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COLLEGE OF BASIC AND APPLIED SCIENCES

A STUDY ON ARTISANAL AND SMALL-SCALE GEMSTONES MINING IN TAITA TAVETA COUNTY, KENYA

BY

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DECLARATION

I herewith declare that this thesis is altogether an outcome of my own original research work undertaken under supervision, with the exception of citations from other sources that have been rightly acknowledged; and that it has not been presented either in part or whole for the award of a degree elsewhere.

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ABSTRACT

This study reports on artisanal and small-scale gemstones mining (ASGM) in the Taita Taveta County in Kenya using a variety of methods including review of literature, key informant interviews, administration of questionnaires to miners and local communities, direct observations in the gemstones mining areas, and collection and analysis of gemstones-bearing rocks for their mineral and element compositions. Literature sources used include legal and institutional documents, geological reports, journals and the internet. Fifteen (15) key informant interviews were done comprising ten (10) mine owners, four (4) government institutions at the County level and one (1) representative of a non-governmental organisation (NGO) concerned with protection of human rights. Two hundred and eight (208) questionnaires were also administered, 103 to miners and 105 to local community members. Direct observations were made at ten (10) artisanal gemstone mining sites regarding the nature of the mining activity. Out of ten (10) mine sites studied, only four (4) gave permission for four (4) rock samples to be collected, i.e. one sample per mine site. The rock samples were analysed for their mineral and element compositions.

Demographic data from responses to questionnaires administered indicate that majority of miners (68.4%) are natives who hail from within the Taita Taveta County and are between 25 and 38 years (51.6%). In addition, 57.9% of miners have had primary education and 72.6% have at least five (5) years' experience in gemstones mining. Majority of the miners (94.6%) and the community members (94.1%) were not aware of the existing framework governing gemstone mining activities.

Information gathered from direct observations at mine sites indicates that majority of the miners do not observe the occupational health and safety practices such as use of personal protective equipment (PPE). Observed environmental effects arising from the mining activity include vegetation loss, un-reclaimed mining pits and waste materials dumped on the landscape. Key informant interviews and responses from questionnaires suggest prevalence of social vices (prostitution and substance abuse) and human rights violations arising from the mining activity. Observations under the microscope indicate that the gemstones-bearing rocks are mainly composed of the minerals quartz, plagioclase, hornblende, muscovite and minor sulphides. Variations in major element contents (wt. %) in four (4) analysed samples of the gemstones-bearing rocks are as follows; SiO_2 (19.88-66.05), TiO_2 (0.11-0.74), Al_2O_3 (2.17-10.83), Fe_2O_3 (1.61-5.89), MgO (0-9.66), CaO (2.34-35.42), K_2O (0.19), MnO (0.03-0.12), P_2O_5 (0-0.38) and SO_3 (0.5-3.86). Trace elements such as Ni, Cu, Zn, As, Pb, Cr, V, U, Sr, Y, Zr, Mo and Nb are low to negligible, suggesting minimal chemical pollution of the surrounding environment from the materials or rocks mined.

Even though the gemstones mining activity provides employment and income to the local communities and the national government, degradation of the bio-physical environment in the form of un-reclaimed pits and indiscriminate dumping of mine waste, together with lack of monitoring and enforcement of mining and environmental regulations, need urgent attention. It is suggested that education to miners and community members on the existing policies, laws and regulations governing the mining sector in general and gemstones mining in particular, including education on their legal rights and obligations, would be beneficial in the long-term to miners, communities and the national government.

DEDICATION

This thesis is dedicated to my dear mother, Mrs. Susan Malemba Njumwa.

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LIST OF ABBREVIATIONS

AMDC	Africa Minerals Development Centre
ASGM	Artisanal and small-scale gemstones mining
ASM	Artisanal and small-scale mining
CSOs	Civil Society Organisations
CSR	Corporate Social Responsibility
DRC	Democratic Republic of Congo
EEITI	Ethiopian Extractive Industries Transparency Initiative
EA	Environmental Audit
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Co-ordination Act
EPA	Environmental Protection Agency
GPS	Global Positioning System
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
IGF	Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development
ILO	International Labour Organization
KNCHR	Kenya National Commission on Human Rights
Ksh	Kenyan shilling
LSM	Large-scale mining
MEAs	Multilateral Environmental Agreements
NAAIAP	National Accelerated Agricultural Inputs Access Programme
NEMA	National Environmental Management Authority
NGOs	Non-governmental organisations

NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Act
PES	Payment for Environmental Services
PPE	Personal Protective Equipment
RCMRD	Regional Centre for Mapping of Resources for Development
REL	Recommended Exposure Limit
SAPs	Structural Adjustment Programs
SEA	Strategic Environmental Assessment
SEM	Scanning Electron Microscopy
SPSS	Statistical Package for Social Scientist
UNECA	United Nations Economic Commission for Africa
USD	United States Dollar
VIP	Ventilated Improved Pit
WHO	World Health Organization
XRF	X- Ray Fluorescence

CHAPTER ONE

INTRODUCTION

1.1 Background

Artisanal and small-scale mining (ASM) is practised in various parts of the world including South America, Asia, Oceania, sub-Saharan Africa and Central America and is a significant source of income and employment to millions of citizens in around eighty (80) nations globally (IGF, 2018). Even though different minerals are extracted, ASM activities are usually centred on gold mining. For example, of the total mineral production by ASM, two-thirds is gold as seen in Ecuador and Ghana, 90% as observed in the Philippines and nearly 100% in Peru (Hentschel et al., 2003). The most common activities are mercury amalgamation and alluvial/placer gold mining (Hentschel et al., 2003). Bauxite, marble, iron ore and limestone, gemstones and various construction materials are also other important minerals mined within the ASM sector.

Even though there is no single or acceptable definition of ASM as an activity, it is usually defined in terms of the production level, the amount of capital invested, the number of people involved, the expanse of the mining claim and the level of technology (Hentschel, et al., 2002; ILO, 1999). According to ILO (1999), in 1993, those engaged in ASM were nearly 6 million people. As of 1999, the number was estimated at 13 million with both women and children included. There were also around 80 to 100 million dependants being supported by ASM as of 1999 (ILO, 1999). By the year 2014, about 20 to 30 million individuals were directly engaged in ASM (García et al., 2015; Veiga et al., 2014). This could be attributed to lack of livelihood alternatives and increase in prices of minerals especially gold (Seccatore et al., 2014).

ASM is an important activity for most developing countries especially in the rural areas with limited financial opportunities as a source of livelihood (Shen and Gunson, 2006).

Recent work suggests that in Africa approximately 8 to 9 million people directly participate in ASM and roughly 54 million others indirectly depend upon the sector for their living (Jønsson and Fold, 2011; Ledwaba and Nhlengetwa, 2016). The above estimate can be considered to be conservative due to the fact that most ASM activities are informal and operate outside the legal regimes in most African countries (AMDC, 2015). Hence there is inadequate data to come up with a good estimation of those engaged in ASM operations in Africa (AMDC, 2015; Hilson and Maponga, 2004).

The environmental and occupational health and safety practices in ASM are usually poor (IGF, 2018). For instance, drilling and blasting activities might lead to respiratory problems and degradation of land, water and air. According to United Nations Economic Commission for Africa (UNECA, 2011), ASM in Africa remains an undertaking faced with sustainability issues due to insufficient policy and regulatory frameworks as the sector has long been perceived as an informal industry. Formalization of this sector has remained a big challenge not only in Africa but globally (Hilson, 2005). This is because most governments have provided a few and unrealistic policy and regulatory structures that do not offer the much-needed assistance to improve the efficiency of operations and stabilize the sector (Bridge, 2004; Hilson, 2002).

For example, over the years Kenya has experienced challenges in regulating the ASM sector due to its exclusion from the mining legal framework (AMDC, 2017). Major artisanal activities in Kenya are gold panning, gemstones mining, harvesting of sand, clay and gravel plus manual aggregate production (AMDC, 2017). According to Rop (2014), gemstones mining is a widely known activity in Kenya and is dominated by ASM operators who contribute to over 60% gemstone production annually (Rop, 2014). However, the sector is characterized by poor occupational safety and health practices,

poor environmental management practices especially in the restoration of abandoned mining sites and lack of enforcement of labour rights as it mainly operates outside the legal regime (Rop, 2014).

1.2 Problem Statement

In Kenya, ASM involving gold panning, gemstones mining, harvesting of sand, gravel, clay and stone quarrying is carried out in various parts of the country and is a significant activity with an estimated population of 146,000 people in 2012 (AMDC, 2017; Barreto et al., 2018a). The gemstones mining which is a sub-sector of ASM sector is a primary source of employment for about 57% of people, well above agriculture (39%), trading (35%) and other activities in the County (Barreto et al., 2018a). Over the years, Kenya has encountered challenges in regulating the sector due to its exclusion from the mining legal framework (AMDC, 2017). Due to this, the sector remains largely informal, yet it produces approximately 60% of the country's gemstones, most of its gold, quarry stones, and other construction materials (Barreto et al., 2018a).

