were collected using field observation, interviews, questionnaire and laboratory tests.

3.4.1.1 Observation

Non participant type of observation was used throughout the field, hand in hand with taking photographs. This method facilitated the availability of information which was not provided by other data collection methods or to validate the information gathered by other data collection methods employed in the field. A list of items to be observe was made. The list consisted of: waste management, mining pits and tunnels, water sources, infrastructure, number of women against that of men, environmental damage, and environmental management practices (Appendix A).

3.4.1.2Interviews

This instrument involved face-to-face discussions, interaction or interpersonal communication between the researcher and respondents intended to elicit opinions, attitudes, perceptions and emotions about the environmental effects of mining in Kitwe and Mufulira. Structured and unstructured questions were used in the interviews. Under the structured interviews, a formal list of open-ended questions was asked to all respondents in the same way (appendix B). For the unstructured interviews, the interviewer probed respondents and guided the interview according to their answers. During the interviews, the researcher asked questions to find out the methods of mining in Kitwe and Mufulira; to establish the environmental effects of mining on local communities in Kitwe and Mufulira; and to design a model for the mitigation of environmental effects of mining on local communities in Kitwe and Mufulira. Interviews were conducted with 96 respondents purposively selected on their presumed knowledge about the subject of study. The respondents included the medical doctors, environmental

health technicians, community leaders, shift boss miners, teacher education college principals, communications officers of mines and spokes persons of local governments. The aim was to collect focused data and data that were hard to observe in order to elicit opinions. Direct contact with the respondents also provided the researcher with the opportunity to gauge the accuracy of the answers given and seek clarifications on unclear responses by asking supplementary questions.

3.4.1.3 Questionnaire

This instrument involved both closed end and open-ended questions which the respondents had to answer in writing. The questions basically covered the main variables of the study which were methods of mining, environmental effects of mining and mitigation of environments effects of mining (Appendix C). The purpose of the questionnaire was to collect a lot of information over a short period of time and moreover majority of the respondents were literate.

3.4.2 Secondary data

Secondary data was obtained from journals, official records from central and local governments, government publications, book reports, official records and newspapers and on the internet through the use of Geographic Information Systems application (GIS) as well as other secondary sources that were available and accessible.

3.5 Data analysis

The data collected were first edited to rid of it of errors (i.e., inconsistencies). Themes [subjects of discussion] related to the objectives of the study were then created. This was preceded by the qualitative analysis (i.e., by the content analysis of the data generated by the interviews, observations and questionnaire). This involved a phenomenological approach of the deep understanding of the observed phenomena and views of the participants, literal description and narration of the emerging issues out of which authentic conclusions were made. During the interviews and observations, the researcher noted down in his diary the relevant issues (episodes, situations, events or instances) for accurate reporting. The main themes that emerged from the field notes and interviews were noted down. The data were then given identification marks or coded for easy analysis and interpretation using SPSS V20. Direct quotations from the respondents were

also adapted for accurate reporting. Data generated by the questionnaire were quantified using SPSS V20 in order to generate frequencies and percentages so as to illustrate the magnitude of the problem of study. Content analysis of the interviews and observations enabled the researcher to identify the main themes, similar phrases, relationships between variables, common sequences, differences and isolated patterns in order to reach conclusions with great authenticity.

3.6 Instrument Validity and Reliability

3.6.1 Instrument Validity

To establish validity, the instrument was given to two examination and evaluation experts to evaluate the relevance of each item in the instrument to the objectives. Content Validity Index of at least 0.7 is to be declared reasonably content valid (Amin, 2005). Validity was determined using Content Validity Index (C.V.I). C.V.I = Items rated 3 or 4 by both judges divided by the total number of items in the questionnaire.

$$\text{C.V.I} = \frac{n3/4}{N}$$

The experts rated the items on the scale; very relevant = 4, quite relevant = 3, somewhat relevant = 2 and not relevant = 1. 23 items in the instrument out of 25 were declared very and quite relevant implying that validity of 0.92 was arrived at, hence the instrument was valid.

3.6.2 Instrument Reliability

A reliability test was carried out using the Cronbach's alpha test to measure reliability of the scale with respect to variables selected. Results indicate an alpha of 0.795 which indicates that the scale had a good reliability and consistently measured.

3.7 Ethical considerations

Ethical issues were highly considered in this study. Participants were informed about the nature and purpose of the study and then consent was sought before data was collected from them. Respondents were assured of high levels of confidentiality. In addition, the respondents were informed that the information gathered was purely for academic purposes.

3.8 Limitations of the study

The study could have covered the whole of Copperbelt Province. However, the case study design and purposive sampling technique confined the study to a relatively small areas of Kitwe and Mufulira. The study was also qualitative which made the interpretation of the findings highly subjective. The tools that were used in data collection (i.e., observations and interviews) also had their own drawbacks. Further, the study was conducted for a short period of time for only one month [in July 2018] using a small sample of 96 respondents. This obviously limited the scope of the data collected. Thus, the methodological shortfalls could limit the generalisation of the study and lower its validity and reliability. Nevertheless, this study provides a fertile ground for further research on the environmental effects of mining in the Copperbelt Province.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.0 Introduction

This study investigated the environmental effects of mining on local communities specifically Kitwe and Mufulira towns, Copperbelt province of Zambia. This was after the realization that the mining activities although they were a major contributor to the economy of Zambia but had also equally negatively impacted on the environment. The challenge was how to mitigate the shortfalls of mining sustainably. The data collected were qualitatively analysed. The presentation analysis and interpretation were presented the sections are in line with the study objectives that include methods of mining, environmental effects of mining and mitigation of environmental effects of mining.

4.1Demographic characteristics of Respondents

The study had a total of 96 respondents of which 23 were Medical doctors, 13 Community Leaders, 31 Environmental Health Technicians, 4 Principals of Colleges, 6 Communications Officers of Mines, 2 Spokes persons of Local Government and 16 Shift boss miners.

4.1.1 Background information of Respondents

The characteristics assessed included residence, sex, marital status, Education attainment, Occupation and number of years in the community of residence. Table 4.1 presents distribution of respondents by the above mentioned characteristics.

Table4.1 Distribution of respondents

Characteristics	Frequency (n)	Percentage (%)
Residence		
Kitwe	44	45.8
Mufulira	52	54.2
Sex		
Male	59	61.5
Female	39	38.5
Marital Status		
Single	27	28.1
Married	62	64.6
Divorced	7	7.3
Education Attainment		
College	16	16.7
University	80	83.3
Occupation		
Medical Doctors	23	24.0
Environmental Health Technicians	31	32.3
Community Leaders	13	13.5
Shift Boss Miners	16	16.7
Principal of Education Colleges	5	5.2
Communications officers of mines	6	6.3
Local Government Spokes persons	2	2.1
Number of years in the community of residence		
1 to 5	24	25.0
6 to 10	14	14.6
11 to 15	8	8.3
16 to 20	31	32.3
21 to 25	15	15.6
26 to 30	0	0
31 to 35	4	4.2
Total	**96**	**100.0**

Results in Table 4.1 show that Mufulira mining town had the highest number of respondents with 54.2% while Kitwe had the least with 45.8%. Males constituted the largest proportion of respondents with 61.5% while females constituted only 38.5%. The results also shows that majority of the respondents were university graduates with 83.3%, leaving only 16.7% for College graduates. Results further shows that majority of the respondents were Environmental Health Technicians with 32.2% followed by Medical doctors with 24.0% and the least respondents were Local Government's Spokes persons with 2.1%. Finally, most respondents 32.3% had 16 to 20 years of residence in the community followed by 1 to 5 years of residence and only 4.2% had 31 to 35 years of residence.

4.1.2 Age of Respondents

Table4.2 Distribution of age

Age group (in years)	Frequency (n)	Percentage (%)
20 to 29	13	13.5
30 to 39	64	66.7
40 to 49	15	15.6
50 to 59	4	4.2
Total	**96**	**100.0**

Table 4.2 shows that age group of 30 to 39 dominated the distribution of respondents with 66.7% followed by the age group 40 to 49 years of age with 15.6% and the least was 50 to 59 years of age. The reasons for the age group 30 to 39 to record the highest percentage is that majority of the economically active falls in this age group and the are always eager to working in urban environments while the reason for the age group 50 to 59 to record the least percentage could be attributed to the fact that the life expectancy for Zambia is low standing at 45 years.

4.2 Methods of Mining in Kitwe and Mufulira

The first objective of the study was to find out the methods of mining in Kitwe and Mufulira. To achieve this objective respondents were asked their views about the methods of mining in Kitwe and Mufulira. The data on this objective where analysed under the question: what methods of mining are used in Kitwe and Mufulira.

The study revealed that numerous methods of mining are employed in the Copperbelt. Among these included; underground, surface and drift mining.

Table 4.3 Methods of mining

	Frequency (n)	Percentage (%)
Surface Mining	4	4.2
Underground Mining	49	51.0
Surface Mining and Underground Mining	43	44.8
Total	**96**	**100.0**

With regards to table 4.3 the nature and methods of mining activities in Kitwe and Mufulira towns of the Copperbelt province of Zambia, involves underground mining with 51.0%, followed by Surface mining and Underground mining with 44.8% and the least is surface mining with 4.2% of respondents. The reasons as to why underground mining records the highest percentage is because it is the most common method used in the mining industry in Zambia and 95% mines are underground mines.

