THE IMPACT OF SMALL-SCALE MINING ACTIVITIES ON THE ENVIRONMENT:
EXAMPLES FROM UIS, XOBOXOBOS, NEU SCHWABEN AND OTJINENE

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BY
ISABELLA CHIRCHIR

9309829

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SUPERVISOR: DR. HEIKE WANKE
ABSTRACT

This study explored the impact of small-scale mining activities on the environment in two regions in Namibia: Erongo (examples: Uis, Neu Schwaben, Xoboxobos) and Omaheke (example: Otjinene). Limited research is done on the activities of small-scale mining in Namibia which results in unavailability of data. Although recent studies reveal that about 5000 to 10 000 Namibians work as small-scale miners, information about mining activities in Namibia remain a rare commodity. Small-scale miners mostly concentrate on commodities that are easily accessible and do not use mechanised equipment, i.e. tin, tantalum, calcrete and semi-precious stones (tourmaline, aquamarine, topaz, amethyst, garnet, rose and smoky quartz).

This study was done through field observations, groundwater analysis and interviews/questionnaires in order to determine the impact of small-scale mining activities on the environment. Groundwater was analysed for pH, oxidation-reduction-potential and conductivity to evaluate the quality of water. In addition, the study determined the possible environmental impact of small-scale mining activities on the lithosphere, hydrosphere and atmosphere. Data from GROWAS Database was used to supplement the primary data.

On the atmosphere, the dust generated by small-scale mining activities was found to be very minimal and thus, only affecting the miners through dust inhalation. This study did not find any evidence of identified impact on the hydrosphere (groundwater) close to the mining sites. The groundwater quality in Neu Schwaben and Uis were excellent based on the analysis done in the field on two boreholes close to the mining sites. The groundwater quality in Neu Schwaben and Otjinene were excellent, but unacceptable for Uis area based on the results from GROWAS database. No boreholes were found in Xoboxobos area. The impact of small-
scale mining activities at the four sites with regard to the lithosphere was land degradation. Neu Schwaben was the most affected amongst all the four sites observed.

Small-scale miners indicated that SSM activities have a positive socio-economic impact through poverty alleviation and employment creation. Although the activities of small-scale miners have a positive impact on the lives of the miners and their families, the same have a negative impact on the environment. The study recommends the government to take an active role in providing mining equipment, training on mining safety, education of small-scale miners on the environment and land rehabilitation. The study further recommends awareness campaigns for small-scale miners in order to ensure that the impact on the environment remains minimal.
DECLARATIONS

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List of Abbreviations

AMD – Acid Mine Drainage

ASM/ SSM – Artisanal small-scale mining/Small-scale mining

EC – Electrical Conductivity

ECC - Environmental Clearance Certificate

EIA – Environmental Impact Assessment

EMP – Environmental Management Plan

ERSMA – Erongo Regional Small Miners Association

ILO – International Labour Organisation

MAWF – Ministry of Agriculture, Water and Forestry

MC – Mining Claim

MET – Ministry of Environment and Tourism

MITSMED – Ministry of Industrialisation, Trade and SME Development

MME – Ministry of Mines and Energy

NEPL – Non-Exclusive Prospecting Licence

NIMA – Neu Schwaben Miners Association

ORP – Oxidation Reduction Potential

TCL – Tsumeb Corporation Limited.
CHAPTER 1: INTRODUCTION

This chapter described the mining industry and its significance to Namibia, mineral resources mined by large, medium and small-scale mining sectors. The focus of the study was small-scale mining in Namibia and this chapter gave its description in terms of resources mined, locations, and challenges faced.

1.1 Mining Industry in Namibia

Namibia is rich in mineral resources such as diamonds, uranium, copper, gold, lead, zinc, iron, industrial minerals, dimension stones, precious and semi-precious stones (Ministry of Mines and Energy (MME), 2003). The mining industry has continued to form a significant part of the economy for instance in 2015, the sector contributed 11.9% to the GDP with diamond mining contributing N$ 11.46 billion in revenue and non-diamond mining excelling with N$13.82 billion. The total contribution of the mining industry to the state was N$ 25.28 billion in 2015 (Chamber of Mines, 2015).

Mining in Namibia is undertaken by formal and informal sectors. The formal sector is referred to as large scale and to some degree medium scale whereas the informal sector is known as small-scale mining (MME, 2003). The focus of this study is small-scale mining.

1.1.1 Small Scale Mining in Namibia

The United Nations Economic Commission for Africa acknowledges that there is no universal definition for small-scale mining as countries and organisations define artisanal and small-scale mining differently based on the level of mining, volume and products being mined (Kessey and Arko, 2013). Below are some of the definitions:
• Aryee et al. (2003) define the sector as “individuals or small groups who depend upon mining for a living and who use rudimentary tools and techniques (e.g. picks, chisels, sluices and pans) to exploit their mineral deposits”.

• Small-scale mining is the removal of minerals with the simplest of tools on a subsistence level (Department of Minerals and Energy, 1998).

• In the absence of official definition for small scale mining in Tanzania, Mwaipopo et al. (2004) describe the activities as those that are based on labour-intensive mining, low productivity per capita, employ unsophisticated technology and require low capital investment.

Even though all the above three definitions reflect the Namibian situation, the first definition was adopted in this study as it closely describes Namibia’s small-scale mining situation.

Small scale mining is a sector where a number of unemployed Namibians are involved in, as such, it has the ability to improve local economic development, reduce poverty and combat urban migration (MME, 2003; Speiser, 2000; Nyambe and Amunkete, 2009; NPC, 2010; Angula, 2007; Mupewa, 2014). A study done by Ministry of Industrialization, Trade and SME Development (MITSMED) (2015) revealed that since the semi-precious stone business is informal, little royalties are received by government and most of the time the miners withhold information due to fear and mistrust of government and outsiders. Nyambe and Amunkete (2009) are of the view that there is a lack of data and research reports available regarding small scale mining activities. Therefore, little is known on how the sector contributes to poverty reduction and thus making it difficult to understand the sector. Speiser (2000) and Palfi (2001) assumed that the contribution of small-scale mining activities to the GDP is insignificant due to lack of data regarding the number of small-scale miners involved.
Speiser (2000) and MME (2003) estimated the number of small scale miners involved in the sector to be less than 2500 for legal and illegal miners by early 2000’s. However, the numbers are believed to have increased over the years as MME (2015) and MITSMED (2015) estimated the number of people involved in small-scale mining to be between 5000 and 10 000 by 2015.

Minerals mined by small-scale miners with registered mining claims are but not limited to semi-precious stones such as quartz (rose, smoky, crystals), tourmaline, agate, amethyst, topaz, beryl, prehnite, and heliodore among others; industrial minerals (calcrete, clay and slate stones); dimension stones (for example, sodalite); base and rare metals (tin and tantalum) (Palfi, 2001 & Krappmann, 2006). The extraction of these mineral resources is done on a small and medium scale. The small-scale operators are either illegal (unregistered) or legal (registered) and the medium scale operators are more formal and well organised.

Most of the small scale mining activities take place in Erongo, Kunene, //Karas, Otjozondjupa, Hardap, Omaheke and Khomas Regions (MME, 2015). Small-scale mining is done using simple tools such as picks, hammers and chisels resulting in low productivity and low capital investment. On the other hand, medium-scale mining is well structured with advanced mining equipment such as Ground Penetrating Radar (GPR) and well-established market for their products (MITSMED, 2015; Krappmann, 2006).
1.1.2 Challenges faced by Small Scale Mining Sector

According to MME (2015), lack of data about informal sector mining activities makes it difficult to regulate the sector and this results in many challenges such as:

- Lack of capital from financial institutions as the business is regarded as risky;
- Harsh working conditions;
- Unsafe or wrong mining methods;
- Lack of proper mining equipment;
- Lack of geological information;
- Limited access into some farms to conduct operations; and
- Lack of expertise or finance to rehabilitate mining sites.

Lack of resources and time are the main contributing factors as to why the small-scale miners are not rehabilitating the mining sites, which in turn negatively affects the environment. This study assessed the impact of the small-scale mining activities on the environment.

1.1.3 Environmental Impact by small scale mining activities

Speiser (2000) and NPC (2010) categorise the environmental problems caused by small-scale mining activities as primary and secondary impacts. The primary impacts are risks/hazards caused from mining activity, which include water consumption and pollution, scars on landscape and destruction of natural habitat (flora and fauna). The secondary impacts include the accessibility of an area [access to exploit flora/fauna, fire wood (deforestation)], littering, sewage, family members who follow with small livestock which results in more pressure on the flora and fauna, the migration of people from other regions and the income generated from mining is not spent in the region where mining is taking place.
Primary impacts:

- The risks/hazards from mining activities result in land degradation by excavating the land to extract minerals through open pit mining, thus destroying plant species and cause waterways to be blocked (Speiser, 2000; Angula, 2007). Small scale miners are expected to cover the mining sites after mining which is not done and this violates Part VII section 43 subsection 2(c) in the Minerals (Prospecting and Mining) Act, No. 33 of 1992, which states that “If a mining claim is abandoned as contemplated in subsection (I), the holder of such a mining claim shall take all such steps as may be necessary to remedy the reasonable satisfaction of the Minister any damage caused by any prospecting operations and mining operations carried on by such holder to the surface of, and the environment on, the land in the claim area in question” (MME, 1992).

- Ground and surface water can be polluted by inappropriate use of chemicals and pits left uncovered can be a potential acid mine drainage source during rainy seasons (Angula, 2007 and MITSMED, 2015). Water pollution can also be caused by littering and sewage waste.

- Air pollution is affected by dust generated through the breaking or rock in order to extract minerals (Angula, 2007).

Secondary impacts:

- Small scale miners migrate with their families to mining areas where there are no regional or local authorities to provide basic services such as sanitation resulting in littering and sewage waste (Speiser, 2000; NPC, 2010).

- The families of miners and their livestock clear land in order to setup camps, overgraze, cut down trees to have wood for cooking and build shelters which results
Deforestation is a permanent destruction or clearing of land or area for other uses (http://www.livescience.com/27692-deforestation.html).

Much as there are a number of impacts of small scale mining activities on the environment, this study was not able to cover all of them but focused on the primary impacts with emphasis on the landscape, water, air pollution. This study looked at the secondary impacts such as littering and wastage and their impacts on groundwater.