ASM is acknowledged as a very important livelihood option, both directly and indirectly to millions of people globally. Nevertheless, it is also linked to adverse environmental and socio-economic impacts. Previous studies have focused generally on impacts of all types of mining such as gemstones mining, sand mining, quarrying and iron ore mining. Gemstones mining, characterised mainly by artisanal and small-scale miners (Rop, 2014), is one of the main economic activities carried out in Taita Taveta County. The gemstones from the County significantly add to the foreign income earned from minerals in Kenya whereby about 25% that is earned comes from the gemstones mined by artisanal and small-scale miners (Rop, 2014). In addition,

gemstones mining is an economically important activity of many people for decades and provides significant employment and income to many rural dwellers and migrating groups in and around the County.

Previous studies in Kenya (for example Anyona and Rop, 2015a and Mghanga, 2011) have focused on general impacts of various types of mineral extractions including artisanal sand mining, quarrying for building stones, limestone mining, large-scale iron ore mining and gemstones mining that take place beyond the County. For example, even though Anyona and Rop (2015a) suggested that mining activities posed several impacts such as vegetation cover loss, loss of biodiversity, soil degradation, aesthetic pollution, occupational hazards and human health impacts, these were generalised and not specific to the Taita Taveta County. Other studies have also mainly focused on the economic potential and contribution of the sector in the area and impacts on women in one of the gemstones mining zones, i.e. Kasigau area in Taita Taveta County (Barreto et al., 2018a; Mwakumanya et al., 2016; Rop, 2014).

To date, there is no known research specifically related to the environmental and socio-economic effects of gemstones mining in the area of study within the Taita Taveta County. It is against this backdrop that this study was done to gather relevant data and/or information as a contribution to knowledge on possible environmental and socio-economic effects of artisanal and small-scale gemstones mining in Taita Taveta County in Kenya.

1.3 Aim and Objectives

The aim of the study was to assess the possible environmental and socio-economic effects of the artisanal and small-scale gemstones mining in Taita Taveta County, Kenya.

The specific objectives for the study were:

a) To collect and analyse gemstones-bearing rocks for their mineral and elemental contents to establish their potential in causing environmental effects.
b) To document the methods of extraction utilised in artisanal and small-scale gemstones mining.
c) To establish the socio-economic effects of the artisanal and small-scale gemstones mining.
d) To examine the existing policy, legal and regulatory framework that governs artisanal and small-scale gemstones mining.

1.4 Research Questions

1. What minerals and elements compose the gemstones-bearing rocks and what are the concentration levels of the elements and their potential in causing environmental effects?
2. Which methods of extraction are utilised in the artisanal and small-scale gemstones mining?
3. What are the socio-economic effects of the artisanal and small-scale gemstones mining?
4. What is the existing policy, legal and regulatory framework that governs artisanal and small-scale gemstones mining?

1.6 Justification for the study

ASM is a significant employment and revenue generation source for most developing countries especially in the rural areas with limited financial opportunities (Shen and Gunson, 2006). In spite of this, the sector is faced with several critical environmental and socio-economic challenges such as the adverse impacts of vegetation cover loss, loss of biodiversity, soil degradation, aesthetic pollution, occupational hazards and human health impacts. Also, the sector is faced with a challenge of formalisation as noted by (Hilson, 2002, 2005) because of inadequate legal and regulatory framework for the sector (UNECA, 2011).

Being one of the famous areas in Kenya for the mining of gemstones, Taita Taveta County is thus an appropriate study area for assessing the effects of the artisanal and small-scale mining, specifically gemstones mining. This is because of the limited research in this area and the fact that previous studies focused generally on the impacts of all types of mining (artisanal gemstones mining, artisanal sand mining, quarrying for building stones and limestone and large-scale iron ore mining) in the County. Therefore, the study was to fill this knowledge gap to contribute data that would benefit both the National and County governments, academia and society at large. The study also provides vital information on the environmental and socio-economic effects of the activity.

1.7 The Scope and Limitations of the Study

The study was done in Taita Taveta County, Kenya in two sub-Counties where artisanal and small-scale gemstones mining is concentrated. These two sub-Counties are Mwatate and Voi. The field work was undertaken in a period of three (3) months from

November 2018 to January 2019. During the study, a few challenges were encountered such as the bureaucracy involved in acquiring or information or data from government and regulatory institutions, some mine owners and local community members. Lack of cooperation by some respondents also hindered effective questionnaire administration. Access to some of the mines was also not possible as the areas were remote and could not be covered during the period of field work.

1.8 Definition of Terms

Artisanal and small-scale mining - It is usually defined in terms of the production level, the amount of capital invested, the number of people involved, the expanse of the mining claim and the level of technology (Hentschel et al., 2002).

Environmental impacts - Refer to the direct effects of natural phenomena and socio-economic activities on the constituents of the environment (Organisation for Economic Co-operation and Development, 2007)**.**

Gemstones - Refers to minerals (precious or semi-precious stones) which are crystalline in nature that exist naturally and are quite uncommon, and are utilised as jewellery or ornaments (Katupotha, 1997).

1.9 Organisation of the thesis

The thesis is arranged into six chapters. Chapter one introduces the study through presentation of the background, research objectives, justification, scope and limitations of the study and organisation of the thesis. Chapter Two examines the theoretical literature and presents a conceptual framework on artisanal and small-scale gemstones

mining and environmental and socio-economic impacts. Chapter Three describes the study area and the methods employed. Chapters four and five present the results of the study and discussion respectively while chapter six gives the conclusion drawn from the results and recommendations made.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter presents the literature review and the conceptual framework for the study. The literature review presents a review of ASM globally, in Africa and Kenya and environmental and socio-economic impacts of ASM. The review also entails governance issues in ASM and information on policy, legal and institutional framework that governs ASM in Kenya. The conceptual framework represents the elements of the study and their nexus.

2.2 Literature Review

2.2.1 Global Artisanal and small-scale mining

ASM is a worldwide phenomenon which has been of concern in different parts of the world especially the developing nations. It plays a significant role in poverty alleviation through job creation. However, it is accompanied by several adverse consequences to the environment and human health such as land degradation, water pollution, vegetation cover loss, exposure to toxic particulate matter and occupational accidents (Hentschel et al., 2003; IGF, 2018). These adverse effects are attributed to weak governance, unskilled workforce and the use of unsophisticated tools and techniques (IGF, 2018). It is practised in various parts of the globe, especially in the south. Major parts include South America, Asia, Oceania, sub-Saharan Africa and Central America. However, the actual number of those working in ASM is just an approximation because of the deficient official statistics, seasonality of some of those in the sector and the informal nature of most of ASM activities (Hentschel et al., 2002). In 1993, nearly 6 million people were engaged in ASM. As of 1999, the number was estimated at 13 million.

There were also around 80 to 100 million dependants being supported by ASM as of 1999 (ILO, 1999). In 2009, 5-20% of people in almost all of the African nations were directly depending on ASM; in Asia 0.1-1% depended on it while in Latin America 0.1-5% were dependent on it (Dorner et al., 2012). In the year 2014, the figures were on the rise again for those directly engaged in ASM to nearly 20 to 30 million persons (García et al., 2015; Veiga et al., 2014). Lack of livelihood alternatives and increase in prices of minerals mainly gold could be attributed to this rise in numbers (Seccatore et al., 2014). In 2017, those directly involved in ASM were approximated to be 40.5 million indicating that numbers are ever increasing (IGF, 2018). ASM is understood to be as a casual industry for a long time now hence Hilson (2005) asserts that formalization of this sector has remained a big challenge.

According to Hentschel et al. (2003), ASM is known to be important in bringing about rural development hence alleviating poverty as the majority of those engaged in it are poor. Nonetheless, this industry is best understood as one that has deficient occupational safety and health practices and outrageous environmental costs. The industry is continually viewed by the majority as not economical and also unsustainable. For the past 30 years, ASM has been the talk of international development. In the 1970s the policy or research focus in this sector was anchored on definition issues. The attention further shifted to technical issues in the 1980s and in early 1990s focused on consolidation of technical, environmental, legal and socio-economic issues. In the mid to late 1990s, the sector developed further to include unique consideration on formalisation and legalisation of the industry, the nexus of ASM and large mining companies and child labour and gender concerns. In the 2000s it evolved to include sustainable livelihoods and community-related concerns.