4.2.1 Underground mining

According to the finding majority of the responds cited that underground mining is the most common mining method used in Kitwe and Mufulira. This can be validated by the shift boss miners who said,

> *"The work environment underground was heavily polluted. It is very dark, hot and wet. This makes their work unpleasant and extremely difficult. So we rely on the head lumps to talk to each other. There is poor ventilation and we go with our water bottles...even when you go with an ice block of water underground within two minutes the ice block turns into hot water" (Shift Boss Miner).*

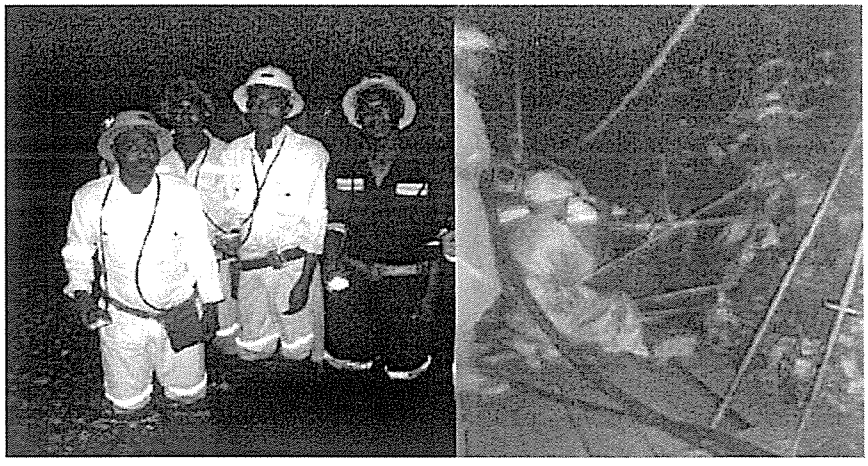


Figure 4.1Underground, Copperbelt, Zambia

4.2.2 Surface mining

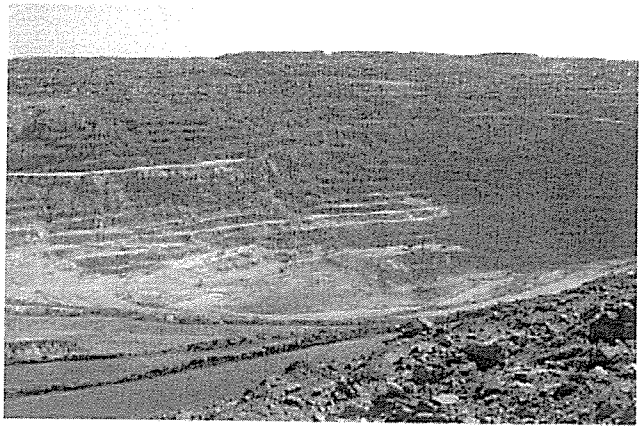


Figure 4.2 **Surface mining, Copperbelt, Zambia**

Surface mining was also cited as another method of mining in Kitwe and Mufulira, this method of mining involves the extraction of minerals from the surface of the earth.

4.2.3 Methods of operations by mining companies have effects on the environment.

Table 4.4 Methods of operations by mining companies have effects on the environment

	Frequency (n)	**Percentage (%)**
Yes	96	100.0
Total	**96**	**100.0**

The results revealed that 100% of the respondents agreed that specific methods of operation by mining companies have effects on the environment. This implied that mining methods practiced in Kitwe and Mufulira has led to the destruction of the environment in terms of biodiversity, air, soil and water.

4.3 Environmental effects of mining on local communities of Kitwe and Mufulira

The second objective of this study was to establish the environmental effects of mining on local communities in Kitwe and Mufulira. To achieve this objective, respondents were asked to give their views on the environmental effects of mining on local communities in Kitwe and Mufulira? The data on this objective was analysed under the question: What are the environmental effects of mining on local communities in Kitwe and Mufulira? The results showed land degradation, vegetation depletion, water, air and noise pollution.

Table 4.5 Environmental effects of mining

	Frequency (n)	Percentage (%)
Land degradation	40	41.7
Vegetation depletion	14	14.6
Water pollution	17	17.7
Air pollution	13	13.5
Noise pollution	12	12.5
Total	**96**	**100.0**

Results in Table 4.5 above show that land degradation was the most adverse environmental effect of mining with 41.7% of respondents followed by water pollution with 17.7% and the least being noise pollution with 12.5%. The reasons to why most of the respondents cited land degradation, water pollution and vegetation depletion as the major effects of mining is because mining takes up space for activities such as sitting of mines, heap leach facilities, trailing dump and open pits, mine camps, roads and resettlement for displaced communities. This has momentous adverse impact on the land and vegetation, the main source of livelihood of the people. The above results can be evidenced by figure 4.3

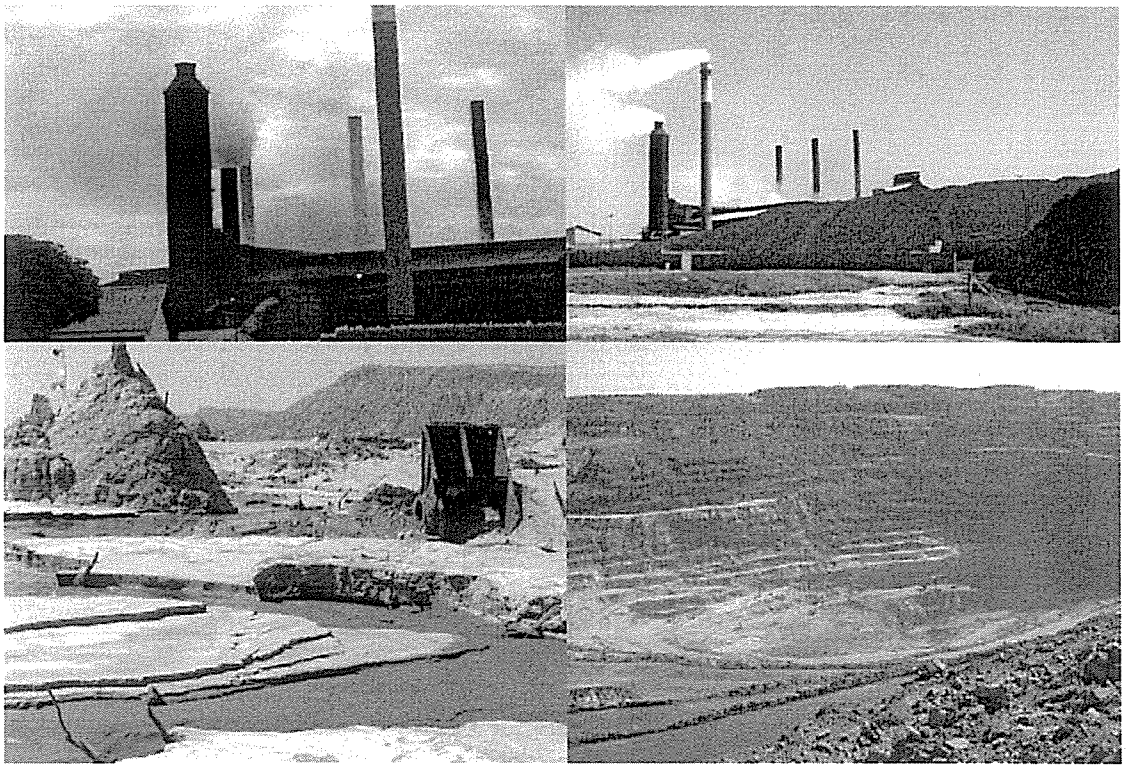


Figure4.3 Environmental effects of mining

One of the chief effect of mining, according to the respondents interviewed in the five sites of mining, is land degradation. The removal of top soil, vegetation cover and trees with heavy machines deprives the land of its much need nutrients and renders the land infertile for agricultural purpose. For example, in Mufulira's Kankoyo, there were areas where the land was covered with rocks and other debris from mining activities. These have not only impeded plant growth on the land but also has rendered the surface rugged, making it impossible for farming activities to take place there. In addition respondents complained that pits and heavy hole/trenches are created as a result of mining activities and these areas eventually have become inaccessible to the people as they are fatal zones. Field observations confirms this as such pits were observed in Kitwe and Mufulira with a depth ranging 15 – 95m deep. Even such are backfilled by the mining companies, they are covered with rocks (which render the land infertile) or converted into trailing dams where waste and other toxic materials are deposited.

4.3.1 Causes of Land degradation

Causes of land degradation was evaluated based on nine criteria ranked by respondents (Medical doctors, Community Leaders, Environmental Health Technicians, Principals of Colleges, Communications Officers of Mines and Spokes persons of Local Governments) on a four likert scale from strongly disagree, Disagree, Agree and Strongly agree. The criteria included presence of trailing dams, use of toxic materials, use of heavy machines, clearance of vegetation, long period of extraction, waste disposal, transporting, processing and excavations.

Table4.6 Causes of land degradation

Causes of land degradation	1 = Strongly disagree	2 = Disagree	3 = Agree	4 = Strongly agree	Mean
Presence of trailing dams	10 10.4	15 15.6	17 17.7	54 56.3	**3.20**
Use of toxic materials	2 2.1	4 4.2	47 49.0	43 44.8	**3.36**
Use of heavy machines	14 14.6	16 16.7	40 41.7	36 37.5	**3.12**
Clearance of vegetation	2 2.1	21 21.9	61 63.5	12 12.5	**3.86**
Long period of extraction	4 4.2	6 6.3	55 57.3	31 32.3	**3.18**
Waste disposal	4 4.2	0 0.0	16 16.7	76 79.2	**3.71**
Transportation	15 15.6	18 18.8	43 44.8	20 20.8	**2.71**
Processing	7 7.3	0 0.0	40 41.7	49 51.0	**3.44**
Excavations	2 2.1	18 18.8	28 29.2	48 50.0	**3.27**

Results in Table 4.6 above showed that waste disposal was the most considered criterion of the cause of land degradation with 79.2% of respondents expressing strong agreement that waste disposal causes land degradation followed by presence of trailing dams 56.3%, processing 51.0% and excavations 50.0%. The other criteria, though considered strongly agreeable by less than 50.0% of respondents, were considered agreeable with respective medians of three (3). Results show that 63.5% of respondents expressed agreement that clearance of vegetation causes land degradation followed by long period of extraction 57.3%, Use of toxic materials 49.0%, transportation44.8%, use of machines and processing 41.7% each. According to the Field Interview No. 2 most of the respondents cited waste disposal, presence of trailing dams, processing and excavations

to be the major cause of land degradation. This is attributed to the fact that mineral extraction involves the excavation of underground pits and the destruction of rocks using explosives, which has caused regional land degradation. The number of pits in the small-scale mining areas lies between 100 and 1000, at shaft depths ranging between 10 and 100 m; both agricultural and grazing lands have been destroyed.