1.2 Basis of the study

1.2.1 Problem statement

Speiser (2000) indicates that small-scale mining operations are viewed in a negative light and is associated with negative environmental impacts, lack of capital, health and safety. This led to the question: Are small-scale mining activities still having negative environmental impacts? If so, to what extent?

1.2.2 Objectives

The objectives of the study were to:

1. Determine whether small-scale mining activities have a negative impact on the environment specifically on landscape, water, air pollution and littering.
2. Determine the extent of the impact and whether the impacts indicated in previous studies, done more than 10 years ago on the industry, have either increased, decreased or the status quo has remained the same.
3. To recommended some measures or practices on how to minimise the impact of SSM on the environment.
1.2.3 Hypothesis

Small-scale mining activities negatively impact the environment.

1.2.4 Significance of the study

Even though there is a legislative framework in place to govern the small-scale mining industry, the problems with rehabilitation of mining sites still exist. The effectiveness of the legislative framework on environment protection was discussed by Angula (2007). There is a need to assess the situation every five years and this study will be of great significance, as it looked at the current impact of the small-scale mining activities on the environment and determined if the situation has worsened, become better or remained the same as was determined by previous studies seven years ago. The study also addressed some of the areas, which were not covered by the previous studies; such as impact of small-scale mining activities on the quality of groundwater, air pollution and littering by small-scale miners.

Furthermore, government institutions can use findings from this study as a basis to create awareness and inform small-scale miners about the impact of their activities on the environment.

1.2.5 Limitations of the study

This study was carried out at four mining sites: Neu Schwaben, Uis, Xoboxobos (Erongo Region) and Otjinene (Omaheke Region). Four sites in two regions might not give the complete picture of the magnitude of the environmental impact as opposed to more regions or more mining sites. However, due to the nature of the mini thesis, the study was limited to four mining sites to represent all small-scale mining activities in Namibia.
1.3 Summary

Namibia is rich in mineral resources which contribute significantly to the development of the country. The mining sector is categorised into large, medium and small scale, the latter being the focus of this study. Although small-scale mining has positive impact on the lives of the people, there are negative effects on the environment caused by small-scale mining activities (MME, 2003). Since the small-scale mining sector to some extent is driven by poverty and lack of employment, its activities negatively affect the environment. The next chapter reviews literature and shows gaps filled by this study.
CHAPTER 2: LITERATURE REVIEW

This chapter looked at mining regulations governing the small-scale mining activities, an outline of the studies done in Namibia in the past, their’ findings, recommendations and what gaps were observed. This chapter also looked at small-scale mining sector in Africa and demonstrated that the problems small-scale miners face are not unique to Namibia but is a global phenomenon with references to three neighbouring countries.

2.1 Mining Regulations for SSM in Namibia

The Mining sector in Namibia is regulated by the Minerals (Prospecting and Mining) Act, No. 33 of 1992 under the Ministry of Mines and Energy and the Environmental Management Act, No. 7 of 2007 under the Ministry of Environment and Tourism. The Minerals (Prospecting and Mining) Act, No. 33 of 1992 made provisions that Non Exclusive Prospecting Licenses (NEPL) and Mining Claims (MC) are only reserved for Namibians. The Act stipulates that for Namibians (18 years and older) or 100% owned Namibian companies who want to take part in small-scale mining activities should apply for NEPLs before acquiring mining claims. The NEPL costs N$ 50 and it is valid for 12 months and is not transferrable or renewable. It is not confined to an area and does not give exclusive prospecting rights but gives the holder the right to look for potential areas before registering mining claims. NEPL is a license given to potential prospectors in order to seek permission to access private farms for the purpose of prospecting. After a potential area is located, the NEPL holder should inquire from the Ministry of Mines and Energy if the area is occupied before the holder can peg his/her claims and within twenty-one (21) days apply for registration of MC (MME, 1992).
The Mining Claim costs N$50 and gives exclusive rights to the holder to extract minerals with the purpose of trading. Namibians are allowed to peg up to 10 claims of 18 ha in size (600 x 300 m) per area or in several areas across the country, except in protected areas such as National Parks. The Mining Claim is valid for three years from date of registration and after that, it can be renewed every two years for an unlimited time. The holder of a Mining Claim should enter in agreement with the landowner before commencing any mining operations (MME, 1992).

The Environmental Management Act stipulates that before a Mining Claim can be registered, the holder of an NEPL needs to complete a questionnaire or enter into an environmental contract with the Ministry of Environment and Tourism (MET) in order to obtain an Environmental Clearance Certificate (ECC). The ECC is required as prerequisites for granting the Mining Claims, with proposed operational methods, anticipated environmental impacts and rehabilitation measures. If the impact is low then the certificate is granted without any further assessment, but if the impact is high then the Ministry of Environment and Tourism will request the miner to provide an Environmental Impact Assessment (EIA) as well as Environmental Management Plan (EMP). In most cases small-scale miners’ operations have low impact and therefore the EIA and EMP are not required (MET, 2007).

2.2 Studies done on Small-scale Mining in Africa

Africa has around 9 000 000 miners employed or involved in artisanal small-scale mining and an estimated number of 50 000 000 people are dependent on the sector (Dreschler, 2001 and Hayes, 2008). The number of miners involved in the sector can be more as there are illegal miners threatening the sector (Dreschler, 2001 and Hayes, 2008). The employment or involvement in artisanal small-scale mining activities can be fulltime, seasonal or occasional. The sector is faced with many problems such as inappropriate technology; lack of capital;
inadequate legal and regulatory framework; low productivity; no support from government, large-scale mining or private sector; isolation from mainstream economic development; adverse environmental effects; health and occupational hazards (Hayes, 2008). ASM in the SADC region are estimated to be 1 500 000 with the number expected to increase over the years (Dreschler, 2001). There are 30 different easily mineable and marketable minerals mined by ASM operations with gold being the dominantly mined commodity. Even though ASM can lead to wastage of non-renewable resource and hazardous to humans and the environment, it can empower disadvantaged communities economically (Dreschler, 2001). In most cases, there is no data on how much ASM operations can contribute to the country’s economy, but in Zimbabwe and Tanzania the contribution can be up to 25% of total gold production (Dreschler, 2001).

2.2.1 Small-scale Mining in Zimbabwe

There are over 1 000 000 legal small-scale miners, 50 000 to 350 000 illegal small-scale miners and over 2 000 000 people dependent on small-scale mining activities in Zimbabwe (Dreschler, 2001; Shamu and Wolff, 1994; International Labour Organisation (Sectoral Activities Programme), 1999; Svitwa et al., 1999). The majority of miners are involved in gold panning and semi-precious stones. The small-scale mining sector is regulated by the Mines and Minerals Act Chapter 21:05 and all the legal or formal small-scale miners are those that have their mining claims registered with the Ministry of Mines and Mining Development. The smallest mining claims is a block of ten hectares in size measuring 500 m x 200 m (Phiri, 2011).

Phiri (2011) indicates that the Second Five Year National Development Plan noted that the unplanned gold panning is one of the biggest contributors to land degradation, deforestation, health and safety in Zimbabwe. Some miners use mercury to recover the gold, which results in siltation of rivers; pollutes water and ecosystem; weirs and dams downstream leading to
plant poisoning, and destructions of animal life that are dependent on river systems for survival (Maponga, 1995). Mercury poses a threat to humans and aquatic based food chains through bioaccumulation (Donkor et al., 2006).

2.2.2 Small-scale Mining in Zambia

According to Dreschler (2001), there are more than 30,000 small-scale miners in Zambia. Dreschler (2001) and Mwenechany (2000) indicate that small-scale mining operations comprise of registered and licensed non-mechanized or semi-mechanized mining operations in gemstones such as; diamond, emerald, amethyst, aquamarine, beryl, topaz, corundum, tourmaline and garnet with amethysts being the largest output by volume. Other commodities are building materials and base metals such as copper and manganese. Small-scale miners operate under the prospecting permits, small-scale mining licence, artisans mining rights and small-scale gemstone licences which are granted under the Mines and Minerals Development Act of 2008, Explosives Act, Mining Regulations and Environmental Protection and Pollution Act, 1990 in the Ministry of Mines, Energy and Water Development.

Environmental problems of small-scale miners are acid soil erosion and river silting. The use of heavy-duty earth moving equipment results in generation of waste piled up in heaps (Dreschler, 2001).

2.2.3 Small-Scale Mining in South Africa

In South Africa, miners involved in artisanal and small-scale mining are around 30,000 (Hoadley and Limpitlaw, 2004). The main commodities mined are diamonds, dimension stones, industrial minerals, kaolin, phosphate, graphite, gold, salt and talc. The sector is regulated by Minerals and Petroleum Resources Development Act, No. 28 of 2002 and the Mine Health and Safety Act, No. 29 of 1996 (Dreschler, 2001). ASM are required to have a
mining permit before any mining operations can commence. Mining methods are through pick-and-shovel and simple technology for gold and diamond panning.

The government, parastatals, private companies and NGOs have assisted ASM with safe mining practises, marketing of products, drafting of business plans and organising ASM in associations or groups. Environmental hazards associated with SSM in South Africa ranged from environmental degradation; health hazards due to the usage of mercury in the extraction of gold, brick-making and mining kaolin; water pollution, and land conflicts (Dreschler, 2001).

2.3 Previous studies done on small-scale mining in Namibia

Speiser (2000), Angula (2007), Nyambe and Amunkete (2010) conducted studies to assess the current situation of small-scale mining in Namibia, focussing on the following points:

• Impact of poverty alleviation through small-scale mining activities,

• Effectiveness of the existing legislative framework such as the Minerals Policy and the Minerals (Prospecting and Mining) Act with regards to environmental protection,

• Support structures to small-scale miners,

• Effective resource utilisation and

• The environmental impact of small-scale mining

Studies were carried out in two regions namely in;

i) Erongo Region in the following places: Neu Schwaben (Speiser, 2000; NPC, 2010); Otjimbingwe & Omaruru (Nyambe & Amunkete, 2009; NPC, 2010); Spitzkoppe (Speiser, 2000; NPC, 2010); Okombahe (Nyambe & Amunkete, 2009); Usakos – Henties Bay T-
Junction (Nyambe & Amunkete, 2009); Erongo Mountain (Speiser, 2000; NPC, 2010); Uis (Angula, 2007; NPC, 2010), Xobobobos (NPC, 2010).

ii) Karas Region: The only study done in the southern part of Namibia was by Speiser (2000) in Grunau, north-west of Keetmanshoop, Brukkaros and Aus.