Various minerals are extracted from ASM but it is usually centred on gold mining (Hentschel et al., 2002). Other important minerals mined under the ASM sector include bauxite, marble, iron ore and limestone, gemstones including various building and construction materials. Tin, silver, zinc and other base metals in some nations are known to be produced on a remarkable level. Hentschel et al. (2003) admit that in some countries like Bolivia, the numbers engaged in base metal extraction are more than those engaged in gold mining.

2.2.2 Artisanal and small-scale mining in Africa

In Africa, ASM is extensively practised especially in the sub-Saharan region. It renders millions with employment and income both directly and indirectly, besides providing support to a big number of dependants (UNECA, 2011). A huge figure of those engaged in ASM around Africa can partially be linked to lack of employment opportunities in most countries besides the few restrictions to entry as noted in artisanal mining (UNECA, 2011). The sector is marked by very poor levels of skills, inadequate infrastructure, little initial capital and ease of entry and exit. This leads to ever-changing ASM figures (UNECA, 2011). Like other regions, ASM in sub-Saharan Africa extracts several minerals. The main mineral exploited is gold while others include diamond, coloured gemstones and industrial minerals such as tin, tungsten, tantalum, iron ore, limestone and clays (Dorner et al., 2012; Hentschel et al., 2003; UNECA, 2011). In sub-Saharan Africa, millions of people are directly employed in ASM (Table 2.1) and many millions more are indirectly dependent on it (Hilson, 2016; UNECA, 2011).

Table 2.1: Approximate figures of ASM operators and dependants in some chosen sub-Saharan African nations and corresponding main minerals mined by ASM

Country	ASM Operators	Estimated dependants	Main Minerals mined by ASM
Tanzania	1,500,000	9,000,000	Diamonds, coloured gemstones and gold
Burkina Faso	200,000	1,000,000	Gold
Uganda	150,000	900,000	Gold
Ghana	1,100,000	4,400,000	Sand, diamonds and gold
Chad	100,000	600,000	Gold
Democratic Republic of the Congo	200,000	1,200,000	Coltan, diamonds and gold
South Sudan	200,000	1,200,000	Gold
Guinea	300,000	1,500,000	Gold and diamonds
Côte d'Ivoire	100,000	600,000	Diamonds and gold
Ethiopia	500,000	3,000,000	Gold
Madagascar	500,000	2,500,000	Gold and coloured gemstones
Mali	400,000	2,400,000	Gold
Liberia	100,000	600,000	Diamonds and gold
Niger	450,000	2,700,000	Gold
Sierra Leone	300,000	1,800,000	Gold, diamonds
Angola	150,000	900,000	Diamonds
Central African Republic	400,000	2,400,000	Diamonds and gold
Mozambique	100,000	1,200,000	Coloured gemstones and gold
Nigeria	500,000	2,500,000	Gold
Zimbabwe	500,000	3,000,000	Diamonds, coloured gemstones and gold
Eritrea	400,000	2,400,000	Gold
Malawi	40,000	Not known	Gold and coloured gemstones
South Africa	20,000	Not known	Gold

Sources: Data drawn out from UNECA (2011) and Hilson (2016)

In Africa, ASM is linked to other economic activities as demonstrated by some previous studies. Hilson (2009) asserts that ASM in sub-Saharan Africa can be depicted as entrepreneurial-driven and chaotic whereby many of those involved in it are seeking fortune. The activity is also often viewed to be a "distress-push" one as many see it as

one that can alleviate them from poverty. Therefore, people engage in it in order to diversify their income from other economic activities.

Farming and ASM in sub-Saharan Africa are strongly linked in such a way that small-scale farmers engage in ASM during dry seasons to diversify their income. Afterwards, they utilise the income earned to sustain their agricultural-based livelihoods. Nonetheless, generalisation cannot be made as in Africa mining activities are extremely varied with seasonality, level of engagement, migration and many more. Hilson (2009) notes that ASM is linked with agriculture where farmers engage in it to increase their earnings and where the activity has become more significant, agriculture is merely undertaken for upkeep reasons. In East Akim in Ghana, Komana West in Mali and Brong-Ahafo, Ghana; families practice artisanal mining during the dry season (Hilson and Garforth, 2012, 2013; Okoh and Hilson, 2011).

In Liberia, subsistence rice farming is undertaken during the rainy season while artisanal diamond mining is undertaken during the dry season (Hilson and van Bockstael, 2012). In some areas, rice harvested is used to feed labourers hired to extract diamond from family lands. Persaud et al. (2017) note that in Senegal artisanal and small-scale gold mining is linked with other undertakings like agriculture and trading. During the mining off-season, some of the miners engage in the aforementioned activities to support their traditional agricultural livelihoods. In Geita District, Tanzania, artisanal gold mining is intertwined with other economic activities such as petty businesses, agriculture, charcoal production, lumbering and transport services (Kitula, 2006). In Finishi village found in Malawi, those involved in agriculture as their chief economic activity engage in artisanal gemstone mining temporarily during the dry

season to boost their proceeds and support their agricultural activities (Kamlongera, 2011).

Pijpers (2014) notes that in Sierra Leone, abandoned mining pits are usually converted into farms after extraction is over. Also, small-scale farms with short time maturing crops are usually converted into mine pits. It is also noted that there is vertical intertwinement of agriculture and mining as seen in South Africa where gold mining activities are done beneath large-scale maize farms and in Ghana until the 1980s, cocoa farming used to exist very well with mining as it was mainly shaft mining (Pijpers, 2014).

2.2.3 Artisanal and small-scale mining in Kenya

ASM is practised in several parts of the country. The main ASM activities carried out are gold panning, gemstone mining, quarrying and winning of clay, sand and gravel (AMDC, 2017). Although large-scale mining (LSM) companies have operations in the country, ASM remains a significant activity. LSM currently employs around 9,000 workers while ASM population was estimated to be 146,000 people in 2012 in Kenya (Barreto et al., 2018a). The sector remains largely informal, yet it produces approximately 60% of the country's gemstones, most of its gold, quarry stones, and other construction materials (Barreto et al., 2018a).

According to Davies and Osano (2005), the ASM industry is significant as it plays a crucial role in alleviating poverty through job creation though it is accompanied by several environmental and social consequences. The challenges being faced by ASM in Kenya include land ownership conflicts, inadequate geological data, lack of

strategies for mineral marketing, promotion and value-addition, inadequate institutional and human capacity, inadequate funding, obsolete infrastructure and low attraction and retention of technical experts, gender-related issues and child labour and lack of equity in sharing of the benefits accrued from mineral production between the local communities, County governments and the National government (Government of Kenya, 2016a).

2.2.4 History of Artisanal and small-scale gemstones mining (ASGM) in Taita Taveta County

The history of gemstones mining in the County dates back to 1971 when the first gemstones were discovered (Pardieu and Hughes, 2014). These gemstones are the green grossular garnet popularly known as the 'Tsavorite'. The discovery was made by a Scottish geologist; Campbell Bridges near Tsavo National Park (Pardieu and Hughes, 2014). Soon after his discovery, other explorers followed like Peter Morgan from South Africa and a Kenyan called W. Kimani. A gemstone rush eventually followed and the closest town of Voi quickly changed into an active gem-trading centre. Since then, new gemstones have been discovered. These include ruby, sapphire, red garnet, amethyst, rhodolite, kyanites, zoisite, opal and green and yellow tourmaline (Rop, 2014).

Currently, most of the gemstones mining in the area is characterised by artisanal and small-scale miners (Rop, 2014). The ASM operators are mainly men who have little or no education at all (Anyona and Rop, 2015b). The artisanal gemstones mining in the County tends to be migratory as miners usually relocate from one mining site to another in search of gemstones. This is attributed to lack of land ownership and lack of designated areas for carrying out the mineral extraction (Anyona and Rop, 2015b).

Hence the majority of the artisanal miners operate illegally in some ranches, public land or in other people's mining locations. These operators are often called 'Zururas' meaning those without borders.

2.2.5 Challenges faced in ASM

The ASM sector is faced with several challenges. These hinder the sustainable growth of the sector leading to the several negative environmental and socio-economic effects seen in the sector. Some of these challenges are discussed in this section.

2.2.5.1 Limited access to finance/credit facilities

In 1999, the ILO documented that lack of access to finance was the major challenge affecting artisanal miners. In most nations, miners are incapable of securing loans from financial institutions like banks as their initial capital. This is mainly a problem for those without licenses and female miners (Hilson and Ackah-Baidoo, 2011; Nyambe and Amunkete, 2009). This can be attributed to the lack of security and perhaps the unwillingness and lack of ability to repay the loans (Adesugba, 2018; Mutemeri and Petersen, 2002; Nyambe and Amunkete, 2009).

2.2.5.2 Lack of geological information

Many artisanal miners lack geological information about mineral ore deposits; where they are located and their quantity and quality (Hentschel et al., 2003; Rop, 2014).