4.3.2 Air and Water pollution and Biodiversity depletion (Vegetation)

Due to restrictions by the mining company to conduct direct stuck emissions from the smelter, the research had to use indirect method of getting air pollution results from the smelter. This involved review of the data earlier collected by ZEMA and other institution. The data for soil pollution came from direct sampling in the affected communities. The data that was reviewed covered a period of 4 years (2014-2017) and soil and water samples collection was between January and August 2014. The researched data is given in Appendix 5-8.

4.3.2.1 Ambient Air

Table 4.7 below shows the concentration of pollutants in ambient air for a period of 4 years which was under review. The figures are an average of monthly readings.

Table 4.7 Concentration of pollutants in ambient air.

Pollutant	Averages concentration (Ng/m3)	Limit (Ng/m3)	Times higher than limit
SO2	164,995	1000	165.00
Dust	1505.636	50	30.11
Cu	187.7873	1.0	187.79
Co	1.115909	0.5	2.23
Pb	43.89812	0.2	219.49

Source: *Nyambe, 2017*

As shown in Table 4.7 above, the concentration of all the pollutants in ambient air was higher than the emission limit as prescribed by ZEMA and WHO. The Mufulira Smelter underwent some upgrading and this has reduced the levels of emission. This plan was to upgrade the smelter to a treatment capacity of 850,000 tpa of concentrates by the replacement of the existing electric smelting furnace with a high-intensity Isa-smelt

smelting furnaces. This upgrade involved among others, the Installation of a single contact sulphuric acid plant to treat about 80,000 Nm3/hr of 9-16% SO2 tenor process off gas produced in the Isa-smelt furnace for the production of 98.5% sulphuric acid. However, the pollutants continue to be periodically released in the atmosphere, mostly during periods of electronic control and monitoring system failure during unplanned power outages.

Furthermore all the respondents in the study complained that in the morning there is a lot of dust from the mine dust that has been heaped in the area. A community leader noted that, *"the moment you come into this Township of Kankoyo you even feel the bitter taste and dryness in your mouth and you feel like chocking"*

Mine workers and people living in Kitwe' Nkana and Mufulira's Kankoyo have been exposed to air pollution heavy mainly from sulphur dioxide since the 1930s when the mines were established. The testimonies of the miners are indicative of their frustrations. *"The issue is that this whole environment is polluted. Almost everything in this place is contaminated. You don't need to even do laboratory examinations to understand that this place is polluted. When you come you will just note the difference. For us our understanding is that the government brought foreign mining companies to come and kill us. The separation of copper involves the use of acid. The acid as you know is very toxic and we are able to smell it in the air. Sometimes we go into town just to breathe some fresh air"* (Interview 2, Kitwe and Mufulira, 2018).

According to the residents heavy pollution is mostly experienced at night when most people are sleeping. They speculated that this was meant to prevent any protests from the people.

> *"The amount of pollution is worse in the night. Sometimes there is no smoke but you just experience a choking smell...when the Ministers come here they don't release any pollution...what does that mean? May be they are scared that the government will discover their lies about minimizing the pollution".*

Furthermore, toxic wastes released from the processes of mining are dumped or directed into trailing dams, these serves as points of land and air pollution to nearby communities.

4.3.2.2 Soil Quality

The research area was divided into mining sites. The sites concentrated in areas of mining that showed predominantly less or no plant life and that showed some form of plant life. The area nearer to the slag dump was avoided during sampling point selection so as to avoid biasness in the results, as it would have been hard to ascertain as to which the pollutant would be smelter fallouts or slug dump blows. Using the theory of plum effect, soil samples were collected from 13 different (Figure 4.4) locations in the 5 quadrants. The samples were taken using an auger to a depth of 25cm at each sampling point. The samples were tested for presence of heavy metals and soil acidity and the results are presented in Table 4.8.

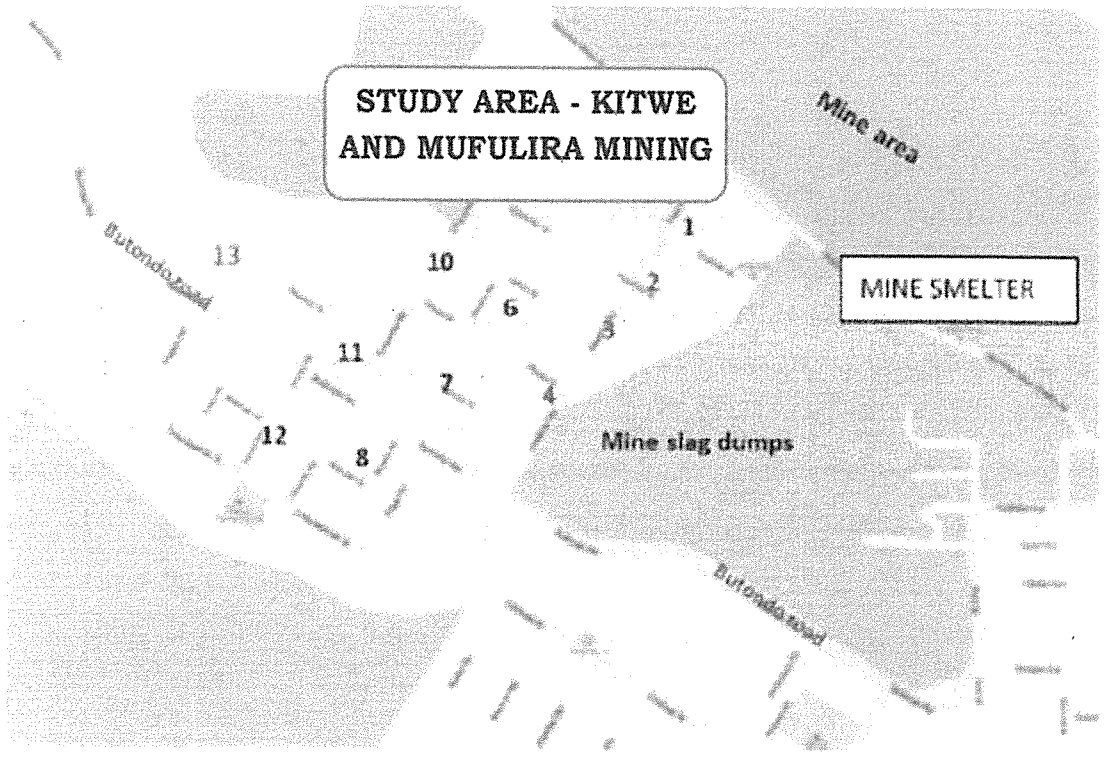


Figure 4.4 Sampling points in Kitwe and Mufulira Mining Towns

Table 4.8 Heavy metals concentration in soil and Soil Acidity

Sample collection point number	Pollutant concentration		
	Copper	Cobalt	pH
1	551.6	25.32	5.8
2	2135.1	45.56	4.2
3	2329.4	52.76	4.5
4	2640.6	49.36	4.9
5	789.3	26.66	5.6
6	1479.7	35.51	6.2
7	197.68	30.18	5.1
8	727.6	19.02	5.2
9	2215.24	20.36	5.8
10	939.92	1.032	5.9
11	4261	4.19	6.6
12	1397.64	15.05	6.9
13	150	7.06	7.6

Source: Field data, 2018

It was noticed that the limit for copper in the soil in order to support plant life had been exceeded in all the location where samples were taken, except for one location in the far end of the Townships. It was noticed that at this location (location 13) there is even plant life and it can be concluded that, based on plum effect, the pollutants do not reach that far.

Point 2, 3 and 4 shows cobalt contamination in the soil above the limit of 40ppm. These areas are closer to the smelters, hence it can be concluded that Cobalt fallout happens in the first minutes of being blown and as the result areas further from the smelter are not highly affected by this pollution.

Only three locations showed the soil pH within the limit, locations 11, 12 and 13 (World Health Organization, 2015).The other area, which represents the larger part of the Townships, reported the soil pH below the limit (pH 5.5). This means that the soil is too acidic and hence cannot support plant life. This can also be confirmed by visual

observations as only cactus plants, mango and avocado trees survive in mining sites of Kitwe and Mufulira (Refer to figure 4.5).