The methods used to address the impact of small-scale mining activities on the environment were similar, and were both qualitative and quantitative. The primary data was gathered through field visits, interviews with small-scale miners, government officials and environmental consultants. Small-scale miners and stakeholders consisting of staff members from Ministry of Mines and Energy, Ministry of Environment and Tourism, Regional Councils and environmental consultants were interviewed (Speiser, 2000; Angula, 2007; Nyambe and Amunkete, 2009; NPC, 2010). Secondary data such as the Minerals (Prospecting and Mining) Act No. 33 of 1992, Environmental Management Act No. 7 of 2007 and Minerals Policy of Namibia, 2003 were used to supplement the primary data.

This study used the same methodology as in previous studies to gather the primary data. Water samples were taken and analysed from mining sites with boreholes. The secondary data was gathered using data from GROWAS, which is a database of groundwater chemistry. The groundwater chemistry was used to determine the quality of water based on the water quality classification in Namibia (MAWF, 1956). A comprehensive methodology of this study was described in chapter 4.

The study conducted by MITSMED revealed that small-scale mining activities have the ability to contribute to poverty alleviation through employment creation, income-earning opportunities and sustaining businesses within the local economy of the Erongo region. The local economy is sustained when the miners and their families spend their income within the regions mining is taking place as well as spend their income in the regions they are coming.
from. The income is spent mostly on food, transport, education and medication (MITSMED, 2015).

The study done by Speiser (2000) & Angula (2007) revealed that there are measures in place to regulate the small-scale mining sector through the existing legislative framework. The Minerals Policy was implemented to legalise the sub-sector and combat illegal mining, but the fact that the process of acquiring licenses can only be done in Windhoek and is lengthy, most miners opt to mine illegally than go through the process. The policy is not effectively implemented and there is lack of coordination between the two ministries dealing with mining and the environment thus making the licensing process longer. The Ministry of Mines and Energy and Ministry of Environment and Tourism should work together for effective implementation of the environmental protection in the Minerals Policy.

These studies also revealed that the impact on the environment was one of the many challenges faced by small scale miners together with the lack of finance, education, markets, buyers, investors, land disputes and mining equipment (Speiser, 2000; Angula, 2007; Nyambe and Amunkete, 2009; NPC, 2010). Nyambe and Amunkete (2009) pointed out that small-scale miners are not aware of the conditions set in the Minerals (Prospecting and Mining) and Environmental Management Acts. Therefore, it was recommended that government should assist small-scale miners by educating them on the conditions set in both acts, on safety and health issues in order for the sector to grow. The study has also indicated that since the sub-sector is a low income driven activity, the miners do not rehabilitate the mining sites due to lack of finance, equipment and time (MITSMED, 2015). Another hindrance is the ineffective coordination between the Ministry of Mines and Energy and the Ministry of Environment and Tourism.
The negative impacts are open holes, mining pits, trenches, steep walls of the pits and waste rock disposal in the mining area. Miners migrating and settling close to mining sites also contribute to environment degradation by destroying the vegetation which they cut down for firewood, use the open fields as toilets and disorganized domestic waste disposal. Speiser (2000) and Angula (2007) described the problems caused by small-scale mining activities on the environmental as primary and secondary impacts. They indicated that the primary impacts are risks/hazards from mining activity, water consumption and pollution, scars on landscape and destruction of natural habitat (flora and fauna). The secondary impacts are accessibility of an area [people move in, access to exploit flora/fauna, firewood (deforestation)]; littering and sewage. Other impacts are family members moved with their small livestock resulting in more pressure on the flora and fauna as well as migration of people from other regions.

The study by National Planning Commission (2010) concluded that SSM activities do have an effect on the environment, but is minimal compared to that large-scale mining e.g. Uis Tin Mine. Mining intensity of SSM activities varies from one area to another, for instance in Neu Schwaben there are more un-rehabilitated deeper pits and less un-rehabilitated shallower pits in Xoboxobos and Erongo Mountain. The impact has a significant effect on the biophysical and socio-economic environment, where the impacts with significant effects are namely; disruption of day-to-day activities, damage to archaeological heritage, security risk to landowners, and poaching. The impacts of medium significance are; wildlife displacement, collection of firewood which leads to deforestation, visual scarring, risk of fire, erosion, biophysical impact of poaching, interference with tourism and safety to mines.
Nyambe and Amunkete (2009) suggested that miners should be assisted with necessary mining equipment (such as jack hammers and compressors) in order to improve the sector. Furthermore, Nyambe and Amunkete (2009) recommended implementation of training programmes to improve the understanding of the legislative framework and to create environmental awareness. Larger and well-established mining companies should assist small-scale miners technically and financially. In the absence of institutional infrastructure, better coordination between relevant government bodies should be established to achieve a sustainable situation in the future. If the two ministries (MME and MET) could work together to effectively implement the Minerals Policy on environmental protection the negative impact on the environment will be minimised (Speiser, 2000 and Angula, 2007).

The National Planning Commission (2010) recommended mitigation actions in order to reduce the environmental impact to low significance by proposing Environmental Management Plan (EMP) and the development of Environmental Code of Practise (ECOP). The ECOP focuses on five main points, such as:

i) Co-operation with landowners;

SSM should enter into agreement with landowners, Communal Land Board or Traditional Authority after MME and MET have granted them the permission to carry out mining activities. The agreement involves the compensation to the landowners, waste disposal and any working conditions.

ii) Mine “light” and rehabilitation

SSM should keep the disturbed areas to a minimum; trees and other plants should not be removed unless necessary; backfill should be done while digging where possible and exhausted holes should be closed before opening new holes.

iii) Work safety
Safe mining practices should be put in place in order to ensure conducive working environment and reduce injuries.

iv) Locate camps cleverly.

SSM should locate their camps in secluded areas away from tourists and 2 km away from water holes or springs.

v) Waste Management.

Waste should be disposed of in designated areas as per agreement and not dumped everywhere where it will pollute, affect the health of wildlife or people.

2.4 Gaps

Out of all the four studies done, the studies by NPC (2010) and Angula (2007) focused on the impact of small-scale mining activities on the environment and the other two were looking at the situation of the sector and the economic impact in terms of poverty reduction. It should be noted that these studies were done more than seven years ago and there is a need to conduct a study on the current situation. The only study done in the last 5 years was by MITSMED, which was looking at sector growth with emphasis in gemstones value chain.

No studies were conducted to assess the impact of small-scale mining of calcrete on the environment. This study also analysed existing data on groundwater to determine the quality of water around the small-scale mining areas, which was not done before. The next chapter described the study area in terms of location and geology.
CHAPTER 3: STUDY AREAS

This chapter describes the general geology of Namibia and the geology of the four study areas. The areas covered in this study were Neu Schwaben, Uis, Xoboxobos in Erongo Region and Otjinene in Omaheke Region. The study areas are shown in Figure 1.

Neu Schwaben

Neu Schwaben 73 is a Government Farm located 8 km south-east of Karibib. The farm was formally private owned but was recently bought by the government. Small-scale miners have been resettled on one unit of the farm with thirty-four (34) registered mining claims.

Uis

Uis is a small settlement located 370 km North West of Windhoek in Erongo Region. The tin mine in Uis was known as the largest hard rock mine in the world (Diehl, 1992).

Xoboxobos

Kotze (2002) refers to this area as Gobbobos but the local people are refer to it as Xoboxobos as reflected in this study. Xoboxobos is located 90 km northwest of Uis and west of the Brandberg on the Xoboxobos Mountain.

Otjinene

Otjinene is located about 360 km northeast of Windhoek. The calcrete deposit is on a communal area on a village called Otjiue Tjombungu about 50 km east of Otjinene.
Figure 1: Map indicating the study areas (Xoboxobos, Uis, Neu Schwaben and Otjinene) in red
3.1 General Geology of Namibia

Miller (1992) described the Namibian geology into five periods of lithogenesis: the first period consist of the oldest rocks within the Metamorphic Complexes of Vaalian (>2000Ma) to Early Makolian (2000 to 1800Ma) Age, e.g. the Epupa and Abbabis Metamorphic Complexes (Figure 2). The second period is the formation of Rehoboth-Sinclair Magmatic arc and the Namaqualand Metamorphic Complex during the late Makolian (1800 to 1000Ma) age. The third period is the Damaran Orogenic phase (650 and 450 Ma) which started with intracontinental rifting and sedimentation. The fourth period is the extensive peneplain which resulted in the deposition of Karoo Sequence between the Carboniferous and early Cretaceous (300 to 135 Ma). The last and youngest period is the Kalahari and Namib Sequence of the Cretaceous to recent (<135 Ma) age.

In Erongo Region, the pegmatites where most gemstones are mined is part of the Damara Sequence belonging to the Pan African Orogenic System (Miller, 1983). The Damaran Orogenic Belt was a result of successful phases of rifting, spreading, subduction and continental collision and it subdivided into several zones; namely, Northern Platform, Northern Zone, Central Zone, Okahandja Lineament Zone, Southern Margin Zone, Southern Zone, Southern Foreland and Naukluft Nappe Complex as indicated in Figure 3 (Miller, 1983).
Figure 2: Simplified Geological Map of Namibia (Miller, 2008).

Schneider (2004) describes the Zones as follows, “The Northern Platform is made up of carbonates of the Otavi Group which is overlain by the molasses of the Mulden Group. The Northern Zone is the transition between the platform carbonates and the shelf sediments of the Swakop Group. The Central Zone is also known as Swakop Zone and is regarded as the
high temperature low - pressure zone which is characterised by granitic plutons and sillimanite – coedierite metamorphic assemblages. The Central Zone is divided by Omaruru Lineament – Waterberg Fault into northern and southern portions. The Okahandja Lineament marks the southern edge of the Central Zone and is being considered as the most important boundaries in the Damara Orogen and consists of Kuiseb Formation with different metamorphic structures (Miller, 1979).