2.2.5.3 Limited access to equipment and technology

ASMs are faced with the lack of appropriate equipment and technology for carrying out mineral extraction mainly due to lack of finance to buy the required equipment.

Globally, most ASM operators utilise unsophisticated equipment and techniques in extracting minerals such as hoes, hammers, chisels and shovels (Mutemeri and Petersen, 2002; Nyambe and Amunkete, 2009). In general, there is the inaccessibility of suitable and low-cost methods of mining.

2.2.5.4 Inaccessibility of markets

ASM has a complicated marketing system that is usually past the comprehension of miners, particularly for gemstones and precious minerals. Some ASM operators are usually sponsored with mining equipment and therefore the sponsors or lenders decide the price of the minerals regardless of the existing mineral prices. The miners become the least beneficiaries in the value chain (UNECA, 2011). Also, miners lack marketing knowledge and access to potential buyers as many operate in rural areas (Adesugba, 2018; Mkubukeli and Tengeh, 2016).

2.2.5.5 The Insecurity associated with land tenure

ASM operators do not have accession to suitable land and mineral rights as almost all mineralised land has been given out to multi-national corporations in concessions (Mutemeri and Petersen, 2002). Land that has been apportioned to miners is one that has not undergone geological survey and it might be without any mineral deposits (Lungu, 2007).

2.2.5.6 Lack of clear and transparent policy and legal framework

In many nations especially in Africa, deficient policy and regulatory frameworks are the main hindrance in facilitating ASM operations to emerge and grow sustainably (UNECA, 2011). In some nations, there is no differentiation of ASM and LSM as all

of them fall under the overall mining policy. Therefore, the unique challenges in ASM are not accorded adequate consideration as deserved. Even for nations with separate ASM policy and regulatory frameworks, the process of getting a license is usually complex thus a hindrance to formalisation (Nyame and Blocher, 2010; UNECA, 2011).

2.2.6 Environmental impacts of ASM activities

ASM activities can lead to several adverse environmental effects as revealed by several studies on ASM. The nature and extent of the effects depend on factors such as where the activity is done, the methods of extraction and duration of the activity. Some of these effects are discussed in the subsequent sub-sections.

2.2.6.1 Loss and threats to biodiversity

It is noted that ASM activities lead to loss and disturbance of biodiversity. ASM activities (gold and gemstones mining) could have profound impacts on biodiversity due to vegetation cover loss and disturbance of natural vegetation and pollution of water bodies like rivers (Cook and Healy, 2012). Habitat loss due to deforestation also leads to biodiversity loss and threats to it. Abandoned mines and open pits left without being rehabilitated pose danger to biodiversity as some get trapped in them and die (Anyona and Rop, 2015a; Mwakumanya et al., 2016).

2.2.6.2 Vegetation cover loss and disturbance of vegetation

ASM activities lead to vegetation cover loss and disturbance of vegetation as land clearing has to be carried out before mining is done. In Madagascar, ASM activities in gold and gemstones mining have led to mass surface clearance of mangroves (Cook and Healy, 2012). In Brazil, emerald mining and artisanal gold mining has led to

deforestation as forests are usually cleared or burnt for emeralds and gold to be accessed (de Oliveira and Ali, 2011; Veiga and Hinton, 2002). Forest degradation due to mining is also evident in Ghana where some forest reserves are being degraded because of illegal mining undertaken in the reserves (Boadi et al., 2016). Destruction of vegetation means disruption of ecosystem services provided by different variety of plant species (Brockerhoff et al., 2017; Lindenmayer, 2017). For instance, habitats get destroyed and/or fragmented.

2.2.6.3 Air pollution

Blasting of rocks leads to the release of dust and other particulate matter which affect the surroundings by causing air quality loss. Malisa and Kinabo (2005) note that underground blasting causes emission of hydrocarbons, dust and other particulate matter that impact on air quality. Dust and particulate matter exposures due to use of explosives during blasting and during excavation processes and during crushing and milling can lead human health impacts such as respiratory diseases at mine sites and surrounding areas (Anyona and Rop, 2015a; Barreto et al., 2018a).

2.2.6.4 Threats to wildlife conservation

ASM activities in or near Protected Areas threatens wildlife conservation due to poaching and hunting for game/bush meat, habitat destruction and fragmentation due to vegetation loss (Cook and Healy, 2012; Rop, 2014; Mwakumanya et al., 2016; Barreto et al., 2018a).

2.2.6.5 Land degradation

Removal of topsoil, soil erosion, soil pollution and physical disruption of the landscape due to ASM activities has been observed (Rop, 2014; Mwakumanya et al., 2016; de Oliveira and Ali, 2011; Malisa and Kinabo, 2005). Removal of topsoil could lead to removal of soil nutrients thus reduction in soil quality (Ghose, 2004; Swain et al., 2011).

Physical disruption of the land due to the creation of open pits and abandoned mines not forgetting haphazard disposal of excavated waste materials (soil and rock debris) lead to aesthetic pollution. Soil pollution results when toxic chemicals are introduced into the soil due to mineral extraction and processing especially gold where mercury and cyanide are used. Soil contamination by heavy metals has been noted in artisanal gold mining areas of Migori, Kenya and Serra Pelada, Brazil (de Souza et al., 2017; Ngure et al. 2017a; Odumo et al., 2011; Torrijos et al., 2014).

2.2.6.6 Impact on Water resources

Water resources are impacted by ASM activities as noted in some studies. Nthambi and Orodho (2015) reveal that artisanal sand mining in Kathiani, Machakos County, Kenya has led to the reduction of river water volumes and drying of rivers. In Brazil, it is noted that emerald and gold mining leads to water pollution due to the washing of the debris and discharge of mercury-rich tailings into streams and rivers (de Oliveira and Ali, 2011; Veiga and Hinton, 2002). Nyame and Grant (2014) note that artisanal gold mining in Ghana has led to the introduction of mercury into water bodies during the gold amalgamation process thus causing pollution of water bodies. In Migori, Kenya, artisanal gold mining is noted to have led to increased concentration of heavy metals

(mercury, cadmium, copper, arsenic, chromium and lead) beyond the WHO guidelines for their maximum limits in water (Ngure et al., 2017b).

2.2.6.7 Noise and Vibrations Pollution

The use of explosives and heavy machinery for excavation leads to noise and vibrations which may have profound effects on mine workers and the surrounding areas. During blasting operations, noise and vibrations are usually high thus posing a significant negative impact on mine workers who do not use protective gear and surrounding infrastructure which may crack or even collapse thus threatening human life (Anyona and Rop, 2015a; Mwaguni and Munga, 2015). Excessive noise could lead to temporary deafness, complete loss of hearing, an increase of stress levels, the effect on the heart function as the rate of pumping blood tends to increase when one is exposed to excessive noise thus may lead to heart diseases and hypertension (Jariwala et al., 2017; WHO, 1999). Wildlife could be impacted through reduced habitat quality and changes in behavioural responses (Shannon et al., 2016). For example, some birds have been noted to sing at night in areas that are noisy by the day (Fuller et al., 2007) and some male frog species were noted to call at higher tones in areas with high noise levels which could affect reproduction as female frogs prefer low-pitched calls (Parris et al., 2009).

2.2.7 Socio-economic impacts of ASM activities

ASM activities can lead to both beneficial and adverse socio-economic effects. Some of these effects are discussed in the subsequent sub-sections.

2.2.7.1 Employment and Income generation

ASM has always been acknowledged to be very significant in providing revenue to millions of citizens of around 80 nations globally (IGF, 2018; the World Bank, 2013). ASM has undergone tremendous growth. As of 2017, 40.5 million people were estimated to be engaged in ASM globally (IGF, 2018). ASM has been noted to be a vital source of livelihood in rural areas as it provides both direct and indirect source of income to locals (Barreto et al., 2018a; Kitula, 2006; Mwakaje, 2012; Oramah et al., 2015).

2.2.7.2 Occupational safety and health hazards

ASM activities lead to several occupational and health hazards such as exposure to mercury, dust, silica and other toxic particulate matter, physical injuries, accidents and loss of life due to the collapse of mines. These are due to poor ventilation, long working hours, lack of safety gear, no health or life insurance and high temperatures (Malisa and Kinabo, 2005; de Oliveira and Ali, 2011). Exposure to dust, silica and other toxic particulate matter is associated with several occupational respiratory diseases such as emphysema, asthma, acute and chronic bronchitis, silicosis and pneumonia (Ayaaba et al., 2017). Other health conditions observed include decreased lung function, skin rashes, eye irritations, impaired hearing and impairment of renal function (Henry et al., 2017). A study by Gottesfeld et al. (2015) revealed that airborne crystalline silica exposures from artisanal gold mining activities in Tanzania were above the exposure limits. Thus, there is a health concern for the occurrence of acute and chronic silicosis and tuberculosis to the mining communities.