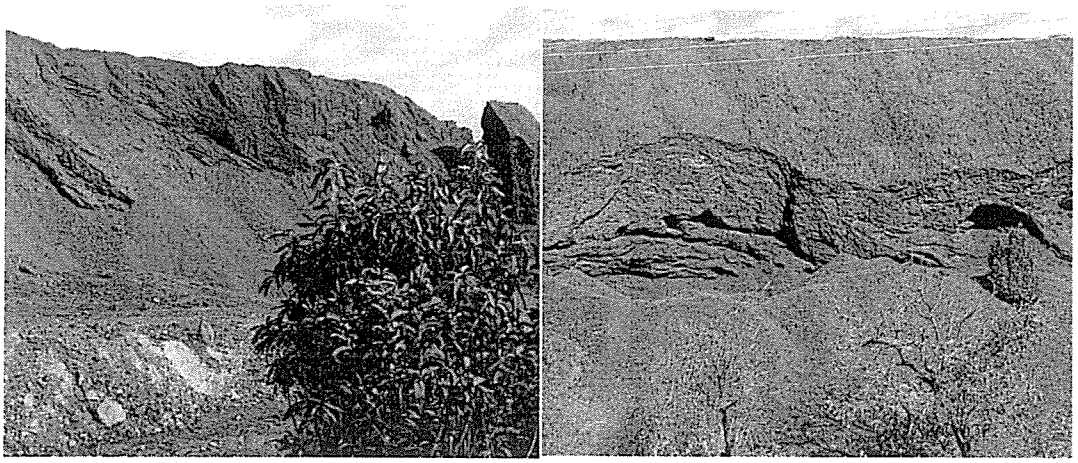


Figure 4.5 Cactus plants, mango and avocado trees survive in mining sites

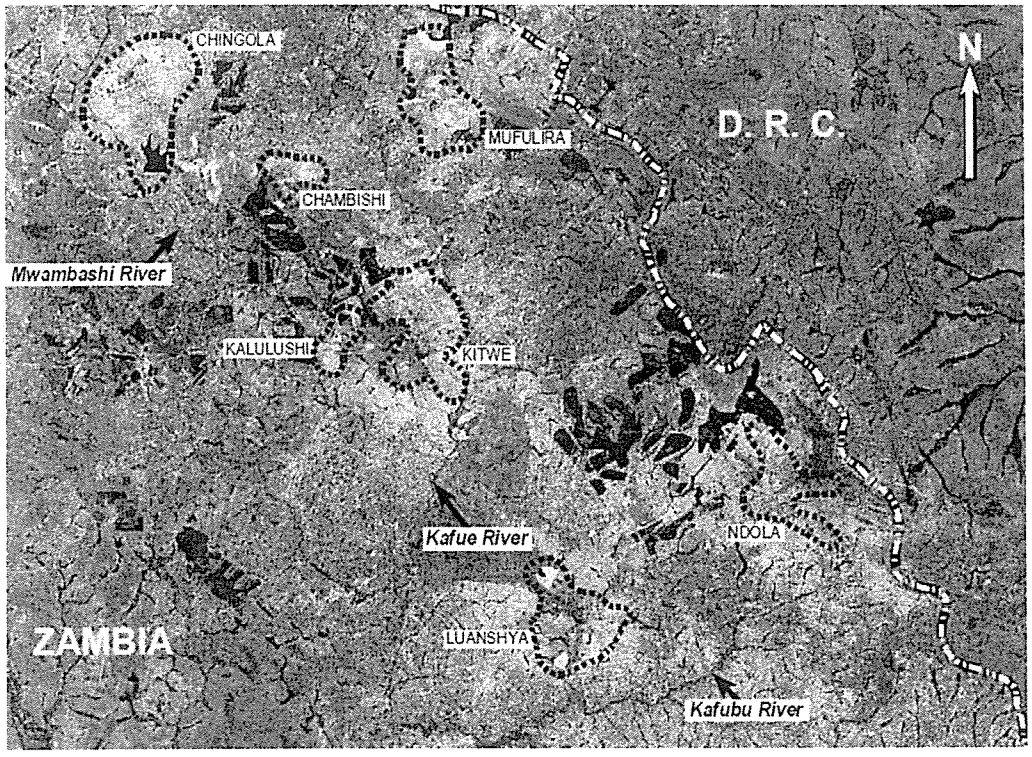
4.3.2.3 Water Quality

Water from a near-by Mufulira stream which also flows through Kitwe and Mufulira located on the western side of the research area was used as a test check. The reason being that the stream is also used as a repository for mining underground and concentrator effluence. The stream water was sampled and tested for presence of contaminants during the research period and the results are given in Table 4.9 below. The results show that the water was well within statutory limit. This result was used to conclude that the soil contamination in the research area was directly related to the fallout pollution from the smelter whose direction plume path passes over the study area. It was noted that all the parameters of water quality where within limit during the period of research (Organization Health World, 2011).

Table 4.9 Water quality parameters

	pH	TDS	TSS	TCu	TCo
January	8.1	762.4	44.0	0.8	0.1
February	7.8	745.3	35.3	0.2	0.2
March	7.7	728.2	30.6	0.2	0.1
April	7.8	835.0	11.6	0.2	0.1
May	8.0	1249.3	13.5	0.4	0.1
June	7.9	463.3	12.8	0.3	0.3
July	7.8	114.9	24.8	0.3	0.1
August	8.5	74.7	10.75	0.4	0.1
Limit	**6.0-9.0**	**<3000**	**<1000**	**<1.5**	**<1.0**

4.3.2.4 Biodiversity depletion (Vegetation)



Green: Vegetation
Light purple: gravel
Yellow: deciduous
Orange: dry ground cover
Red: wet ground cover
Blue (light): water
Source: Researcher generated composite map, 2018

Figure 4.6 Biodiversity depletion (Vegetation)

With regards to figure 4.6 above trend analysis of Radar images for period of 4 years shows that over 80% of the vegetation of Kitwe and Mufulira mining towns has been cleared to pave way for mining activities. The figure further shows that the amount of underground water in mining sites of Kitwe and Mufulira is low, this can be attributed to the fact that mining of minerals involves the pumping out of underground water for mining to be successful hence lowering the water table. In areas where mining does not occur wet ground cover dominates with a red colour and water with a light blue colour. Furthermore the lowering of the water table and absence of enough moisture in the soil around the mining sites of Kitwe and Mufulira makes the soil to be poor/unfertile for plant growth and agricultural production (See Appendix O: Photo Gallery).

4.3.3 Effects of mining on human population

Table 4.10 Effects of mining on human population

	Frequency (n)	**Percentage (%)**
Creation of employment	4	4.2
Accidents (injuries and death)	7	7.3
Ill-health (cancer, TB and other diseases)	6	6.3
Creation of employment and accidents	8	8.3
Accidents and Ill-health	18	18.8
Ill-health and Rundown infrastructure	2	2.1
Creation of employment, accidents and Ill-health	7	7.3
Accidents, Ill-health and rundown infrastructure	3	3.1
Prostitution	4	4.2
Creation of employment, accidents, ill-health (cancer, TB and other diseases), rundown infrastructure and prostitution	37	38.5
Total	**96**	**100.0**

Results in Table 4.10 shows that creation of employment, accidents, ill-health (cancer, TB and other diseases), rundown infrastructure and prostitution are some of the effects of mining on human population with the highest number of respondents of 38.5% followed by accidents and ill-health with 18.8%, ill-health and rundown infrastructure recording

the least of respondents with 2.1%. This implies that mining contributes both positive and negative on human population.

4.3.4 Disadvantages of mining in communities

Table 4.11 Disadvantages of mining in communities

	Frequency (n)	**Percentage (%)**
Pollution (air, water, soil and noise)	4	4.2
Vegetation depletion and land degradation	4	4.2
Displacement of people	8	8.3
Accidents and outbreaks of diseases	21	21.9
Pollution, vegetation and land degradation, displacement of people and lowers water table, loss of farm land, prostitution, promotes migration and theft	59	61.4
Total	**96**	**100.0**

Results in Table 4.11 shows that 61.4% of respondents said pollution, vegetation and land degradation, displacement of people and lowers water table, loss of farm land, prostitution, promotes migration and theft are some of the disadvantages of mining while 21.9% said accidents and outbreaks of diseases, 8.3% of the respondents cited displacement of people whereas pollution and vegetation depletion and land degradation recorded the least percentage of respondents with 4.2% respectively. A shift boss miners also noted that,

> *"Dust is another problem that nearby communities and mine workers face in their daily experiences at work and areas of residence. This is worsened by blasting in the process of mineral extraction. In addition to this, is the smell of chemicals from the explosives*", (Interview 11, Kitwe and Mufulira, 2018).

The other problem is that there is always an inherent danger of accidents with rock falls being the most common. The miners explained that the pillars that they erect in the tunnels easily fall, making life underground very dangerous. The respondents explained that a number of miners have died due to rock falls. Because of the noise and darkness many miners have been crashed by the loaders because the drivers cannot see properly (Interview 19, Kitwe and Mufulira, 2018). The environmental conditions underground

are worsened by absence of conveniences such as toilets and clean drinking water. According to the respondents (both Mopani and Konkola miners) the fact that there are no toilet facilities underground implies that us miners who want to help ourselves will either do it just there where we are working or will simply pass urine in the uniforms as it makes no difference.

"when you are underground and you feel like passing urine (ukusunda) you simply do it in the work suit and nobody will know because the wet environment" (Miner, 2018)

4.3.5 Benefits of mining in communities

Table 4.12 Benefits of mining in communities

	Frequency (n)	**Percentage (%)**
Creation of employment	31	33.3
Tax/revenue to the government	2	2.1
Creation of employment and Tax/revenue to the government	34	35.4
Creation of employment and infrastructure development	29	30.2
Total	96	100.0

The results in Table 4.12 shows that 35.4 of the respondent said that creation of employment and Tax/revenue to the government are the major benefits of mining in communities while 33.3% cited creation of employment, 30.2% creation of employment and infrastructure development and 2.1% Tax/revenue to the government was the least.

4.4 Mitigation of environmental effects of mining in Kitwe and Mufulira

The third objective of this study was to design a model for the mitigation of environmental effects of mining on local communities in Kitwe and Mufulira. To achieve this objective, respondents were asked to give their views on which mitigation measures can be useful to curb environmental effects of mining on local communities in Kitwe and Mufulira? The data on this objective was analysed under the question: What mitigation measures can be used to curb environmental effects of mining on local communities in Kitwe and Mufulira?

4.4.1 Efforts to reduce the adverse effect of mining on the environment

Respondents were interviewed on whether mining companies are doing something to reduce the adverse effects of mining on the environment and their responses are presented in Table 4.13 below.