The Southern Zone is known as the Khomas Zone and consists of Kuiseb Formation as well. The Southern Margin Zone is known as the Hakos Zone with intense thrusting which occurred during continental collision. The Nama Group belongs to the Southern Foreland and consists of foreland and molasses sediments. The Naukluft Nappe Complex was emplaced from the Southern Margin Zone onto the Southern Foreland. The coastal branch has been subdivided into the Western, Central, Eastern and Southern Kaoko Zones” (Miller, 1979).
Figure 3: Tectonostratigraphic zones of Namibia. Compiled by Petzel and Schreiber (1999).
3.2 Geology of the study areas

3.2.1 Neu Schwaben Pegmatites Deposit

According to Schneider (1992), the pegmatite is known to belong to the group of zoned, lithium–beryllium rare-metals, which is situated on the southern part of the Central Zone of the Damara Orogen. The stratigraphy of Neu Schwaben according to Brandt (1985) is shown in Table 1.

Table 1: Stratigraphy of Farm Neu Schwaben 73

<table>
<thead>
<tr>
<th>Formation</th>
<th>Rocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuiseb</td>
<td>Schist</td>
</tr>
<tr>
<td>Karibib</td>
<td>Calcitic marble</td>
</tr>
<tr>
<td>Etusis</td>
<td>Muscovite-bearing feldspathic quartzites</td>
</tr>
<tr>
<td>Abbabis Metamorphic Complex</td>
<td>Quartzo feldspathic augengneiss</td>
</tr>
</tbody>
</table>

Semi-precious stones are recovered from Late Pan African pegmatites and zones linked to epizonal highly evolved granites, except amethyst, which is recovered from deposits hosted by Damaran Marbles (Schneider and Seeger, 1992). The authors also mentioned that the pegmatites can be found in the southern part of the Central Zone of the Damara Orogen. The zone is characterised by high temperature and low-pressure metamorphism known for sillimanite–cordierite metamorphic assemblages intruded by several granitic plutons. Ashworth (2014) indicated that the pegmatites are rich in Nb, Li, Sn, U, REEs, Columbite-Tantalite and gemstones (tourmaline, topaz and amethyst).
3.2.2 Geology of Uis

The oldest rocks occurring are the meta-sedimentary, which include quartzites, phyllites, quartz-schists, quartz-mica-schists and mica schists situated in the northern part of the Central Zone of the Damara Orogen in Figure 3. These rocks strike NE-SW to N-S direction with a south to southeast gentle dip and belonging to the Amis River Formation included in the Swakop Group (Singh, 2007). The post- tectonic pegmatites are complex in nature and contain several rare elements and minerals include quartz, microline to microclinoperthite, albite and muscovite with accessory minerals of cassiterite, columbite-tantalite and zircon and lithium minerals such as amblygonite (Singh, 2007; Haack & Gohn, 1988). The tin and tantalum are the base and rare metals mostly mined by the small-scale miners in Uis and Xoboxobos as well as semi-precious stones (tourmaline, amethyst and rose quartz).

3.2.3 Geology of Xoboxobos

The geology of the area is complex and diverse and is dominated by older rocks of the Damara Sequence. The area is known for its recent intrusive and extrusive episodes that have resulted in the creation of lava sequences of the Etendeka Plateau, the Messum Crater and the Brandberg (Kotze, 2002). The lava flows of the Etendeka Group give rise to “pockets” of semi-precious stones and rare metals mined in the area (National Planning Commission, 2010). The semi-precious stones mined include aquamarine, tourmaline, amethyst, rose quartz, smoky quartz, other crystals, prehnite, tin and tantalum.

3.2.4 Geology of Otjinene Calcrete

Calcrete is widely distributed in Namibia especially in the east and northern half of the country as shown in Figure 4. Krappmann (2007) indicates that there is no common
agreement on the origin and conditions of the formations of calcrete, but Netterberg (1969, 1980) describe the formation of calcrete from southern Africa as accumulations of carbonate resulting in the production of calcareous soil. As the calcium carbonate (CaCO$_3$) content increases, the soil is calcified forming calcrete nodular and then honeycomb which ends up forming hardpan calcrete. The latter represents the mature and last stage of calcrete development (Netterberg and Caiger, 1983). Krappmann (2007) mentioned “the final stage of hardpan calcrete precipitation, replacement and cementation within a distinct horizon of the soil profile results in the formation of sheet-like relative impervious layer which is invariably underlain by softer calcrete material which does not exceed 0.8 m in thickness”. Calcrete is widespread in Namibia especially in the east and northern half of the country (Figure 4). Calcrete is mined for the sole purpose of building material, which is cut into bricks for low income houses. Krappmann (2007) indicates that the use of calcrete as building blocks is long forgotten and has been replaced by clay bricks or blocks made of concrete. However, there are small-scale miners in Omaheke and Kunene Regions making a living out of calcrete mining (Sibeso-Mweemba and Kandjii, 2012).
3.3 Summary of study areas

The chapter described general geology of Namibia and the geology of the study areas. The areas described are Neu Schwaben, Uis, and Xoboxobos in Erongo Region and Otjinene in Omaheke Region. Namibian geology is divided in five periods of lithogenesis, the oldest rocks being >2000 Ma and the youngest is <135 Ma. The semi-precious stones, tin and tantalum are mined from late pan-African pegmatites (Neu Schwaben) and post-tectonic pegmatites in the Central Zone of Damara Orogen. The calcrete deposit is found in young surficial deposits of the Kalahari and Namibia Deserts by cementation and alteration of pre-existing soil and rock by predominantly calcium carbonate under the semi-arid condition. The next chapter describes the methods that were used in gathering the data for this study.
CHAPTER 4: RESEARCH METHODOLOGY

This chapter discusses the methods and procedures that were used for data collection. This study was both qualitative and quantitative and relied on primary and secondary data. The primary data was collected through field observation, open-ended questions to small-scale miners and stakeholders. Secondary data was obtained by reviewing existing literature and GROWAS Database. Information from literature was obtained from published and unpublished reports in the Ministry of Mines and Energy, Geology Department at UNAM, Mining Department at NUST and various websites.

This study focused on Neu Schwaben, Uis and Xobobos in Erongo Region and Otjinene in Omaheke Region. These areas were selected because most small-scale miners operate in them.

4.1 Qualitative and Quantitative analysis

The study was based on qualitative and quantitative data to supplement each other and relied on primary and secondary sources. The primary data was collected through field observation, open-ended questionnaires to small scale miners, government officials and Association coordinator. The questionnaires were presented in a form of interviews to the miners in order to get as much information as possible. The data was collected by visiting mining sites and carrying out assessments in order to determine the effects of mining operations on the environment. Visual observations were done on vegetation and air around the mining sites, the quality of water in boreholes was analysed using pH, oxidation-reduction-potential and electrical conductivity meters. Electrical conductivity was measured in order to determine the amount of salts or impurities in the water at a certain temperature. The pH analysis was done to determine the acidity or alkalinity of the water. The Oxidation–Reduction Potential was used to determine the oxidation and reducing state of the water. Data from GROWAS
Database was used to determine the quality of ground water in the study areas to supplement the primary data as only two boreholes were close to mining sites in two study areas.

The secondary data was obtained by reviewing existing articles and reports of researches conducted on the effects of mining operations in Namibia and other countries. Most of the reports and articles on the geology and mining in Namibia, were sourced from published and unpublished sources from the Ministry of Mines and Energy (Department of Geological Survey, National Earth Science and Energy Information Centre [NESEIC] and Department of Mines); GROWAS database from Ministry of Agriculture, Water and Forestry, University of Namibia (UNAM) and University of Science and Technology (NUST). Various websites were also used in this research. Reports from previous studies were analysed to determine if the impact of SSM activities on the environment was in agreement with this study and to see if the situation had worsened or remained the same over the years.

4.2 Population

The target population of the study included small-scale miners, officers from Ministry of Mines and Energy and Coordinator of Erongo Small Miners Association. The population was classified into three broad stakeholder groups whose perspectives the researcher felt were important to obtain in this study: small-scale miners; Government (staff members in the Small Scale Mining Division – Department of Mines) and Small Scale Mining Association. The government officials and Association Coordinator were referred as stakeholders for analysis purposes in this research whilst small-scale miners are referred to as such. The target population was limited to small-scale miners who were involved in the mining or selling of gemstones. It should be noted that at the time of conducting this study, there was only one member of the association operating in the ERSMA office.
4.3 Sampling Techniques

The target population was comparatively too large to successfully examine under the time constraints of mini thesis and budgetary confinement of the study. The researcher therefore employed a random selection in sampling respondents and gathering information about environmental impacts associated with small-scale miners in Erongo and Omaheke Regions.

The total number of small-scale miners sampled were 11 people; staff at Department of Mines responsible for the development of small-scale miners in Namibia (6); Coordinator of Small Mining Association (1) totalling to 18 respondents. For small-scale miners a simple random technique was applied and interviews were conducted as it enabled them to give more information. During the research it was assumed that all small-scale miners had similar behaviour, working conditions and challenges so the results was generalised to the entire country. This therefore means that every group or individual found on site was deemed as a suitable candidate to participate in this study. For the small-scale miners semi-structured interviews were done randomly with groups and individuals found on sites. Qualitative and quantitative sampling were used to sample the population listed and was also used to analyse the responses and simple statistical tools were used to analyse the data.

4.4 Research Instruments

The study used observational fieldwork, interviews and archival data from files and other published and unpublished records to ascertain themes arising from small-scale miners and stakeholders’ perspectives. In this study a set of questionnaires (appendix A and B) and interviews of eleven (11) miners, six (6) government officials and one (1) association coordinator was set up for interviews. A meter instrument was used to measure the size of mining sites.
The water samples collected were analysed in the field using portable pre-calibrated electrodes of pH, Oxidation–Reduction Potential (ORP), electrical Conductivity Meters and Temperature (Hach HQ40 and HQ10).