2.2.7.3 Lack of proper hygiene and sanitation

Hygiene and sanitation are crucial issues in ASM. It has been observed that some mining sites usually lack sanitation facilities (Basu et al., 2015), safe and clean drinking water and poor or no housing as many are temporary. Cholera, diarrhoea, malaria and dengue fever outbreaks are usually reported in mining sites and in their neighbourhoods due to poor sanitation (Cook and Healy, 2012; Mwakumanya et al., 2016).

2.2.7.4 Human Insecurity

Human insecurity is of concern in several ASM areas as observed by some studies. Nyame and Grant (2014) observed that mining communities, migratory miners and road users in artisanal mining areas in Ghana have been targeted by armed robbers. Also, abandoned mine pits can act as hideouts for criminals (Mwakumanya et al., 2016).

2.2.7.5 Child labour

This is a critical issue in most ASM sites in most nations in Africa, Latin America and Asia. Children normally work for long hours and thereby get exposed to various hazards because they commonly lack personal protective equipment and training (Dreschler, 2001). These hazards are mostly exposure to harmful gases, dust and fumes, injuries, fatigue and physical strains. In Uganda, it is estimated that 20-30% of the workers are children in Karamoja area where artisanal gold mining is carried out (Barreto et al., 2018b). Interestingly, girls seem to be more involved in the activity than the boys in the area. In Ghana, child labour is also evident in artisanal gold mine sites where children are involved in carrying the excavated materials from the mining location to the processing facility (Bansah et al., 2018; Hilson, 2010).

2.2.7.6 Land ownership conflicts

Conflicts associated with land ownership are commonly experienced in ASM areas. Land conflicts associated with mineral resources have been reported in Taita Taveta County. These cases are linked to the deficiency of land ownership rights in the gemstones mining areas due to lack of title deeds leading to the conflicts between miners and local communities (Anyona and Rop, 2015b; Mghanga, 2011). In Ghana, ASM activities that some are usually transitory in nature have led to land disputes between artisanal miners, mining companies, local communities and the government as some transitory miners trespass into large-scale mining companies concessions or local communities lands without permission (Nyame and Grant, 2014). It has also been observed that large-scale miners and artisanal miners are always in conflict because of the multi-level land rights system as seen in Ghana and other African countries (Hilson and Yakovleva, 2007).

2.2.7.7 Human Rights Violations

This is an issue in ASM as some mine workers' rights are usually abused either by the government, mine owners or other mine workers. Human rights are in terms of land ownership rights, labour rights, clean and healthy environment rights, women's rights and consultation and participation rights (Institute for Human Rights and Business, 2016). Abuse of women workers' rights in Taita Taveta County, Kenya have been reported, mainly related to the assault of approximately 100 women involving intimate body searches for gemstones by a mine owner (Barreto et al., 2018a). Sexual abuse of women in ASM has also been documented in Eastern part of Democratic Republic of Congo (DRC) where women are raped and forced to engage in sex for them to get employment and continue being employed (Kelly et al., 2014). In the Karamoja region,

Uganda where artisanal gold mining is practised, violation of human rights is evident. The local people lack proper rights to land ownership hence they have not been receiving compensation (Muloopa, 2012). It is also observed that women are discriminated from undertaking certain mining activities or prevented from going to work in the mines when they are pregnant irrespective of the kind of work they do (Bashwira et al., 2014).

2.2.7.8 Prostitution, Substance Abuse and HIV/AIDS

Women are susceptible to sexual abuse and sexually transmitted diseases in mining areas especially single women and young girls (Malisa and Kinabo, 2005). In Ghana, it is noted that substance abuse and prostitution are becoming serious social issues and consultations with health experts indicated that there could be high rates of spread of HIV/AIDS in artisanal gold mining 'galamsey' communities (Bansah et al., 2018; Yakovleva, 2007). In the Eastern parts of DRC, prostitution has been observed to be practised around artisanal mining sites especially by young women and even women with children. It is associated with poverty hence seen as a way of making ends meet (Kelly et al., 2014).

2.2.7.9 Impact on Family stability

ASM activities can lead to family instability and/or breakdown due to the fact miners usually leave their families to go and mine thereby staying away from home for a long time. It was noted that some women who have joined 'galamsey' (artisanal gold mining) in the Eastern region of Ghana had begun to break up with their husbands and that divorces were on the rise overall due to the activity (Yakovleva, 2007). Mallo (2012) notes that because artisanal miners often migrate from one area to another,

families get abandoned eventually leading to break-ups and some partners end up having multiple sexual relations.

2.2.8 Governance issues in Artisanal and small-scale mining

Governance issues in ASM are varied and complex. The informality of the sector is the main challenge. In the latest years and decades, ASM has seen a huge boom globally. In spite of this boom, many ASM activities still take place outside the legal and regulatory framework of host countries (Verbrugge and Besmanos, 2016). The expansion is attributed to the Structural Adjustment Programs (SAPs) which were launched in the 1980s by the international financial organisations (World Bank plus International Monetary Fund). Their emphasis was on carrying out big projects for development and encouraging economic liberalization in some of the developing nations that had huge debts (Hilson and McQuilken, 2014). In exchange for these loans, nations were expected to strictly follow certain rules. These included deregulating and privatizing industries, halting grants and removing services that assisted domestic agriculture and decreasing government expenditure and lowering labour in major public sector institutions (Hilson and McQuilken, 2014). For instance, Hilson and McQuilken (2014) argue that the reforms brought about by the structural adjustments in Africa have led to the fast growth of ASM in rural areas such as the increase of the informal gold mining industry as many people who became redundant have ended up seeking employment in the industry.

During the adjustment period, ASM was still not seen as one that had the potential to bring about development. This is in spite of it revealing characteristics of an industry that has the capacity to nourish growth and create jobs especially in rural (Hilson and

McQuilken, 2014). However, the current explosion of non-formal ASM activities in many parts of the developing world has been noticed by donors and some policymakers like the United Nations and the World Bank (Hilson et al., 2017). It is noted that approximate figures indicate that in most nations in the world, 70-80% of ASM operators operate informally (ILO, 1999). These figures could be more in some nations. For example, in Ethiopia, about 94% of artisanal miners operate informally (EEITI, 2015).

ASM in sub-Saharan Africa is mainly affected by informality due to unwieldy, costly and bureaucratic policy, legal and institutional frameworks which are inappropriate for poverty-driven people (Hilson, 2016; McQuilken and Hilson, 2016; Nyame and Blocher, 2010). For instance, it is noted in both Niger and Ghana that the cost of licensing and the bureaucracy therein are the major impediments to the formalization of the ASM sector (Hilson et al., 2019; Hilson et al., 2017). In Tanzania, it was found out that the institutional framework governing artisanal mining activities is unfavourable (Mwakaje, 2012). The regulatory agencies were found to be centralized thus making it hard for them to be in close touch with the miners. As a result, most miners do not have knowledge of the existing institutions and regulations some of which are contradictory (Mwakaje, 2012).

The issue of land tenure also has an influence on the formalization of ASM. For example, in Ghana customary land tenure practices have a profound influence on artisanal mining as most land is owned by traditional societies rather than the state (Nyame and Blocher, 2010). This system of land ownership where stools, families or skins allow ASM activities in their lands, causes increased ASM activity and hampers

government's attempts to legalize the sector. Some of the chiefs normally demand a substantial amount of money to allow ASM activities to be undertaken in the lands they control. However, this is informally done. This discourages the miners to seek formal licenses as they have already spent lots of money on acquiring land from the chiefs (McQuilken and Hilson, 2016). In Senegal, it is observed that ASM activities rights are managed by customary authorities which are not fully recognised by the government. Thus, ASM informality still exists (Persaud et al., 2017). Hence, there is a need for integration of customary and government institutions for the formalisation of ASM to be successful.

Hirons (2014) notes that though Ghana has managed to decentralize governance of the ASM sector, the sector is still faced with challenges mainly illegality. This is attributed to the sector's local dynamics where chiefs play an important role in land tenure system as they give consent to people to mine in traditional owned lands even without them acquiring the formal licenses as noted by Nyame and Blocher (2010). The continued informality of ASM is also attributed to the fact that many ASM communities either lack information on the existing mining laws and regulations or pretend to be unaware of them (Nyame and Blocher, 2010). Governments are also blamed for creating informality in the ASM sector by using formalization of the sector as an instrument for the state to command the industry as for the case of Zambia where the first formalization efforts were put as a plan to demoralise miners who were later given mining rights in places which were not rich in minerals (Siwale and Siwale, 2017). It is also argued that policy frameworks have flopped in recognising the that ASM is poverty-driven in nature hence formalisation attempts have failed to accommodate more miners in the

formal economy as they are still trapped in the poverty cycle (Hilson and McQuilken, 2014).