Table 4.13 Efforts to reduce the adverse effect of mining on the environment

	1 = Strongly disagree	2 = Disagree	3 = Agree	4 = Strongly agree	Mean
Re-afforestation	94 97.9	2 2.1	0 0.0	0 0.0	**1.02**
Resettlement of affected communities	32 33.3	47 49.0	15 15.6	2 2.1	**1.86**
Providing alternative source of drinking water	66 68.8	12 12.5	14 14.6	4 4.2	**1.54**
Compensation to affected communities	21 21.9	45 46.9	26 27.1	4 4.2	**2.14**
Varying methods of operations	49 51.0	20 20.8	25 26.0	2 2.1	**1.79**

Results in Table 4.13 shows that mining companies are literally doing nothing to reduce the adverse effect of mining on the environment with resettlement and compensation of affected communities recording a mean two (2), while Re-afforestation, providing alternative source of drinking water and varying methods of operations with a mean of one (1). This implies that little effort is invested in restoring the environment by both the mines and the government. This further has an effect on climate in general.

4.4.2 Effectiveness of methods used by communities to reduce the negative effect of mining

***Table* 4.14 Effectiveness of methods used by communities to reduce the negative effect of mining**

	Frequency (n)	Percentage (%)
Effective	2	2.1
Not effective	94	97.9
Total	**96**	**100.0**

Results in Table 4.14 shows that 97.9% of the respondents said the methods of reducing the negative effect of mining were not effective at all while 2.1% of the respondents said the methods were effective. This implies that there no effective methods put in place by the communities and the mines to reduce the negative effects of mining in Kitwe and Mufulira and this has resulted in most of the effects to be felt by the local residents of Kitwe and Mufulira.

4.4.3 Environmental restoration efforts

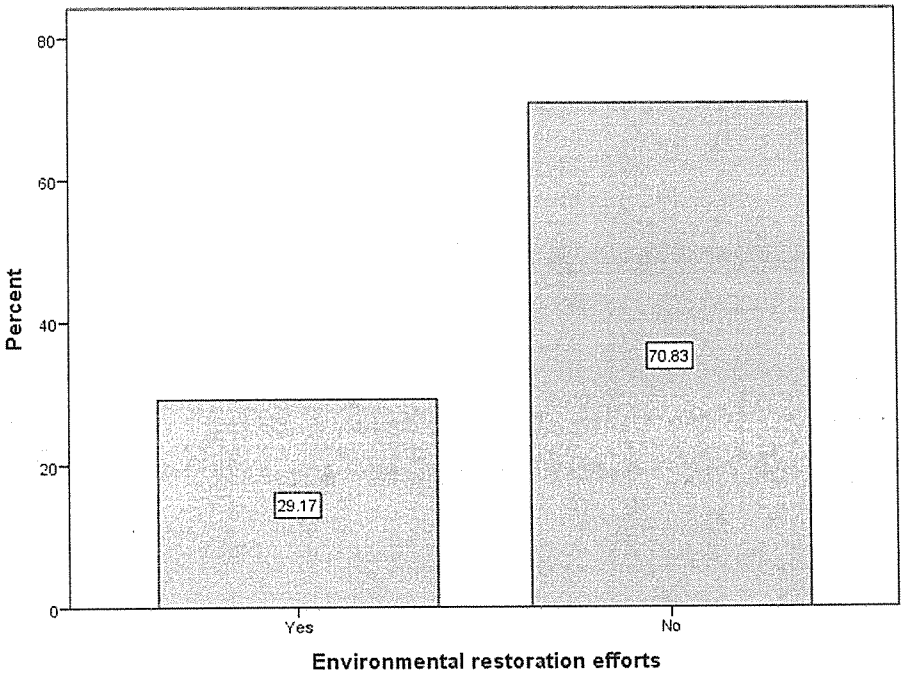


Figure.4.7 Environmental restoration efforts

According to the results in figure 4.6 above 70.83% of the respondents said they were no efforts put in place towards environmental restoration of the degraded environment while 29% of the respondents said yes they were measures or efforts put in place to restore the degraded environment.

4.4.4 Active and responsible agencies/organization for the restoration of the degraded environment

Table 4.15 Active and responsible agencies/organization for the restoration of the degraded environment

	Frequency (n)	Percentage (%)
International Agency (FAO/UNDP)	1	1.0
NGOs	51	53.1
State	14	14.6
CBOs	20	20.8
Mining Companies	10	10.4
Total	**96**	**100.0**

Results in Table 4.15 shows that 53.1% of the respondents said NGOs were active and responsible for the restoration of the degraded environment while 20.8% of the respondents said the CBOs, 14.6% of the respondents said State, 10.4% of the respondents said the mining companies and the least was international agency with 1.0%. This implies that both mining companies and the international agencies are not doing enough to restore the degraded environment.

4.4.5 Roles of NGOs, the state, CBOs and mining companies in reducing the effects of mining socially and environmentally.

Table 4.16 Roles of NGOs, the state, CBOs and mining companies in reducing the effects of mining socially and environmentally.

Variables	Frequency (n)	Percentage (%)
Roles of NGOs		
Advocacy of policy formation	21	21.9
Educating the general public	51	53.1
Providing of resources for re-afforestation	24	25.0
Roles of the state		
Promote afforestation	12	12.5
Policy formation	28	29.2
Embedding environmental education in the curriculum	15	15.6
None	41	42.7
Roles of CBOs		
Tree planting(Environmental sustainability)	49	51.1
Information dissemination	22	22.9
Tree planting and information dissemination	25	26.0
Roles of mining companies		
Adopt safe mining procedure	20	20.8
Adopt green technology	19	19.8
Employ qualified personnel	10	10.4
None	47	49.0
Total	**96**	**100.0**

With regards to the roles of NGOs, the state, CBOs and mining companies in reducing the effects of mining socially and environmentally in Table 4.16 above Non-governmental organizations and community based organizations are doing far much better in terms of reducing the effects of mining because NGOs and CBOs did not record a none response while the state and mining companies recorded none responses of 42.7% and 49.0% respectively indicating that some respondents are not aware about their role in reducing the effects of mining.

CHAPTER FIVE

DISCUSSION OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents a discussion of findings categorized along the defined research questions, conclusion, practical implications of the study findings and recommendations for administrative, policy actions and further research. It also includes a proposed model for community engagement in managing environmental and social effects of mining prepared by the researcher based on the findings.

The study aimed at determine the environmental effects of mining on local communities in the Copperbelt province of Zambia using cases of Kitwe and Mufulira mining towns. Data was collected using questionnaire, key informant interview schedule and participant observation. The sample population included five (5) mining sites and ninety-six (96) key informants' respondents in the study area.

5.1 Discussion of Findings

The findings shows that majority of the respondents attended the university and this has a positive effect on the interview conducted and the findings of the research as most of the respondents had knowledge about the subject matter.

The findings further shows a high percentage of Environmental Health Technicians, Medical doctors and community leaders, implying that Environmental Health Technicians, Medical doctors and community leaders have a better understanding on the environmental and social effects of mining for the benefits are not based on the taxes raised from mines.

On the number of years in the community of residence, finding show that the longer the person live or stays in the mining community, the more he or she is affected by the environmental and social effects of mining.

5.1.1 Methods of mining in Kitwe and Mufulira towns

The study findings reveals that the current mining activities practice in Kitwe and Mufulira which is underground and surface mining would in the next five to ten years pose a serious risk and changes to the natural resources of Kitwe and Mufulira since the

continual clearance of large acres of land and forest cover for mining from time to time would result in serious deforestation and land degradation that would lead to a massive loss of large vestiges of land and forest cover. Though currently the loss is not so great in terms of coverage of area covered and excavated for mining which currently stands at 10,500 acres out of the total 2,414 square kilometres of mining lease in Kitwe and Mufulira (Ministry of Mines and Mineral Development, 2005), the areas earmarked by the company for future mining however gives an indication of the extent to which the damage to the natural resources (vegetation) would reach. This trend inevitably comfirms the observation made by the world Rainforest Movement that surface and underground mining poses a threat to large vestiges of Ghana's forest resource, land, biodiversity and water rosource and hence raises questions of sustainable forest management and mining activities (World Rainforest Movement, 2004:44).

Another finding shows that underground mining causes erosion, formation of sinkholes, loss of biodiversity and contamination of ground water and surface water by chemicals from mining process and products, leads to environmental issues for example use of heavy machines and chemicals. Furthermore underground mining donot only cause instability with the earth crust but also underground water which serves as a source of water to various water bodies in the area are affected by infiltration of toxic materials.

5.1.2 Environmental effects of mining in Kitwe and Mufulia

Basing on the findings of environmental effects of mining, the effect is localized and at local level, the uncontrolled digging and abandoning of pits has caused destruction of land beyond economic and technical reclamation. Excavations not only make the land unfavorable for agricultural activities but also adversely affect livestock and wildlife resources, which in turn, affect locals, who depend on power and animal manure.

Trailing and mine waste containing heavy metals and cyanides may negatively affect life even if water standards are closely followed and monitored, because many metals bio-accumulate in humid environments, consumption of contaminated foodstuffs and fish can be harmful.

Another finding shows that mineral exploitation involves the appropriation of land from indigenous people and massive displacement of settlement. Both in rural and urban communities' locals depend on the land as a source of livelihood. According the Local Government Spokespersons for Kitwe and Mufulira, '1,120 households were forcibly displaced in Kitwe and Mufulira districts due to the expansion of the mines. The displacement threatened people's livelihood has resulted in confrontation between the local people and staff at Mopani mines and that an influx of foreign mining companies has made it even more difficult for locals to secure land. In 1991, the government of Zambia amended mineral policies for the purpose of creating a favorable investment climate for foreign mining companies. As a result, several small-scale miners and farmers have lost their mine sites, agricultural and grazing land. The long-term implications of such displacements include accelerated food insecurity to the landless classes, increased poverty and intensified environmental degradation. Finally forced resettlement can be particularly disastrous for indigenous communities who have strong cultural and spiritual ties to the lands of their ancestors and who may find it difficult to survive when these are broken. These findings are in line with Kwesi, (2015) who reported that, 'the displacement of settled communities is a significant cause of resentment and conflict associated with large-scale mineral development'.