The Electrical Conductivity (EC), pH, temperature, ORP, sulphate and Total Dissolved Solids (TDS) were all used to determine the suitability of water for human or animal consumption. EC is used to measure the total ion content of water and it influences the ability of water to carry an electric current. Electrical conductivity is linked to the concentrations of ions and their mobility. In this study, the conductivity was measured to determine to what extent SSM activities (breaking of rocks and household waste) are polluting the groundwater and if there is possibility of AMD. The results from electrical conductivity, pH and temperature were used to determine the quality of water and it was compared to the Classification Water Quality in Namibia (Table 2) as outlined in the Water Act of 1956 (Act No.54 of 1956) (Ministry of Agriculture, Water and Forestry, 1956). The Oxidation-Reduction Potential gives the indication of free electrons and the oxidizing or reducing tendency of water (James et al., 2004).

### 4.5 Data analysis (ground water)

There were two sites in Uis and Neu Schwaben that had boreholes close to the mining sites. Water was collected in a bucket for measurements of on-site parameters. The Electrical Conductivity (EC), pH, temperature, ORP, sulphate and TDS are all used to determine the suitability of water for human or animal consumption. EC is used to measure the total ion content of water and it influences the ability of water to carry an electric current. Electrical conductivity is linked to the concentrations of ions and their mobility. In this study, the conductivity was measured to determine to what extent SSM activities are polluting the
groundwater and if there is possibility of AMD. The results from electrical conductivity, pH and temperature were used to determine the quality of water and it was compared to the Classification Water Quality in Namibia (Table 2) as outlined in the Water Act of 1956 (Act No.54 of 1956) (MAWF, 1956). The Oxidation-Reduction Potential gives the indication of free electrons and the oxidizing or reducing tendency of water (James et al., 2004).

Table 2 below highlights the classification of water quality for human consumption. The analysis determined the concentration of physical and inorganic determinants in the water and grouped them based on the quality of water. Group A is water with an excellent quality; Group B is water with acceptable quality; Group C is water with low health risk and Group D is water with high health risk or unsuitable for human consumption (MAWF, 1956). The data from GROWAS Database was used to supplement the missing data from the study areas.
### Table 2: Water Quality classification in Namibia

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Units</th>
<th>Limits for Groups (Classification)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Conductivity</td>
<td>mS/m at 25˚C</td>
<td>150</td>
<td>300</td>
<td>400</td>
</tr>
<tr>
<td>pH</td>
<td>pH - units</td>
<td>6.0 – 9.0</td>
<td>5.5 – 9.5 (excluding class A limits)</td>
<td>4.0 – 11.0 (excluding class B limits)</td>
</tr>
<tr>
<td>Sulphate</td>
<td>Mg/l</td>
<td>200</td>
<td>600</td>
<td>1200</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>Mg/l</td>
<td>&lt;1000</td>
<td>&lt;2000</td>
<td>&gt;2000</td>
</tr>
</tbody>
</table>

#### 4.6 Ethical considerations

During the field observation and interview process, no direct measurements were done on the small-scale miners. Therefore, ethics were not applicable in this study.
CHAPTER 5: RESULTS

This chapter describes what was observed during the field visits, results derived from water samples analysed in the field, results from GROWAS database and answers from questionnaires.

5.1 Uis Area

5.1.1 Results from field observation

In Uis, twelve (12) mining sites were visited and the out of the twelve (12) mining sites three (3) were active and the rest were inactive. On all the sites there were three (3) women and seven (7) men involved in mining. The women were only mining tin and tantalum while the men were mining tourmaline, amethyst, aquamarine, garnet, tin and tantalum. Out of the seven men, only four were the main miners and the rest were employed as assistance to the miners. Out of the three women, two of them were working together and the third woman was working with her husband.
The rocks that were observed on the sites were pegmatites, marble, schists and quartzites (Figure 5a). At some mining sites, no waste materials could be observed around the sites, but at some sites degraded tins lying around could be observed. The vegetation affected are those that have been removed because of mining (Figure 5b). At one site two small-scale miners were sieving loose weathered soil from the pegmatite ridge to get tin and tantalum out using

<table>
<thead>
<tr>
<th>Mining sites</th>
<th>location</th>
<th>Size (m)</th>
<th>Depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S21.32711 E015.28060</td>
<td>14 m x 7.7m</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>S21.26270 E014.83573</td>
<td>1.5 m x 2.4 m to 27.2 m x 2.5 m</td>
<td>20 to 180 in depth</td>
</tr>
<tr>
<td>3</td>
<td>S21.30856 E014.80934</td>
<td>3.8 m x 17.2 m</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>S21.16666 E014.31223</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>S21.15491 E014.30499</td>
<td>30 m x 60 m</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>S21.15656 E014.30230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>S21.33014 E014.79929</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>S21.53630 E014.71105</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>S21.53658 E014.70449</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>S21.57580 E014.66939</td>
<td>1.5 m x 1.5 m</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>S21.23802 E014.87784</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>S21.18167 E014.89094</td>
<td>4 m x 6 m</td>
<td>120</td>
</tr>
</tbody>
</table>
the panning method (See Figure 8). Due to the breaking of rocks to extract minerals and the sieving of loose soil, dust was being generated.

At the sites where no mining activities took place, the pits were not rehabilitated and they were filled with scrubs and trees as well as trenches and heaps of sand (Figure 6&7). Minimal waste materials; such as torn clothes, degraded tins and metals were observed. It was also observed that some of the pits were deep and some were shallow pits. There was no clear indication whether the activities that took place were for small-scale mining or they were for other purposes. However, it was clear that sand had been removed in some places some time ago since there was evidence of regrown vegetation in the pits. At another site, a beacon was observed indicating that it was a mining area with registered or a pegged mining claim. Unfortunately, all writings on the beacon had faded as seen in Figure 9(a). About 300 m from the beacon, some soil disturbances were observed indicating mining activities had taken place. The one hole found was 1.5 m x 1.5 m in size with a depth of 1 m. Close to the hole it was observed that there were rose quartz of different sizes (1 cm to 30 cm) scattered around (Figure 9b).

Figure 5: Small-scale miners in an active pit (a) and inactive pit (b) mining Tourmaline, aquamarine and garnet.
Figure 6: Picture showing sites with no rehabilitation measure been undertaken.

Figure 7: Waste material (torn clothes) in an un-rehabilitated pit.
Figure 8: Picture of small-scale miners extracting tin and tantalum (a) from loose soil from pegmatite ridge (b).
Figure 9: Mining Claim were a peg (a) was located and rose quartz of different sizes from few 1 cm to 30cm (b).

The Uis Tin Mine has not been in operation for over 26 years and no rehabilitation has been done. About 40 women from the Uis Settlement are mining tin in the mine open pit (Figure 10a). The miners use chisels and hammers to extract the tin. The site visited had been abandoned, because the ore available was only found in the hard rock and it became too dangerous for the women to continue working in the area. Waste materials; such as clothing, metals and old tires were observed in the pit (Figure 10c). Within the Uis open mining pit there were some holes which were not reclaimed as seen in Figure 10b.
5.1.2 Ground water chemistry in Uis and Xoboxobos Area

There was a borehole of 5.2 m deep and 1 km south from one of the mining sites at coordinates S21.33647 and E015.28401. The villagers use the water for their daily needs. The water in the borehole was tested and the results are shown in Table 4.
Table 4: Water chemistry of groundwater at one mining site in Uis

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.97</td>
</tr>
<tr>
<td>Conductivity</td>
<td>145.8 mS/m</td>
</tr>
<tr>
<td>Redox potential</td>
<td>69.7 mV</td>
</tr>
<tr>
<td>Temperature</td>
<td>25.7°C</td>
</tr>
</tbody>
</table>

The GROWAS Database has one thousand eight hundred and twenty six (1826) data entries for Uis areas (Figure 11) and boreholes around the mining site at Figure 12). There are six hundred and fifty (650) data entries with pH values; the average is 7.6 with a minimum of 6.3 and a maximum of 9.5. There are eight hundred and ten (810) data entries with sulphate values; the average is 183 mg/L with a minimum value of 3 mg/L and a maximum value of 2500 mg/L. For the Total Dissolve Solids, the data entries is six hundred and four (604) with an average of 1449 mg/L, a minimum value of 191 mg/L and a maximum of 34 550 mg/L. The initial water level has data entries of seven hundred and ninety four with a minimum value of 0.30 m and a maximum value of 490 m depth. The data of borehole close to the mining sites are shown in Table 5.
Figure 11: Google Earth map showing all boreholes (in black dots) in the Uis area.

Table 5: Water chemistry of boreholes in the vicinity of the Uis area from GROWAS Database

<table>
<thead>
<tr>
<th>Number</th>
<th>pH</th>
<th>Conductivity</th>
<th>Sulphate</th>
<th>TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3460</td>
<td>6.8</td>
<td>596</td>
<td>640</td>
<td>3809</td>
</tr>
<tr>
<td>3461</td>
<td>7.4</td>
<td>1347</td>
<td>1380</td>
<td>9412</td>
</tr>
<tr>
<td>60951</td>
<td>7.5</td>
<td>596</td>
<td>590</td>
<td>3675</td>
</tr>
<tr>
<td>60952</td>
<td>No data</td>
<td>No data</td>
<td>1750</td>
<td>534</td>
</tr>
<tr>
<td>81302</td>
<td>7</td>
<td>740</td>
<td>1750</td>
<td>5391</td>
</tr>
</tbody>
</table>
5.1.3 Results from questionnaires

In Uis the five interviews were conducted with three (3) women and four (4) men. Two of the women were working together at the Uis Tin Mine and the interview was conducted as one. The third woman was interviewed with her husband and the other three men separately. All miners will be referred to as seven (7) respondents.

The questionnaires can be viewed on Appendix A and only the questions relevant to this study will be summarised. The miners were interviewed on possible impacts or damages to the environment because of their mining activities, only three out of seven respondents indicated that land degradation (holes in the ground) is the possible impact on the environment due to mining activities. On the question of rehabilitation method, the four men and the couple indicated that they rehabilitate their sites after mining using the backfilling method. The women indicated that they have not done any rehabilitation as they were still busy mining in the Uis Tin open pit. The women are also waiting for assistance with equipment before they can resume mining in the case of unmined holes. When questioned on
the reason for being involved in small-scale mining, all seven respondents interviewed mentioned that they are mining because of unemployment and they do get return on their labour to feed their families. They were questioned on having knowledge of or training in the small-scale mining business, five out of the seven respondents interviewed indicated that they picked up knowledge from other miners that started before them and two said that they got training from Rössing Foundation.