In ensuring that formalization of the ASM is attained several suggestions have been recommended by different studies. Hirons (2014) in his study which focused on decentralisation of ASM governance in Ghana recommends that in future any reforms should integrate the traditional and state institutions for better governance. Hilson (2016) recommends that the licensing procedures be simplified, adequately decentralized and unnecessary costs eliminated to facilitate the formalization of the sector. McQuilken and Hilson (2016) also emphasise decentralisation of the licensing process and consolidation of the process by making it be available online and provision of incentives to those miners that cannot afford the license fees.

IGF (2018) suggest that a wider, consolidated and comprehensive process as formalization has to be appraised anchoring on the poverty nature of the industry. Also, formalisation can be attained through eliminating complex administrative and licensing procedures, enabling access to technical and financial aid, demarcating areas for artisanal mining and ensuring participation of the discriminated operators in the process through deliberations (IGF, 2018). Banchirigah (2008) argues that getting rid of the challenge of non-formal mining activities needs reviewing the inquiry of why operators are informal. For example, it is noted that insufficient regulations and encouragement of foreign investment in large-scale mining schemes have caused difficulty in acquiring an artisanal mining license by the rural communities. Therefore, improving the mining regulatory frameworks and making them flexible to miners is key in solving informality in the ASM sector.

Siwale and Siwale (2017) argue that for formalisation to bear good results, then government organisations are key in creating capacity for this. They made some commendations for the Zambian case that the organisations involved in implementing regulations are supposed to be capacitated and strengthened. Also, deficient policy direction and insufficient knowledge of the dynamics of ASM are crucial points that are to be dealt with. Being a very challenging undertaking, formalisation hence needs robust regulatory institutions and staunch political commitment. A study on the governance of artisanal sand mining at Kangonde, Machakos County in Kenya revealed a disjointed governance structure in the industry (Augustine, 2013). Therefore, the study proposed a multi-sectoral governance approach for the achievement of sustainability in the sector. It was noted that though Tanzania passed important legislation reforms to formalize the ASM sector, the reforms still do not entirely embrace the varied nature of the sector (Spiegel, 2012). The study recommended that distinctive legal definitions for artisanal mining be developed for the legal framework to be further reactive to local preferences. Also, decentralisation of mining institutions was seen to be of priority for the local needs to be met.

Lungu (2007) suggests possible solutions for ASM formalization to succeed. One is stakeholder participation where the engagement of miners would furnish policymakers with data required to come up with integrated policies. Decentralisation of administration, registration and licensing of ASM activities thus offering nearness to registration and licensing centres, little graft habits and enabling effective monitoring and enforcement of regulations is also seen as a solution. Moreover, capacity building to both government institutions and miners to facilitate the transition of ASM into

formal economy and partnerships betwixt ASM, large-scale miners and government. For example, the Acupan Contract Mining Project in the Philippines.

2.2.9 Governance and Institutional framework of ASM in Kenya

The governance and institutional framework of ASM in Kenya comprised of several policies, laws, regulations and institutions. The goal of the framework is to ensure protection, conservation and sustainable use of natural resources.

2.2.9.1 Existing Policies, laws and regulations

The following are some of the main policies, laws and regulations that govern ASM in Kenya:

a) The Constitution of Kenya, 2010

The Constitution of Kenya (2010) (Government of Kenya, 2010) champions for sustainable and productive regulation of land resources. The nation is obliged to promote public participation in protecting, conserving and managing the environment and biodiversity. The nation is anticipated to create regulations concerning environmental impact assessment, auditing and monitoring of the environment; and get rid of undertakings and processes that can to jeopardise the environment. Moreover, the nation is supposed to make sure that exploitation, conservation and stewardship of natural resources and the environment is sustainable and that accruing benefits are shared fairly. Also, the government is supposed to ensure that the environment and natural resources are used for the interest of the citizens. This is to ensure that natural resources such as gemstones are not used for personal or non-public benefits. Nevertheless, these constitutional provisions are only basic guidelines and

principles and envisage operationalization through policy formulations, enactments and regulations.

b) Mining and Minerals Policy, 2016

Mining and Minerals Policy (2016) (Government of Kenya, 2016a) sets out a framework, strategies and principles that make provision for the search and use of mineral resources for socio-economic development of the nation. It proposed coming up with an uncomplicated, solid, predictable, efficient, straightforward and integrated regulatory framework for the mining industry. This will regulate the rights and interests for all kinds of minerals including construction and industrial minerals; develop specific environmental and health and safety legal and regulatory frameworks that are aligned with international standards and best practices; development of a new steady, clear, certain and competitive fiscal regime; development of a framework to formalise artisanal mining for the purpose of encouraging business plus means of life through assistance in obtaining fair market prices, setting up of a licensing system that is simplified, facilitating access to land and credit and provision of a structure that ensures equitable sharing of mineral benefits which includes intergenerational equity among county governments, the national government and the communities inhabiting areas where mining takes place.

c) National Environment Policy, 2013

National Environment Policy (2013) (Government of Kenya, 2013) provides a framework for an integrated strategy for ensuring sustainable conservation and supervision of the country's natural resources and the environment. This is to be done through the strengthening of the regulatory framework for better governance, effective

coordination and control of natural resources and the environment. It calls for the use of current environmental management tools such as indicators of sustainable development, Strategic Environmental Assessment (SEA), Payment for Environmental Services (PES), total economic valuation of environmental resources and Environmental Impact Assessment (EIA) and Environmental Auditing (EA). It also encourages ratification and implementation of Multilateral Environmental Agreements (MEAs) for maximisation of benefits gained from them.

d) The Mining Act, 2016

The Mining Act (2016) (Government of Kenya, 2016b) replaced Mining Act Cap. 306 of 1940 which did not provide for economic and technological developments, environmental and occupational and safety stipulations. It creates various institutions thus reducing the powers the Cabinet Secretary. The institutions established include the National Mining Corporation, the Mineral and Metal Commodity Exchange, the Directorate of Geological Survey, Mineral Rights Board and the Directorate of Mines. It makes provision for ASM operations where different permits are allowed such as artisanal mining, reconnaissance, prospecting and mining permits. These are to be issued through the County office of the Director of Mines and also the office has the mandate to renew and revoke the permits among other obligations.

e) The Environmental Management and Co-ordination Act, 1999 (EMCA Cap 387)

EMCA Cap 387 of 1999 (Government of Kenya, 1999) provides for the application of EIA for projects listed under it or any other project with the potential of causing an adverse environmental effect. It also has provisions for EA and monitoring where the Authority established under it is supposed to carry out inspections on any land and

projects in order to ensure that conditions set in licenses are complied with and the environmental management plan is duly executed. The Act also stipulates environmental offences and their penalties under it when its provisions are contravened.

f) The Environmental Management and Co-ordination (Amendment) Act, 2015

The Environmental Management and Co-ordination (Amendment) Act (2015) (Government of Kenya, 2015) is a revision of EMCA Cap 387 of 1999; the Principal Act so that it be in line with the new constitution of Kenya passed in 2010 that created the national and county governments. It provides for SEA to be applied to policies, plans and programmes. The Act also amends the penalties for the environmental offences and the Second Schedule of the Principal Act which list activities for which environmental impact assessment should be undertaken.

g) The Land Act, 2012

The Land Act (2012) (Government of Kenya, 2012) has provisions that are to ensure the sustentation of land-based resources. It directs the National Land Commission to formulate guidelines for the conservation of land-based natural resources in a sustainable manner. These regulations are expected to have provisions for the protection of important habitats and ecosystems and modes of registering natural resources in a proper register. Besides, processes on the engagement of stakeholders in utilisation and regulation of natural resources and ways to cater for the sharing of gains to communities.

h) The Mining (Licensing and Permit) Regulations, 2017

The Mining (Licensing and Permit) Regulations (2017) (Government of Kenya, 2017) set out procedures for application and issuing of licenses and permits for mineral dealings and rights. These are to be done through an Online Mining Cadastre. Under small scale mining operations, three permits can be issued which are reconnaissance, prospecting and mining permits at the national level by the Cabinet Secretary in charge of mining. Under artisanal mining operations, only one permit exists called artisanal mining permit which will be issued at the county level through the county office of the Director of Mines.

i) The Environmental (Impact Assessment and Audit) Regulations, 2003

Under the Environmental (Impact Assessment and Audit) Regulations (2003) (Government of Kenya, 2003), none of the undertakings with the potential to cause adverse environmental effects or for which an EIA is mandatory under the Act or the Regulations shall be carried out until an EIA is done and accepted and the project licensed in accordance with the Regulations. The regulations also require the initial and annual EAs for the projects licenced for them to be reviewed every subsequent year.