With regards to the findings in Table 4.4.1 the case of mining induced poverty largely results from displacement (resettlement and compensation of affected communities). Akabzaa notes that mining companies annex vast lands in their operational areas and deprive communities of their chief source of livelihood with such rampant dislocations of communities for mining activities fostering poverty among these displaced communities (Akabzaa, 2009). Their poverty situation is also compounded by inadequate compensation for their lost livelihoods with the "monetary compensation commonly quickly spent, leaving everyone worse off than before with no land or money left for them again" (Richards, 2008). In essence, "low levels of compensation payments exacerbate the problem of poverty in mining communities" (Owusu-Koranteng, 2005) and is a major contributor to the worsening poverty in Kitwe and Mufulira since most resident continually complain of the inadequacy of the compensation packages given them in spite of the loss of their major source of livelihood, the land.

The findings further shows that mining takes up space for activities such as sitting of mines, heap leach facilities, trailing dump and open pits, mine camp, roads and resettlement for displaced communities. This has a momentous adverse impact on the land and vegetation, the main source of livelihood of the people.

Cyanide and spillages, and improper disposal of mine wastes, can be deadly to humans and can poison ground water, farmland and the resources in the water bodies which the livelihood of majority of copperbelt residents depend on for survival. Furthermore since most of the water resources in mining areas are used as sources of drinking water for inhabitants and livestock, pollution of water by cyanide and spillage of toxic materials is a burden to the women and children who collect it for household use and livestock in rural communities.

Environmental pollution is a major problem in the mining areas of Kitwe and Mufulira. Continuous disposal of mine waste contributes to air, soil and water contamination, which are detrimental to human health, livestock and biodiversity, and have serious effect on the welfare of the mining communities, especially groups of women and children. The health and safety and the nearby communities are at risk from a variety of factors, ranging from the inhalation of polluted air and dust, to water contamination and poor safety procedures. Unprotected pits, for instance, during the rainy season form breeding ground for disease vectors such as mosquitoes and houseflies – the agents that spread malaria and waterborne diseases.

The soil acidity due to SO_2 has affected plants growth leading to a desert condition in Kitwe and Mufulira. Figure 5.1.1 below shows the devastating effect of SO_2 pollution in Mufulira's Kankoyo mining area.

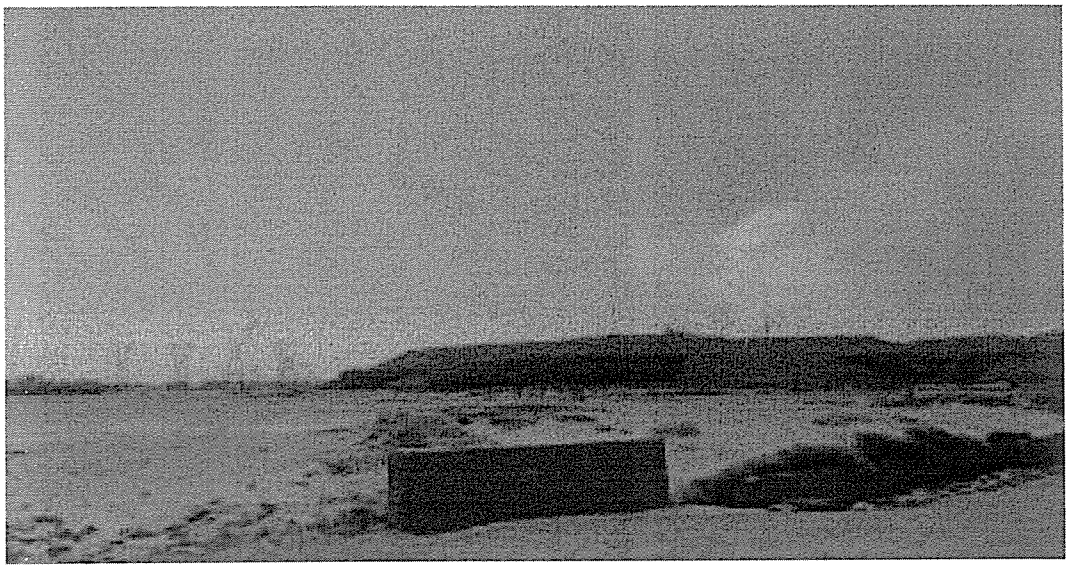


Figure 5.1 Bare land- plants struggle to grow

The Water quality in the Mufulira stream parameters where all within the limit. This can be attributed to the fact that river water is continuously flowing with fresh from uncontaminated upstream.

5.1.3 Mitigation of Environmental effects of mining

Mopani mines, on its part, has realized the effects of their activities (mining) on the people living in the communities and has consequently sought to institute certain measures to curtail and mitigate the environmental, social and other effects on the people. Measures that have been undertaken, to some extent, include reviewing methods of operation, resettlement of affected communities and providing alternative sources of drinking water like bore holes to communities whose water resources have been contaminated with toxic chemicals though at a minimal rate.

On social, Mopani mine has built hospitals, clinics, health posts and schools within the communities for the benefit of both workers and people within the communities. In addition, the Company has embarked on health educational programmes for the benefit of the people. Mopani has also adopted safe mining procedure and green technology to

reduce the effects of mining on the environment. With the view to ensuring better conditions for residents within the mining area, some public sector mining industry support organizations such as the Zambia Environmental Management Agency (ZEMA), the state and Zambia Chamber of Mines are playing specific roles in diverse ways.

The Zambia Environmental Management Agency (ZEMA), whose primary duty is to ensure that mining companies (including Mopani and Konkola) undertake their operations in conformity with the laws, has sought to monitor the activities of the companies from time to time. An official interviewed commended Mopani and Konkola with the level of compliance with EPA guidelines but said that there is more room for improvement.

The Zambia Chamber of Mines, a governmental agency (State) responsible for fostering the efficient and effective regulation and management of the utilization of Zambia's mineral resources has not only provided mining lease to companies but has also provided the legal framework under which mining activities can be carried out in the country. In addition, the agency has implemented and supervised social support programmes in mining areas (Ministry of Mines and Mineral Development, 2005).

Despite efforts by these organizations in ensuring that mining activities are carried out on sustainable basis without serious problems to the environment and the host communities, the public is yet to feel the impact of their activities. A critical assessment of their activities therefore shows that there is more to be achieved than what has been accomplished so far as far as environmental, social-health and economic problems in the mining industry are concerned.

5.2 Proposed model for managing of environmental effects of mining

Based on the findings, the researcher proposes a model for community engagement in managing environmental and social effects of mining as illustrated in figure 5.2 below. This model should be applied across all mining activities to ensure sustainability of effect management on the environment. The model proposes four key stages (see Fig. 5.2) community engagement model in managing the effects of mining.

Mining (Environmental effects): This stage involves all the environmental effects that come as a result of mining activities. These may include biodiversity depletion (vegetation, wildlife etc), soil, air and water pollution, etc.

Community (Towns, Villages etc): Refers to the group of people with diverse characteristics who are linked by social ties, shared common perspectives and engage in joint action in geographical locations or settings (Robinson, D and Wilknson D, 1995). This stage includes areas of habitation by living organisms specifically people in the environment. At this stage the community has the resource which include human capital and norms of trust and network, capacity and knowledge to contribute to mitigation of environmental and social effects of mining through re-afforestation, complaining to civic leaders and state, non-governmental organizations.

Mining companies (Mopani, Konkola): The mining companies which are part of the community develops strategies and measures for managing effects of mining through expertise and technical competence.

Sustainable effect management systems, strategies and programmes: These include re-afforestation, policy formulation and sensitization.

Proposed model for community engagement in managing environmental and social effects of mining