5.2 Xoboxobos Area

5.2.1 Results from field observation
The Xoboxobos mining area has seven (7) different camps with 200 miners and their families. The site visited consisted of six (6) households with 10 mining pits at close proximity of each other (Figure 13 and 14). Out of the ten (10) pits, only four (4) were active and the rest inactive. The sizes of the active pits are summarised in Table 8. The small-scale miners are mining amethyst, prehnite, smoky quartz, quartz crystals and zeolites for the past 15 years. The mining equipment being used by small-scale miners at this site are hammers, chisels, pjönjär, diamond chainsaws, a front-end loader and a hydraulic splitter. The use of these equipment to break the rocks result in the generation of dust. Lots of rubbish, such as cans, papers, rusted metals and clothing materials were observed in the camp from household wastes. Dust in the Xoboxobos area is generated by moving vehicles and the evidence can be seen on the Welwitchia mirabilis close to the road covered in dust (Figure 15). The water body closest to the camp site is 15 km away so there is no possibility of water pollution. The water used in the households at the mining campsite comes from Uis and is transported using a water truck.
Figure 13: Small scale mining sites at Xoboxobos mining amethyst, smoky quartz, prehnite and zeolites

Figure 14: Mining pits at Xoboxobos community (household)
Figure 15: *Welwitchia Mirabilis* close to the access road to the mining site.

Table 6: Sizes of some mining pits at Xoboxobos

<table>
<thead>
<tr>
<th>Holes</th>
<th>Width (m)</th>
<th>Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15 in diameter</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>10 x 8</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>3 x 4</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>3 x 3</td>
<td>5</td>
</tr>
</tbody>
</table>
5.2.2 Results from water chemistry in Xoboxobos Area

From the Google Map (Figure 16) it is evident that there were no boreholes close to the mining site and therefore there are no data regarding the water chemistry in the area.

![Google Earth map showing no boreholes close to Xoboxobos mining site.](image)

Figure 16: Google Earth map showing no boreholes close to Xoboxobos mining site.

5.2.3 Results from questionnaires

In Xoboxobos, three interviews were conducted with three (3) men. There were no women involve in mining at this site. All miners will be referred to as respondents.

The questionnaires can be viewed on Appendix A and only the questions relevant to this study will be summarised. The miners were asked about possible impacts or damages to the environment as a result of their mining activities, the three respondents indicated that land degradation (holes in the ground) is the possible impact on the environment due to mining activities. As for the question on rehabilitation method, the three respondents indicated that they rehabilitate their sites after mining using the backfilling method. When questioned on the reason for being involved in small-scale mining, all respondents interviewed mentioned that they are mining because of unemployment and they do get return on their labour to feed their families. When questioned about having knowledge of or training in the small-scale
mining business, one out of the three respondents interviewed indicated that he picked up his knowledge from working Tsumeb Copper Mine. The mine was formerly known as Tsumeb Corporation Limited (TCL) and now Weatherly Mine and the other two respondents learn from other miners that started before them and they also got training from Rössing Foundation.

5.3 Neu Schwaben Area

5.3.1 Results from field observations

Neu Schwaben is a farm 20 km southwest of Karibib at S22.09436° and E015.90920°. The farm was bought by the government and about 205 miners are resettled on Unit A. The miners belong to the Neu Schwaben Miners Association (NIMA), which is affiliated to the Erongo Regional Small Miners Association (ERSMA). There are about 34 claims on a mining area of 575 ha in size. The claimed area has more than 15 pits where miners are digging for gemstones (Table 7), such as blue and green tourmalines and smoky quartz for the last 20 years (Figure 17). Miners are using spades, hammers and hydraulic splitters to extract the minerals. They are also using explosives to extract the semi-precious stones where the rocks are too hard to use any of the manual tools mentioned above. The use of hydraulic splitters and blasting generate some dust in the area. The pits are of depths ranging from 2 m to 8 m and width of 60 m x 30 m. Most of the holes were not filled up, some have been left for years and trees are growing in these pits with some of them being encroacher species (mainly Acacia millefera). Some holes have not been worked on for years and no rehabilitation has taken place (Figure 18a and b).
Table 7: Locations of the some open pits on Farm Neu Schwaben

<table>
<thead>
<tr>
<th>Pit</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S22.09348</td>
<td>E015.91036</td>
</tr>
<tr>
<td>2</td>
<td>S22.09221</td>
<td>E015.91027</td>
</tr>
<tr>
<td>3</td>
<td>S22.09159</td>
<td>E015.91128</td>
</tr>
<tr>
<td>4</td>
<td>S22.09153</td>
<td>E015.91231</td>
</tr>
</tbody>
</table>

Figure 17: Small-scale miner mining tourmaline and smoky quartz at Neu Schwaben.

Figure 18: Mining sites at Neu Schwaben for tourmaline, smoky quartz, a) and b) are sites where no rehabilitation measures have been undertaken.
5.3.2 Ground water chemistry in Neu Schwaben

A borehole at the homestead was sampled and the analytical results are recorded in Table 8.

Table 8: Water Chemistry of groundwater at farm Neu Schwaben

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.90</td>
</tr>
<tr>
<td>Conductivity</td>
<td>239 mS/m</td>
</tr>
<tr>
<td>Redox potential</td>
<td>148.3 mV</td>
</tr>
<tr>
<td>Temperature</td>
<td>21.7°C</td>
</tr>
</tbody>
</table>

According to GROWAS Database, there are one thousand one hundred and seventy two (1172) data entries for Karibib (Figure 19). There are five hundred and ninety six (596) data entries with pH values; the average is 7.5 with a minimum of 6.4 and a maximum of 9.1. There are six hundred and ninety (690) data entries with sulphate values; the average is 238 mg/L with a minimum value of 1 mg/L and a maximum value of 3570 mg/L. For the Total Dissolved Solids, the data entries is six hundred and ninety three (693) with an average of 1533 mg/L, a minimum value of 117 mg/L and a maximum of 13 767 mg/L. The initial water has data entries of four hundred and eighty nine (489) with a minimum value of 1 m and a maximum value of 180 m depth. The data of borehole close to the mining sites are shown in Table 9 and shown in Figure 20.

Table 9: Water chemistry from the GROWAS database at Neu Schwaben

<table>
<thead>
<tr>
<th>Number</th>
<th>pH</th>
<th>Conductivity</th>
<th>Sulphate</th>
<th>TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>81884</td>
<td>7.9</td>
<td>295</td>
<td>180</td>
<td>1825</td>
</tr>
</tbody>
</table>
Figure 19: Google Earth Map of showing boreholes (black dots) around Karibib area, Neu Schwaben is 20km southwest of Karibib.

Figure 20: Google Earth Map of Neu Schwaben Farm 48, showing mining tourmaline with one borehole close to the mining site (red dot).
5.3.3 Results from questionnaires

In Neu Schwaben two interviews were conducted with two (2) men. There was one lady with her husband. All miners will be referred to as respondents.

The questionnaires can be viewed on Appendix A and only the questions relevant to this study will be summarised. The miners were asked what could be the possible impacts or damages to the environment because of their mining activities, only one respondent indicated that land degradation (holes in the ground) is the possible impact on the environment due to mining activities. On the question of rehabilitation method, only one respondent indicated that he rehabilitated the sites after mining activities had ceased, but some sites have been observed that no rehabilitation has taken place in many years. The method used for rehabilitation is an unstructured way of filling the holes using spades or front-end loaders.

When questioned on the reason for being involve in small-scale mining, the two respondents interviewed mentioned that they are mining because of unemployment and they do get return on their labour to feed their families. As for questions on having knowledge of or training in the small-scale mining business, the two respondents interviewed indicated that they picked up knowledge from other miners that started before them and one miner said that he got training from Rössing Foundation.

5.4 Otjinene Calcrete

5.4.1 Results from field observations

During the study only one site was visited where calcrete is being mined at Otjiue Tjombungu in Otjinene Constituency (S21.34249 and E019.14263). There was only one male miner working (Figure 21b). In 2012, the Ministry of Mines and Energy conducted a similar study in Omaheke Region, visiting 15 sites and due to time and financial constraints,
only one site was visited during this study period. The method of calcrete mining and equipment used were similar and therefore the results will be drawn from the previous study (Sibeso – Mweemba and Kandjii, 2012).

The miners are using simple tools such as chisels, pangas and spades for digging and shaping the calcrete into bricks for building houses as seen in Figure 22 a & b. At this site, piles of calcrete off cuts could be seen on three different mining sites. No waste materials could be observed in the vicinity (Figure 21a). Not much grass could be observed only thorny shrubs.

![Figure 21: Mining site in Otjinene, (a) inactive mining site (b) showing a miner busy shaping calcrete into bricks.](image)
5.4.2 Ground water chemistry in Otjinene

As per the GROWAS Database, there are one thousand three hundred and eight (1308) data entries for Otjinene areas (Figure 23). There are six hundred and ninety six (696) data entries with pH values; the average is 7.6 with a minimum of 6.8 and a maximum of 9.4. There are eight hundred and seventy five (875) data entries with sulphate values; the average is 72 mg/L with a minimum value of 1 mg/L and a maximum value of 2396 mg/L. For the Total Dissolve Solids, the data entries are eight hundred and seventy four (874) with an average of 565 mg/L, a minimum value of 5 mg/L and a maximum of 12 875 mg/L. The initial water level has data entries of seven hundred and sixteen (716) with a minimum value of 0.30 m and a maximum value of 270 m depth. The data of borehole close to the mining sites are shown in table 10 and Figure 24.

Figure 22: Mined calcrete bricks (a) and a house built with the bricks (b)
Table 10: Water chemistry of boreholes in the vicinity of the study areas from GROWAS Database.