2.2.9.2 Institutions involved in ASM governance in Kenya

With regard to institutions involved in the governance of ASM in the country, the following institutions mandated to implement and enforce the provisions of the policies, laws and regulations. Some ensure that interest of stakeholders (miners and the public) are represented:

a) Ministry of Mining and Petroleum

The ministry supervises the mining industry in terms of developing it through the formulation of policies and regulations, mapping mineral resources and maintaining up to date geological data of the same and supervising the exploitation of minerals through issuing of licenses and permits.

b) Ministry of Environment and Forestry

The ministry has the mandate to ensure the protection and supervision of natural resources and the environment for economic development. It is supposed to promote excellent governance for sustainable development.

c) National Environmental Management Authority (NEMA)

It supervises and coordinates all issues related to the environment. It has a key role in implementation and adherence to EIA/EA and monitoring requirements for projects as required under sections 58 and 68 and the second schedule of EMCA Cap 387 of 1999 and granting of such approvals/licences as may be necessary. It establishes and reviews guidelines for regulating natural resources and the environment at large through deliberations with other lead agencies.

d) The County Environment Committees

These are mandated to safeguard the environment within counties. They are tasked to come up with a county strategic environmental action plan every five years.

e) Kenya Chamber of Mines

It was formed in the year 2000 to take care of the interests of miners, mineral traders, mineral firms and professionals in the mining industry. Its role is to ensure an enabling environment for investors in the mining sector. It acts as a spokesperson for miners, communities and other stakeholders.

f) The National Land Commission

The commission is mandated to manage all public land and formulate regulations for the sustentation of land-based natural resources in a sustainable manner. It also carries out investigations on land disputes and recommends solutions.

g) Civil Society Organisations (CSOs) and Non-governmental organisations (NGOs)

These organisations are involved with activities such as public awareness creation on environmental matters, prevention and alleviation of environmental degradation of activities such as mining.

2.3 Conceptual framework

The concept elements adopted for the study include ASGM, policy, legal and regulatory framework, environmental and socio-economic impacts and sustainable artisanal and small-scale gemstones mining (Figure 2.1).

In this study, ASGM is linked to various environmental and socio-economic effects. These effects can be positive or negative. The positive effects include income generation and employment either directly or indirectly. Some of the negative ones include land degradation, vegetation cover loss, biodiversity loss, air pollution, noise

and vibrations pollution, occupational hazards, prostitution, substance abuse, gender-based violence and human-wildlife conflicts.

There is also a linkage between ASGM and the policy, legal and regulatory framework governing it. These include policies, laws and regulations formulated to manage the activity and implementing/regulatory institutions. These can have an effect on the activity either positive or negative in terms of how formalisation procedures are stipulated within the framework and how the regulatory institutions are mandated in carrying out their duty. Policy, legal and regulatory framework has an influence on the sustainability of the artisanal and small-scale gemstones mining. Sustainability of the mining activity is influenced by the framework in such a way that if the framework is inadequate then the sustainability of the activity will be compromised hence won't be achieved. Therefore, there is a need for the formulation of adequate and realistic policies, laws and regulations and establishment of robust regulatory institutions for sustainability to be achieved in the mining industry.

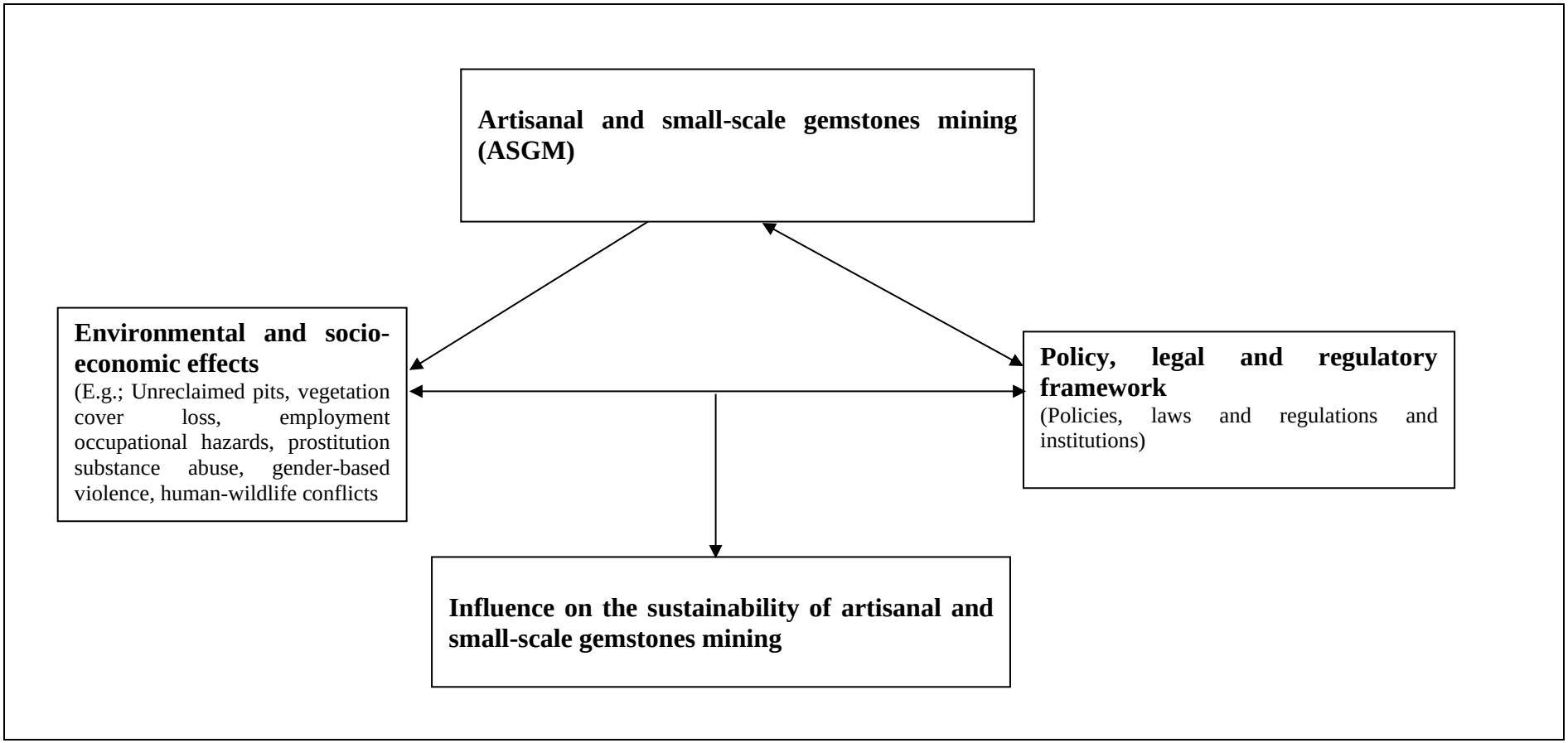


Figure 2.1: Conceptual framework

Source: Researcher (2019)

CHAPTER THREE

STUDY AREA, MATERIALS AND METHODS

3.1 Introduction

This chapter entails description of the study area with respect to location, size, administration, physical features and socio-economic characteristics. It explains the methods utilised in the study, the target population, sampling design and sample size. Methods of data collection and data analysis techniques are also described herein.

3.2 Study area

3.2.1 Location, Size and Administration

The study was done in Taita Taveta County, Kenya (Figure 3.1). The County is found in the south-eastern part of Kenya and is approximately 360km southeast of Nairobi, the capital of Kenya and 200km northwest of Mombasa. It is found within longitudes 37º 30' 00" and 39º 30'00" East and latitudes 2º 30'00" and 4º 30'00" South. (Taita Taveta County Government, 2013). It is bounded by Kilifi and Kwale Counties in the east, Tana River, Makueni and Kitui in the north, Kajiado in the northwest and Republic of Tanzania in the southwest. The size of the County is approximately 17,084.1km^2. Of this total area, about 11,100km^2 is occupied by the Tsavo National Park (Tsavo East and Tsavo West) (Taita Taveta County Government, 2013) which, as a protected area, represents nearly 62 % of the total area of the County. Water bodies such as Mzima Springs, Lakes Jipe and Chala, ranches, wildlife sanctuaries, sisal plantations and Taita Hills forests occupy the remaining area (Rop, 2014). For administration purposes, the county is subdivided into four sub-Counties which include Wundanyi, Mwatate, Voi and Taveta which are further subdivided into twenty County Assembly Areas, the

lowest political units in the Kenya governance system (Taita Taveta County Government, 2013).