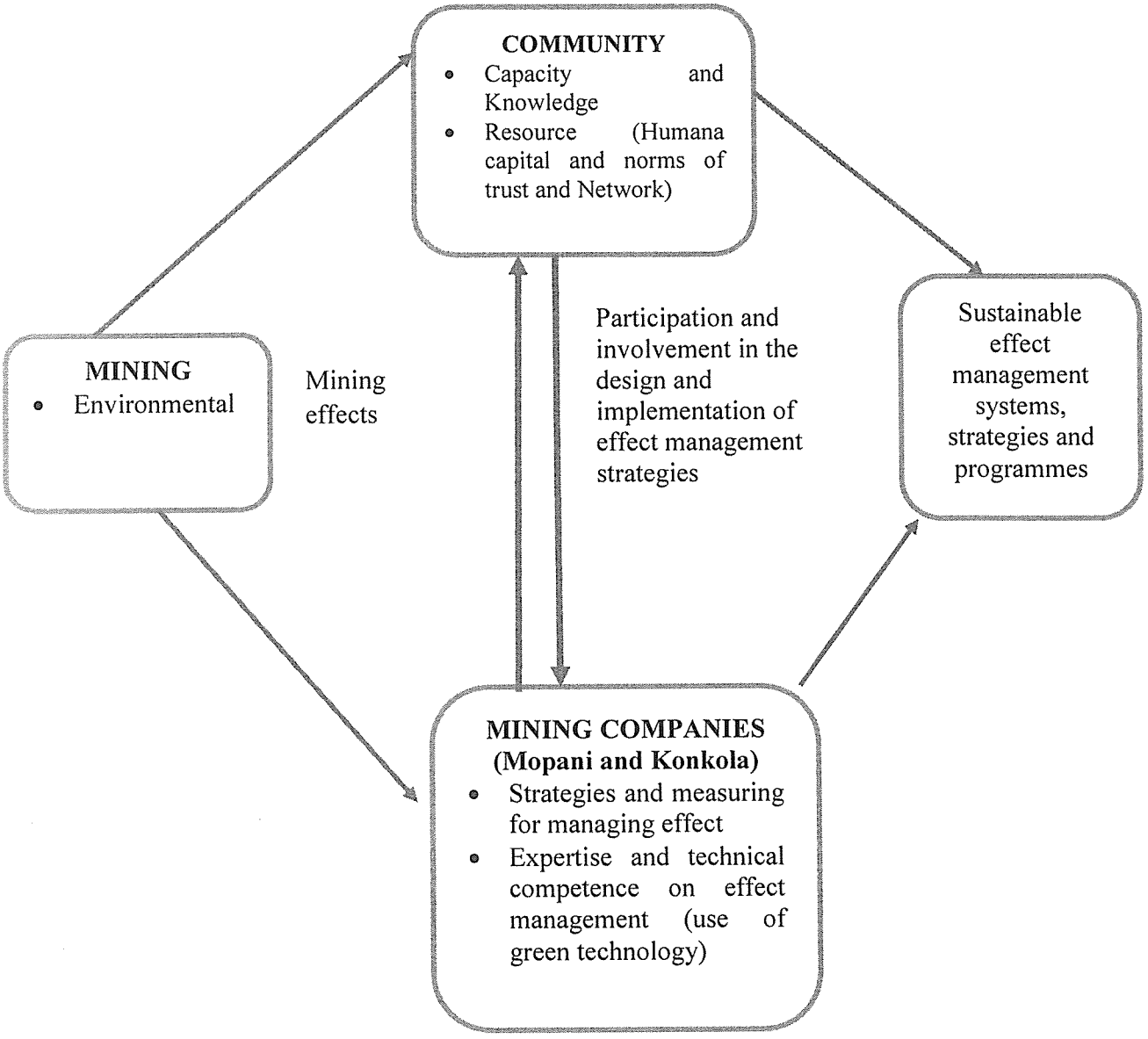


Figure 5.2 Community engagement model in managing the effect of Mining

5.3 Conclusions

The study investigated the environmental effects of mining on local communities of Kitwe and Mufulira. It was intended to determine the environmental effects of mining unleashed on local communities. The research specifically sought to examine the methods of mining, establish the environmental effects of mining on local communities and design a model for the mitigation of environmental effects of mining on local communities in Kitwe and Mufulira. The study established that;

Objective One: Methods of mining.

The methods of mining activities in Kitwe and Mufulira mining towns involves underground and surface mining with underground mining dominating the scene.

Objective two: Environmental effects of mining on local communities

The environmental conditions of the study area, have a localized effect which includes uncontrolled digging (excavations), land degradation, abandoning of mine pits, mining takes up large areas, pollution from tailings and mine wastes, massive displacement of settlements. Furthermore there is severe soil pollution and this has resulted in the soil failing to support plant life as only cactus plant and avocado trees survive in the mining sites of Kitwe and Mufulira towns.

Objective three: Mitigation of environmental effects of mining

Only few measures have been put in place by relevant authorities and communities, on to reduce the adverse effect of mining on both environmentally and socially for instance reviewing methods of operations, sensitization are not adequate to curb the problems of mining.

In view of the findings the study concludes that though mining has become a major source of revenue for developing countries like Zambia it has holistic adverse effects. In their very quest to develop and improve lives of citizens, these resources and natural capital are exploited to earn the much need revenue. However in the a countries' desperate quest to develop with mining as one area of reaping substantial revenue to support this development agenda, there is need to address critical questions of 'sustainable development'. How sustainable is mining to countries and especially to

Objective Two: Environmental effects of mining

There is need for the labour movement and environmental organisations to work together in fighting for environmental protection. The aim should be to politicize the environmental question so that it is highly publicized and make it more visible. Finally the mine needs to review its environmental management plans and incorporate strategies that can address the current environmental problems in the area. There is need to initiate afforestation projects in the affected areas within and outside the mine's concession area. The appropriate scientific institutions should be contacted to conduct feasibility studies on the type of afforestation programmes that will be suitable for the degraded areas.

Objective Three: Mitigation of environmental effects of mining

ZEMA and the local people should be adequately equipped and have enough information to provide the various stakeholders on the state of the environment and various sources of pollution that a community may be experiencing. The government should enact a legislative instrument that gives local communities adequate legal backing to fully participate in environmental decisions, management and protection that affect their lives and development. There is also the need to review the mining policies in the country to give more attention to mining and environmental legislation and also embark on research in safety.

5.5 Area for further studies

The study covered only Kitwe and Mufulira towns, hence its findings may not serve as blueprint for generation of data given the limited geographical coverage. Future studies to cover the whole Copperbelt province so as to provide a comprehensive geographical coverage that allows findings to be generalized.

The study looked at determining the effects of mining activities on the environmental and social conditions of local communities in the Copperbelt province of Zambia, however future studies should look at environmental, socioeconomic and health effects of mining by taking a holistic view of the problem. In addition future studies should assess mining, environmental and natural resource policies and laws of the government of the Republic of Zambia.

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Appendix A: Observation Checklist

1. Waste management.
2. Environmental damage.
3. Social Life of the people in the communities.
4. Development projects and initiatives and infrastructure.
5. Health conditions of the people.
6. Environmental management practices.

Appendix B: Interview Schedule

What methods of mining are found in this area?

What environmental effects has mining caused in the area?

How have the environmental effects affected local communities?

What model could be designed for the mitigation of environmental effects of mining?

Appendix C: Questionnaire for Key Informants

Dear Sir/Madam

This is a study on the environmental effects of mining on communities in Kitwe and Mufulira Copperbelt province, Zambia. Please provide the most appropriate answers in your opinion either by ticking of filling in appropriately. The responses will be kept confidential and the questionnaire is an anonymous.

Thankyou,
Yours faithfully,
Siame Kennedy

Section A

Demographic information (Tick or fill-in appropriately)

1. Residence _____
2. Sex Male [ ] Female [ ]
3. Age: 18 to 30 [ ] 31 to 40 [ ] 41 to 50 [ ] 51 to 60 [ ]
4. Occupation _____
5. Marital status Single [ ] Married [ ] Divorced [ ] Widow [ ]
6. Educational attainment

   Illiterate [ ] Primary [ ] Secondary [ ] Tertiary [ ]

   Other, specify _____
7. How long have you been living in this Community? _____

SECTION B

1. METHODS OF MINING

8. Do you have any idea about mining activities in this town/village? Yes [ ] No [ ]
9. If 8 is **Yes**, what method(s) of extraction is/are used by the companies? (***Tick all that apply***)

   Surface Mining [ ] Underground Mining [ ] Dredging [ ] Gallamsey Method [ ]

   Other, specify _____

   _____

2. EFFECTS OF MINING

10. Do you think the specific methods of operation by the mining companies have effects on the environment? Yes [ ] No [ ]

11. If 10 is **Yes,** What are some of the effects on the environment? ***(Tick all that apply)***

Variable	**Tick**
Degradation of land	
Vegetation depletion	
Water pollution	
Air pollution	
Noise pollution	
Others (List)	
Total	

12. What actually cause(s) land degradation?

Variables	**SD**	**D**	**A**	**SA**
Presence of tailing dams				
Use of toxic materials				
Use of heavy machines				
Clearing of Vegetation				
Long period of extraction				
Waste Disposal				
Transportation				
Processing				
Excavations				

13. What cause(s) pollution (of any sort as chosen in Q11) on the environment? ***(Tick all that apply)***

Presence of tailing dams[ ] Use of toxic materials[ ] Use of heavy machines[ ]

Clearing of Vegetation [ ] Long period of extraction [ ] Waste Disposal [ ]

Processing [ ] Transportation [ ]

Other, Specify _____

_____

14. What are the Mining Companies doing to reduce the adverse effects of mining on the environment?

Variable	**SD**	**D**	**A**	**SA**
Re-afforestation				
Resettlement of affect communities				
Providing alternative source of drinking water				
Compensation to affected communities				
Reviewing or varying methods of operation				
Others (List)				

15. What are the effects of mining on the human population?_____

_____

_____

16. List the greatest benefits and disadvantages of mining in the town/communities?

Benefits:_____

_____

_____

_____

Disadvantages_____

_____

_____

3. MITIGATION OF ENVIRONMENTAL EFFECTS OF MINING

17. Are there efforts towards environmental restoration

Yes [ ] No [ ]

18. If Yes, what are the efforts?

A.....

B.....

C.....

D.....

E.....

F.....

19. What is the role of government in reducing environmental effects of mining?

_____

_____

_____

_____

20. What is the role of Non-Governmental Organizations in ensuring reduction of impacts of mining?_____

_____

_____

_____

_____

21. What is the role of Community Based Organizations on reducing the effect of mining on the Community?_____

_____

_____

_____

_____

22. What are the roles of mining companies on reducing the effect of mining on the people? _____

_____

_____

Thanks a lot for your valuable time

Appendix D. Emission limit for ambient air pollutants. Source: Statutory Instrument No. 112 of 2013 (Zambia).

	Pollutant	Guideline limit
1.	Sulphur dioxide (SO_2)	1000 mg/Nm3
2.	Dust	50 mg/Nm3
3.	Copper	1.0 mg/Nm3
4.	Cobalt	0.5 mg/Nm3
5.	Lead	0.2 mg/Nm3

Appendix E. Concentration limit for soil pollutant.

	Pollutant	Guideline limit
1.	Copper	200 ppm
2.	Cobalt	40 ppm
3.	Acidity (pH)	6.5-7.5

Appendix F. Concentration limit for Water pollutant.

	Pollutant	Guideline limit
1.	Acidity (pH)	6.0-9.0
2.	Total Dissolved Solids (TDS)	<3000 (mg/L)
3.	Total Suspended Solids (TSS)	<1000 (mg/L)
4.	Total Copper (TCu)	<1.5 (mg/L)
5.	Total Cobalt	<1.0 (mg/L)

Appendix G. 2014 Ambient air pollutants concentrate results.