<table>
<thead>
<tr>
<th>Number</th>
<th>pH</th>
<th>Conductivity</th>
<th>Sulphate</th>
<th>TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7859</td>
<td>8.3</td>
<td>No data</td>
<td>107</td>
<td>869</td>
</tr>
<tr>
<td>23408</td>
<td>7.9</td>
<td>No data</td>
<td>142</td>
<td>660</td>
</tr>
<tr>
<td>23409</td>
<td>7.9</td>
<td>No data</td>
<td>86</td>
<td>502</td>
</tr>
<tr>
<td>23410</td>
<td>No data</td>
<td>No data</td>
<td>36</td>
<td>359</td>
</tr>
<tr>
<td>23411</td>
<td>No data</td>
<td>No data</td>
<td>64</td>
<td>423</td>
</tr>
<tr>
<td>25401</td>
<td>No data</td>
<td>No data</td>
<td>269</td>
<td>1125</td>
</tr>
<tr>
<td>81237</td>
<td>7.5</td>
<td>74</td>
<td>10</td>
<td>430</td>
</tr>
</tbody>
</table>

Figure 23: Google Earth Map showing boreholes (black dots) around the Otjinene area
5.4.3 Results from questionnaires

In Otjinene, only one miner was found at the mining site and he was interviewed and will be referred to as respondent.

The questionnaires can be found on Appendix A and only the questions relevant to this study will be summarised. The miner was asked what could be the possible impacts or damages to the environment because of the mining activities, he indicated that land degradation (holes in the ground) is the possible impact on the environment due to mining activities. On the question of rehabilitation method, he indicated that no rehabilitation was done after mining activities had ceased.

When asked to give the reason for being involve in small-scale mining, the respondent interviewed mentioned that he is mining because of unemployment and with the return on his labour, he is able to feed himself. He was questioned whether he has any knowledge of or training in the small-scale mining business, the responded indicated that he only knows how to cut extract calcrete blocks and shaped them into building bricks.
5.5 Results of questionnaire for government officials and member of SSM Association

Government Officials and a member of SSM association were approached to take part in the study. Ten (10) questionnaires were presented but only seven (7) replies were received. For SSM Regional Association in Erongo there is only one person working at the office looking after the interests of the small scale miners in the region, hence only one person was interviewed.

1. What is your position in the organisation?

![Position Chart]

**Figure 25: Participants in the study from government and SSM Association.**

Five (5) of the participants that took place in the study were geologists with one coordinator and administration officer.
2. Indicate how long you have been in this position?

![Bar Chart: Years in position for participants.](image)

Figure 26: Years in position for participants.

Six (6) participants were between 0 – 5 years in their current position and only one participant were between 11 – 15 years in the position.

3. Are you aware of small-scale mining activities in Namibia?

All seven (7) participants that took part in the study are aware of SSM activities taking place in Namibia. Three (3) participants went further to indicate that SSM activities are taking place in Erongo, Hardap, Kunene, //Karas and Omaheke Regions.

4. Which commodities are being mined by small-scale miners?

All seven participants mentioned that semi-precious stones are being mined, e.g. aquamarine, tourmaline, topaz, garnet, amethyst, quartz, prehnite, agate and fluorite, as well as dimension stone, e.g. sodalite, calcrite and sandstone.

5. Do you think small-scale mining activities have positive impacts on the people?

All the participants indicated that they think that SSM activities have positive impacts on the people.
If yes, name them:

The impacts mentioned were poverty reduction/alleviation, job or employment creation, economic empowerment, social upliftment, income generation, decrease in rural to urban migration. One participant mentioned that the existence of gemstone market seems to be an ideal testimony how people make their living out of small-scale mining activities. The participant went on to mention that women selling their products at the gemstone centre managed to send their children to school even up to tertiary education, such as NIMT and NUST.

6. Are you aware of any environmental problems caused by small-scale mining activities?

All seven (7) participants indicated that they are aware of environmental problems caused by SSM activities.

If yes, name them:

Environmental problems caused by SSM activities ranged from land degradation, environmental pollution, under groundwater pollution and mining sites with no rehabilitation.

7. Do you think it is important for small-scale miners to possess knowledge on environmental management skills in their operations?

If yes, please explain: All participants indicated that it is important for small-scale miners to possess knowledge, as it will help them to take the necessary measures after the mining operations have ceased. Those measures indicated are:

- Small-scale miners derived their livelihood from the environment and it is important for them to manage the environment well for sustainability in their operations and for the benefit of future generations.
• Small-scale miners need to know the potential area (pegmatite reefs with gemstones pockets) and not mine randomly.

• Small-scale miners should know the important trees and plants on the site in order to minimise unnecessary damage to the environment.

8. Are there any regulations and policies governing small-scale mining activities?

All participants indicated that there are regulations and policies governing SSM activities.

If yes, name them:

Minerals Policy of Namibia of 2003, Minerals (Prospecting and Mining) Act, No. 33 of 1992 and Environmental Management Act, No. 7 of 2007. However, one participant said that there are no separate regulations and policies dealing with the sector even though the answer was yes in a).

9. Are there any structures in place to follow up on these regulations and laws?

![Figure 27: Response of participants aware of structure to follow up on the regulations and laws governing SSM activities.](image)
If yes, name them:

The Ministry of Mines and Energy is conducting regular sites visits. The Ministry of Environment and Tourism should have a structure but the participants mentioned that they are not sure how effective that is.

10. What do you think the government can do to enhance small-scale mining operations?

Four (4) of the participants mentioned that government should allocate more funds for the SSM operations so that they can become more mechanised (given mining equipment). The other three (3) participants mentioned that the government should give training to small-scale miners in safe mining and rehabilitation methods; deploy officials to the regions where small-scale miners are active; SSM Associations should be made into subsectors whereby ensuring smooth flow of information, monitoring, mineral valuation and quick responses to problems in the area.

11. Are there any land rehabilitation activities in place?

All the participants mentioned that there are no rehabilitation activities taking place even though the small-scale miners sign an environmental contract with MET which they commit to rehabilitate the mining areas post operations. Most small-scale miners fail to fulfil the agreement.

12. What challenges are faced in implementing the rehabilitation strategies?

The challenges mentioned by participants are as follows:

• Lack of human capacity on the site of the government to monitor the SSM operations and ensure that small-scale miners are held reliable for rehabilitation.
• Lack of funds from small-scale miners to rehabilitate the site as the miners do not generate enough money to save up for rehabilitation.

• Lack of equipment to carry out the rehabilitation process.

• Lack of technical know-how on the part of the small-scale miners to follow through their promises.

• No support from the government side in terms of mining equipment, marketing of products, training in pricing and mineral identification.

• Some small-scale miners operate for months without hitting the pocket with gemstones and end up losing hope and abandoning the mining sites without rehabilitating.

• Since there are no regular monitoring activities taking place the small-scale miners don not bother rehabilitating the sites.
CHAPTER 6: INTERPRETATION AND DISCUSSION

This chapter discusses the findings obtained from field visits, summarises the questionnaires from the small-scale miners, government officials and Association Coordinator. The chapter also discusses the ground water quality in the study area. Aryee et al. (2003) groups environmental problems associated with small-scale mining activities into three major components, namely, impacts on the lithosphere, hydrosphere and atmosphere.

6.1 Impact on the Hydrosphere

The underground water at one mining site in Uis and Neu Schwaben from boreholes analysed in the field did not yield negative results. The water quality based on the electrical conductivity and pH results for one mining site in Uis was 145.8 mS/m with pH of 6.97 at 25.7 °C and redox potential of 69.7 mV and for Neu Schwaben was 239 mS/m with pH of 6.90 at 21.7 °C and redox potential of 148.3 mV. In this study, the quality assessment of underground water was very limited, but the electrical conductivity and pH are good parameters to indicate water pollution, based on the quality of water. The quality of groundwater for Uis at one mining site is of excellent quality and ground water for Neu Schwaben is of acceptable quality, based on the electrical conductivity and pH according to the Namibian Water Quality Classification. The water quality for both sites are suitable for human and animal consumption. Since only two boreholes were found in two sites it was very limited and no clear conclusion can be drawn from that.

To have a comprehensive understanding of ground water in the four sites, data from GROWAS was used to determine the water quality. Based on the water chemistry for Uis, it was determined that the water is contaminated as the conductivity, sulphate and TDS showed that the water quality belong to Group C. However, it should be noted that there were no boreholes close to the mining sites except for the one borehole analysed in the field, which
does not reflect in the GROWAS Database. The impact on the underground water was not as a result of small-scale mining activities. The cause of contamination was not determined, as it was not the focus of the study.

In Neu Schwaben, there was only one borehole close to the mining site and the quality of water for pH, sulphate and TDS indicated good quality water and the conductivity yielded result of acceptable quality. The results from GROWAS Database and the analysis done in the field agreed.

In Otjinene, there was one borehole in close proximity to the mining site and the results showed that the quality of water based on pH, conductivity, sulphate and TDS were of good quality.

SSM activities in Namibia do not have an impact on the underground water (since no chemicals are used to extract the semi-precious stones) as in comparison with neighbouring countries dealing with mercury to extract gold, namely; Zimbabwe, Zambia and South Africa. The contributing factor of ground water pollution is the alluvial gold mining by the small-scale miners, which is not taking place in Namibia. The use of mercury and cyanide to extract the gold has a severe impact on the environment causing water pollution (Phiri, 2011; Maponga, 1995; Dreschler, 2001). The government officials stated that SSM activities caused underground water pollution, but the results obtained from water analysis in the field for Uis and Neu Schwaben, GROWAS database did not support that statement showing that the water quality is suitable for human consumption, except for underground water in Uis. Detailed research is needed to have a better understanding on the extent of water pollution in Uis.
6.2 Impact on the atmosphere/Air pollution

Dust generated by small-scale mining activities through blasting and the use of mining equipment to break rocks, is having an impact on the lives of the small-scale miners. The small-scale miners at times do not wear protective masks and they can inhale the dust particles, which can lead to silicosis. Trucks transporting bricks from Uis to Henties Bay are generating more dust and is having an impact on the desert plants the Welwitschia mirabilis. The *Welwitschia mirabilis* found close to the gravel roads were covered with dust, which is being generated by moving vehicles and trucks while other Welwitschias far from the road were not covered with dust. The plant is a unique living fossil plant to Namibia and grows in dry river courses (Nature Conservation, 1996). The plant absorbs moisture through millions of stomata on its leaf surfaces, so if it is covered with dust, it will not absorbed the moisture needed for its survival.

6.3 Impact on Lithosphere

Previous studies on the sector, responses from stakeholders and this study are in agreement that small-scale mining activities have the potential to negatively affect the environmental. As observed from earlier studies, the situation of small-scale mining impact on the environment has remained the same over the years, because there are still deeper pits that are not rehabilitated.