	Pollutant concentration (mg/Nm3)				
Month	SO_2	Dust	Cu	Co	Pb
Jan	70,501	727	145.0	0.28	75.90
Feb	28,581	2140	49.0	0.40	20.97
Mar	28,581	646	42.8	0.13	1.38
Apr	15,243	496	42.9	0.10	28.14
May	0	0	0.0	0.00	0.00
Jun	69,739	736	66.2	0.36	15.18
Jul	55,257	538	77.8	0.11	33.90
Aug	62,187	1658	41.5	0.16	28.90
Sep	28,381	408	120.8	0.14	0.90
Oct	45,730	634	58.3	0.08	0.98
Nov	34,297	520	70.0	0.25	6.70
Dec	8,214	611	60.2	0.32	6.20
Sum	**448,722**	**9,114**	**774.5**	**2.33**	**219.15**
Average	**40,793**	**829**	**70.4**	**0.21**	**19.92**

Appendix H. 2015 Ambient air pollutants concentrate results.

	Pollutant concentration (mg/Nm3)			
Month	SO_2	Dust	Cu	Pb
Jan	66,690	707	120.0	4.60
Feb	72,407	1937	485.0	19.50
Mar	110,515	1254	123.0	8.95
Apr	57,163	781	21.0	4.99
May	38,585	724	158.0	44.10
Jun	1,300,046	2820	265.0	42.99
Jul	85,744	1354	301.0	8.50
Aug	45,589	944	45.0	21.20
Sep	78,123	1034	6.0	29.70
Oct	114,326	1194	17.0	33.50
Nov	21,436	803	50.0	42.90
Dec	95,748	5048	427.0	114.50
Sum	**2,086,372**	**20,612**	**2,018.0**	**375.43**
Average	**189,670**	**1,874**	**183.5**	**34.13**

Appendix I. 2016 Ambient air pollutants concentrate results

	Pollutant concentration (mg/Nm3)				
Month	SO_2	Dust	Cu	Co	Pb
Jan					
Feb	196,260	2216	11.0	10.90	67.70
Mar	199,118	478	7.4	0.01	34.10
Apr	95,227	33	0.4	0.01	0.06
May	295,343	652	56.9	0.31	38.80
Jun	241,991	546	49.4	0.27	33.70
Jul	168,631	2168	286.3	0.51	34.23
Aug	16,386	2128	707.2	2.02	32.63
Sep	181,016	470	8.8	0.06	40.13
Oct	291,126	22	0.1	0.00	0.08
Nov	38,108	952	217.4	1.41	49.69
Dec	209,598	522	121.1	0.78	27.69
Sum	**1,932,804**	**12,200**	**1,466.0**	**16.28**	**358.81**
Average	**175,709**	**1,109**	**133.3**	**1.48**	**32.62**

Appendix J. 2017 Ambient air pollutants concentrate results.

	Pollutant concentration (mg/Nm3)				
Month	SO_2	Dust	Cu	Co	Pb
Jan	274,383	480	17.8	0.09	44.99
Feb	166,726	1900	435.1	2.81	99.44
Mar	200,071	986	211.4	0.32	34.3
Apr	119,090	0	276.7	0.46	78.92
May	102,342	520	326.5	0.66	46.2
Jun	114,326	1860	671.0	1.60	191.4
Sum	**976,939**	**7,760**	**1,938.5**	**5.94**	**495.25**
Average	**88,813**	**705**	**176.2**	**0.54**	**45.02**

Appendix K. Work Plan

	PERIOD			
ACTIVITY	JAN - MAY	JUN - AUG	SEPT - OCT	NOV - DEC
Identification of the topic, proposal writing and proposal hearing				
Data collection and data analysis				
Defending work in progress				
Editing and production of the thesis				

Appendix L. Research Budget

S/N	Item	Qty	Unit cost UGX	Total UGX
1	Transport, lodging, and Field access	-	900,000	900,000
2	Printing and Binding	12 books	16,000	192,000
3	Internet (Bundles)	12 GB	50,000	50,000
4	Miscellaneous			100,000
5	Meals and Refreshments			150,000
Grand Total				**1,392,000**

Appendix M: Acceptance Letter

KITWE CITY COUNCIL

TOWN CLERK
P.O. BOX 20070
KITWE – ZAMBIA

TEL: +260 212 224698
Email: kcc@kcc.gov.zm
TEL/FAX: +260 212 224698

REF: DHRA/PERS/GM

6th July 2018

Mr. Siame Kennedy

Kampala International University
Department of Educational Foundations
P.o Box 20000
UGANDA

Dear Sir

RE: PERMISSION TO CONDUCT A RESEARCH– YOURSELF

With reference to the above captioned matter and to your letter dated 25th May, 2017 in which you applied to conduct a research titled ***"Environment and social effects of mining on Local communities of Kitwe and Mufulira in Copperbelt Province, Zambia"***

I am pleased to inform you that Authority has been granted for you to conduct a research in the city of Kitwe.

Please note that you shall conduct your research for a period of One (1) Week effective 6th July, 2018 to 13th July, 2018.

Yours faithfully

P. M. NYIRENDA
DIRECTOR OF HUMAN RESOURCES AND ADMINISTRATION

TOWN CLERK
CITY COUNCIL
06 JUL 2018
REGISTRY
BOX 20070.
KITWE

Cc: Town Clerk

APPENDIX N: Introductory letter

KAMPALA INTERNATIONAL UNIVERSITY

Ggaba Road, Kansanga * PO BOX 20000 Kampala, Uganda
Tel: +256772365060 Fax: +256 (0) 41 - 501974 E-mail: dhdrinquiries@kiu.ac.ug * Website: http://www.kiu.ac.ug

Directorate of Higher Degrees and Research
Office of the Director

Our ref. 1164-06276-09401

Wednesday 30th May, 2018

Dear Sir/Madam,

RE: INTRODUCTION LETTER FOR SIAME KENNEDY
REG. NO. 1164-06276-09401

The above mentioned is a student of Kampala International University pursuing a Master of Arts in Geography.

He is interested in conducting a research for his dissertation titled, *"Environmental and Social Effects of Mining on Local Communities of Kitwe and Mufulira in Copper belt Province, Zambia"*

Your organization has been identified as a valuable source of information pertaining to the research subject of interest. The purpose of this letter therefore is to request you to kindly cooperate and avail the researcher with the pertinent information he may need. It is our ardent belief that the findings from this research will benefit KIU and your organization.

Any information shared with the researcher will be used for academic purposes only and shall be kept with utmost confidentiality.

I appreciate any assistance rendered to the researcher.

Yours Sincerely,

Mugasa

Dr. Claire M. Mugasa
Director

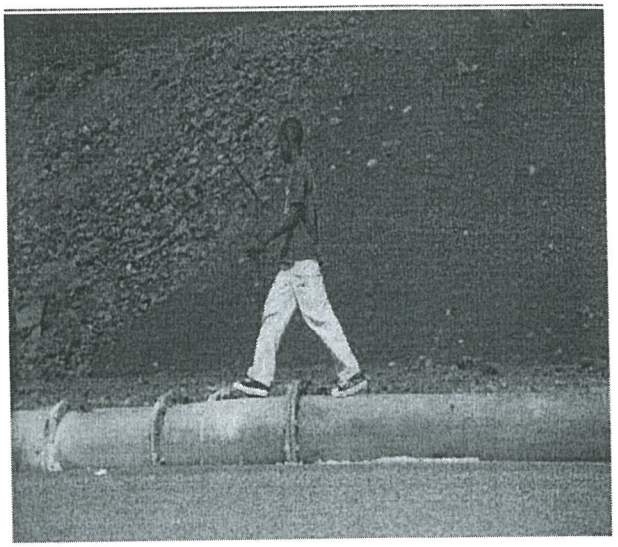
C.c. DVC Academic Affairs
Principal CEODL

Appendix O: Photo Gallery

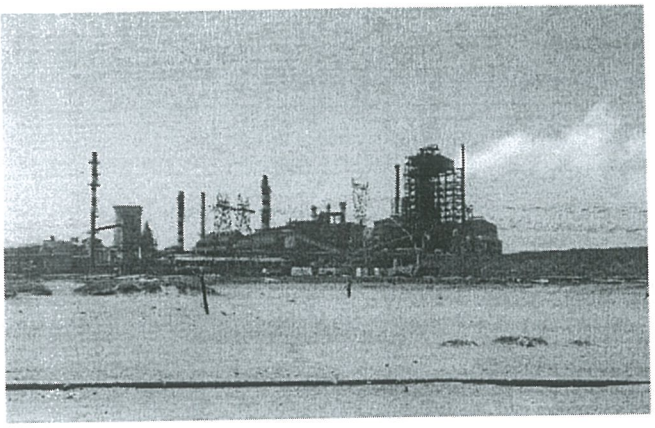
1. Trucks waiting to be loaded with acid at Mopani Copper Mines plant.

2. Drainage carrying waste material in Kankoyo township near Mopani Mine.

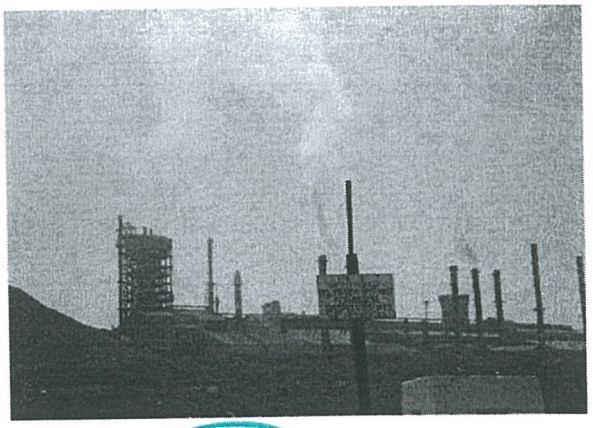
3. Vegetation is affected by the pollution, only selected plants can resist then effects of the pollution from the Mine.



4. A child playing on a tailing pipeline.



5. Sulphur Dioxide emissions by Mopani Copper Mine.



6. More Sulphur Dioxide emissions by Mopani Copper Mine.