Environmental impact by small-scale mining activities at these mining sites was land degradation (holes in the ground and littering through degraded tins, metals, tyres and old clothes. Some miners are aware that they should rehabilitate their sites and are complying with the mining act, but others do not rehabilitate due to shortage of time and lack of equipment to do backfilling. The sites where mining has ceased have been left for many years
and no one has taken responsibility to rehabilitate those areas. Some of the small-scale miners work seasonally and in most cases leave sites unattended for many years. In Uis, the mining pits are further apart and the impact will seems less severe due to the fact that the pits that are closer to the road are not deep, but they pose a threat to the tourism industry as they are eyesore. The mining of semi-precious stones is having a more negative impact than the mining of tin and tantalum. The mining pits for semi-precious stones can be deeper as the miners follow the pegmatite vein looking for pockets containing minerals. Mining of tin and tantalum in Uis involved the extraction of minerals in loose sand or mining in existing pits and therefore no new pits are dug and therefore less impact on the environment. In Xoboxobos, the pits are closer together and numbers of pits are fewer and only one pit was deeper (7 m) and the rest were less than 5m deep. In Neu Schwaben the situation was different as there were more pits in one area that are deeper and un-rehabilitated, thus the impact seems more negative than the other mining sites. Even though there was active mining, taking place there was some pits that have been abandoned for years, as there was evidence of plant regrowth in some pits. The nature of minerals being extracted and years of mining taking place will have a contributing factor to the level of environmental impact. The method of mining in Uis, Xoboxobos and Neu Schwaben was the same for semi-precious stones, but the method of mining in Otjinene was different because it was different commodity. The mining of calcrete is not as deep as mining of semi-precious stones as the calcrete deposit can be found on the surface, but semi-precious can be deeper. However, the different sites visited previously indicated that the intensity ranged from low (0.5 m) to high (5 m) in depth.
6.4 Social Impact

Small-scale mining activities have the potential to contribute to the socio-economic aspects as narrated by all small-scale miners interviewed. Most small-scale miners agreed that they are generating some income and are able to feed their families, send their children to school and create employment for their fellow citizens. They also indicated that if it was not for the opportunity given by the government to mine, they could have resorted to a life of crime to make a living.

The study done by Nyambe and Amughete (2008); responses from government officials and association coordinator also echoed the above sentiment as they indicated that SSM activities have a positive impact on the people as it contributes to poverty alleviation through employment creation, economic empowerment, social upliftment, income generation, and decrease in rural to urban migration. The calcrete in Omaheke Region is shaped into bricks and are used to build low cost housing, which contributes to the socio-economic impact (income generation and affordable bricks) on the community.

The previous studies, questionnaires from small-scale miners, government officials and the association coordinator, indicate that the government and the private sectors need to assist small-scale miners with mining equipment and knowledge so that small-scale miners can mine safely, effectively and expand their operations in order to offer employment to others.
CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

According to the field observation, interviews of small-scale miners, interview with the association coordinator and government officials revealed that the activities of mining of semi-precious stones, tin and calcrete by small-scale miners in Uis, Xoboxobos, Neu Schwaben and Otjinene have a negative impact on the environment. Land degradation was the impact observed on the lithosphere. Looking at the sites visited Neu Schwaben had the deepest un-rehabilitated pits as compared to Uis, Xoboxobos and Otjinene which have less shallower, un-rehabilitate pits. The study revealed that the situation has remained the same over the years.

The negative impact on the environment can be attributed to the lack of training and the lack of effective monitoring by the Ministry of Environment and Tourism as well as the Ministry of Mines and Energy as indicated in the previous studies and stakeholders responses.

Mitigation can be done with the help of the government through training, regular monitoring and awareness creation. From the questionnaires, some small-scale miners in Uis had undergone training and therefore were able to mine strategically resulting in less negative impact on the environment. On the other hand, small-scale miners in Neu Schwaben have not attended any training and they are not mining strategically resulting in severe land degradation. Government officials and the association coordinator mentioned that with knowledge empowerment small-scale miners will manage the environment well, minimise unnecessary damage to the environment and will be able to mine at potential areas instead of random selection with the hope of finding a gemstone pocket.
After analysing the underground water from two boreholes close to mining sites, the results show that the quality of the underground water in Uis and Neu Schwaben is not affected by SSM activities as the water falls under Group A for Uis and Group B for Neu Schwaben, which is excellent and acceptable quality, respectively. However, the results from the GROWAS database is contradicting as it showed that the underground water in Uis was the most contaminated compared to the water in Neu Schwaben and Otjinene. There were no boreholes in close proximity of the mining sites in Xoboxobos. Uis water quality was of Group C and Neu Schwaben and Otjinene was of Group A. It should be noted that the water analysed in the field at one mining site in Uis is of good quality compared to the overall boreholes in Uis area.

Large-scale mining in Namibia has an impact on the environment affecting the stream sediments, underground water and surface water through the mining and ore processing through the dumping of pyrite in the tailings dump resulting in acid mine, e.g. Otjihase Mine (as mentioned in the discussion chapter). SSM activities in Namibia does not have an impact on the water bodies as compared to SSM activities in the neighbouring countries through the use of mercury to extract gold.

SSM activities have a positive impact on the lives of miners and their families through poverty alleviation as well as employment creation. Due to the lack of proper mining equipment and information, small-scale miners are unable to expand their mining operations. The responses from questionnaires indicated that it is important for the Ministry of Mines and Energy to encourage small-scale miners to form associations or cooperatives. This will ensure that information dissemination goes through the associations or cooperatives e.g. one
small-scale miner who took part in the interview indicated that he did not know about any organisation that can give him assistance.

Equipping small-scale miners with the relevant training, information and mining equipment will instil a belief in them that their activities are a viable economic venture and with proper planning, organization and execution will reduce land degradation and yield positive results for the benefit of all.

7.2 Recommendations

In order to minimise the negative impact on the environment by SSM activities, this study recommends that the government must take an active role in the following issues:

Training – Training of small-scale miners on a regular basis on safe mining practices and environmental damage control. This will ensure that the miners are carrying out their operations systematically. The training will equip small-scale miners with skills and knowledge to rehabilitate the sites post mining. This study has observed that small-scale miners that had undergone some form of training are mining systematically as opposed to those with no training. Regional and Local authorities should assist the Central Government in organising training workshops in order to reduce the impact on the environment. Miners should take up the responsibility of rehabilitating the sites and not leave it to nature or cattle to take care of their operations even though they claim not to have money or the right equipment to rehabilitate the mining sites.

Education on the environment, land rehabilitation and awareness campaigns – Small-scale miners need awareness of the long-term effects they are causing to the environment. To
reduce land degradation, small-scale miners need to be educated on land rehabilitation methods, which are back filling of their excavations and re-vegetation. This will ensure that there are no losses of wildlife, livestock and human beings by falling into these pits.

Environmental Reclamation – Remediation process upon completion of mining operations, small-scale miners should use the backfilling method to rehabilitate the sites. All small-scale miners should undertake the backfilling method by using materials extracted during mining. Bigger rocks should be used first to fill up the site, followed up by smaller rocks and finish off with finer materials by using shovels or front-end loader in order to restore the land as close as possible to its original state. Open pits should be fenced off to prevent animals and humans falling into them after mining operations. When funds are available, after rehabilitation the site should be re-vegetated with the natural surrounding vegetation type and species.

Measures and practises to be adopted in order to minimise the impact on the environment – The Ministry of Environment and Tourism and Ministry of Mines and Energy should conduct regular monitoring and penalise small-scale miners that are defaulting on the environmental agreement to rehabilitate the site post mining. Licence fees should be increased so that a percentage can be put aside to fund the rehabilitation practises.

After the implementation of the above recommendations, strict measures should be instituted through the strengthening of existing structures in MET to carry out frequent monitoring operations. A database should be developed to keep record of all the small-scale miners and their operations so that they can be held accountable for rehabilitating the mining sites.
Ministry of Environment and Tourism and the Ministry of Mines and Energy should enter into agreement on how to work together and minimise the impact of SSM activities on the environment. The Ministry of Environment and Tourism should prioritise their activities and recruit more environmental inspectors to conduct regular monitoring on the SSM activities.
CHAPTER 8: REFERENCES


Mwenechanya, S., 2000. A concept/draft paper on a framework for the accelerated development and growth of small-scale mining in the SADC region, UNECA, SADC MCU.


APPENDIX A

Questionnaire for miners

1. Which commodities are you mining?

2. What mining tools are you using? E.g. hammer, jackhammer, excavation, explosives or pick.

3. What is the size of the mining site?

4. What is the depth of mining site? e.g. shallow or deep.

5. Width of mining site?

6. Rehabilitation method?

7. What is the possible impact or damage to the environment? Specify? (look at the list)
   Land degradation
   Water pollution
   Air pollution

8. Why are you in this business / continue with this business?

9. Describe your knowledge of the business.

10. Which aspects of the business do you feel you need to learn more on? Why?

11. Which aspects of the business do you feel confident about?

12. What do you plan to do with the business in future or with yourself?

13. What kind of assistance or support do you think is crucial in your business?

14. Are you aware of any organisation that you can get help from? What kind?
APPENDIX B

Questionnaires to Government Officials and SSM Association

1. What is your position in the organisation?

2. Indicate how long you have been in this position?
   a) 0 – 5 yrs  
   b) 6 – 10 yrs  
   c) 11 – 15 yrs

3. Are you aware of small-scale mining activities in Namibia?

4. Which commodities are being mined by small-scale miners?

5. Do you think small-scale mining activities have positive impact on the people?
   a) Yes  
   b) No
   If yes, name them:

6. Are you aware of any environmental problems caused by small-scale mining activities?
   b) Yes  
   b) No
   If yes, name them:

7. Do you think it is important for small-scale miners to possess knowledge on environmental management skills in their operations?
   If yes, please explain:

8. Are there any regulations and policies governing small-scale mining activities?
   a) Yes  
   b) No  
   c) Don’t know
   If yes, name them:

9. Are there any structures in place to follow up on these regulations and laws?
   a) Yes  
   b) No  
   c) Don’t know
   If yes, name them:

10. What do you think the government can do to enhance small-scale mining operations?
11. Are there any land rehabilitation activities in place?

12. What challenges are faced in implementing the rehabilitation strategies?