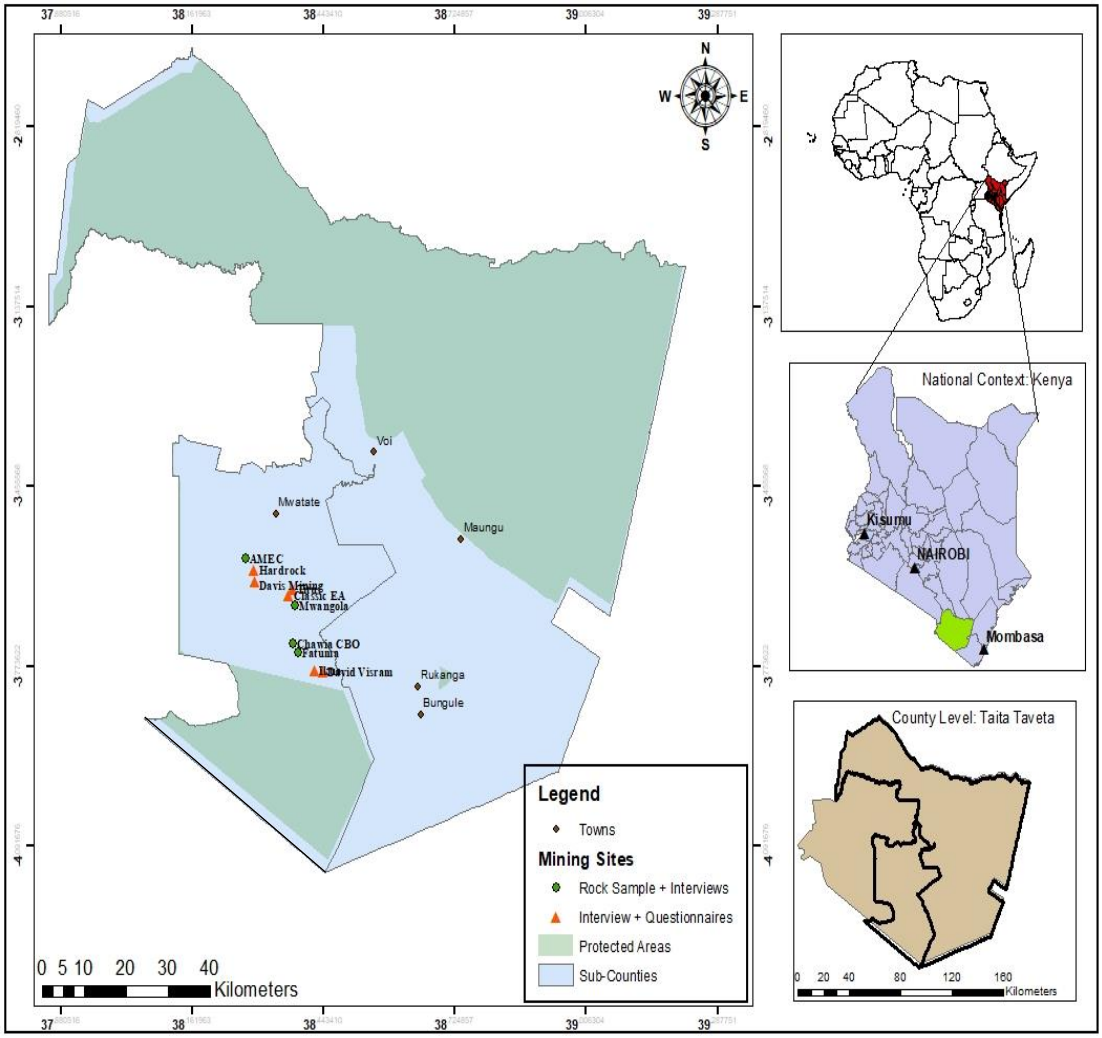


Figure 3.1: Map of Taita Taveta County, Kenya, showing the study sites

Source: Regional Centre for Mapping of Resources for Development (RCMRD) (2018)

3.2.2 Physical characteristics

The topography of the County can be classified into different zones, which are the lowland, volcanic foothills and highland zones (Taita Taveta County Government, 2013). Plains make up the lowland zone where mining, cattle ranching and wildlife conservation take place. The volcanic foothills zone is found in Taveta sub-county. The

Sagalla, Taita and Mwambirwa hill zones comprise the highland zone which ranges in altitude from 304m to 2,208m (Taita Taveta County Government, 2013).

The geology of Taita Taveta County is mainly classified into three regions which are Mwatate, Taveta and Taita Hills. The bulk of the County is found along the Mozambique Belt which stretches from Madagascar and Mozambique through Eastern Africa to Arabia (Pohl and Horkel, 1980). The Taita Hills area is composed of two rock types. The first type is the Mozambique Belt basement system of rocks which include quartzites, quartz feldspar gneiss, amphibolites, pegmatites, calc-silicate rocks and marble. The second type is the superficial deposits which include colluvium, alluvium and soils. The Taveta area is composed of basement system rocks outcrops of which are sometimes found in dry river valleys and inselbergs. Also, tertiary volcanic rocks are present consisting of mainly lava flows and volcanic ashes which erupted from Mt. Kilimanjaro. The Mwatate region is within the Mozambique belt and is composed of Precambrian paragneisses, crystalline limestones, schists and marble (Anyona and Rop, 2015a).

The main types of soils in the County are cambisols, ferralsols, luvisols, acrisols, arenosols, fluvisols and saline and sodic soils (NAAIAP, 2014). Cambisols are sandy-loamy hence they have good drainage and quite fertile. Luvisols, arenosols and acrisols have low to moderate fertility and are found within the dry areas of the hills especially at the lower zones of the hills. Ferralsols which are reddish, very deep sandy-clayey soils are common in the lowlands (within ranches where most gemstones mining undertakings are undertaken and Tsavo Conservation Area). This soil type is very vulnerable to erosion due to its low water holding capacity (Anyona and Rop, 2015a).

Fluvisols are found in valley bottoms and fertility varies from moderate to high. Sodic and saline soils are also found especially within the Taveta region due to the existence of basement rocks and volcanic ashes that were released during the volcanic processes (Anyona and Rop, 2015a).

There are three ecological zones in the County; the highland, lowland and transitional zones. The highland zone comprises the Taita Hills forests which provide habitat to diverse flora and fauna such as butterflies and some birds which are endemic to these areas. The lowlands and the transitional zones comprise woodlands and grasslands where wildlife conservation and cattle keeping in ranches is carried out. The biggest park in Kenya; Tsavo National Park is within this zone (Taita Taveta County Government, 2013).

The climate of the County is mainly dry with exception of the highland zone. Two rainy seasons are experienced with short rains being experienced during the months of October, November and December with a peak in November. The long rains are experienced between March and May with a peak in April. The annual average rainfall ranges from 350mm to 900mm. The temperature ranges from about 17ºC to 30ºC in the County. The county has an average annual temperature of about 23ºC (Taita Taveta County Government, 2013). In general, the County has semi-arid climatic conditions.

The County has several vegetation cover types namely; montane mist forests, dry forests, woodlands, grasslands, riverine forests/swamps and bushland and thicket (Anyona and Rop, 2015a). Forest tree species found here include *Albizia gummifera*, *Ocotea usambarensis*, *Podocarpus latifolia*, *Newtonia buchananii* and *Syzygium*

sclerophyllum. Dry forests species include *Tamarindus indica*, *Terminalia brownii*, fig tree species, among others. Woodlands and grasslands species include acacia, commiphora and grass species such as *Themeda triandra* (Anyona and Rop, 2015a). Plate 3.1 shows woodland vegetation in the area.

Plate 3.1:Woodland vegetation (Acacia and Boscia species)

Source: Field Survey (2018)

Water sources include streams, rivers, springs and borehole water in the County. The County's drainage system comprises four basins which are Mwatate, Voi, Lumi and Tsavo (Anyona and Rop, 2015a). The Lumi River basin comprises Lumi River which emerges from the slopes of Mt. Kilimanjaro in Tanzania and drains into Lake Jipe, Lakes Jipe and Challa (a crater lake) (Anyona and Rop, 2015a). Tsavo River basin comprises Tsavo River which emerges from the Njukini springs found in Taveta sub-county and drains into Athi River (Anyona and Rop, 2015a). The Voi River basin

comprises Voi River which emerges from the Taita Hills and flows into the Aruba dam within Tsavo East National Park. The Mwatate River basin comprises Mwatate River that flows towards the south through Tsavo West National Park into Kwale County and ends up in the Indian Ocean (Anyona and Rop, 2015a).

Geological surveys that have been done in Taita Taveta County suggest that the area has various mineral deposits. The main mineral found here is gemstones though there are other industrial mineral deposits. The gemstones include ruby, tsavorite (green garnet), kyanites, rhodolites, red garnets, yellow and green tourmaline and pink and blue sapphire (Pohl and Horkel, 1980). The area is the main gemstones mining part in Kenya. Gemstones mining operations are found within the Mwatate Quadrangle, Kasigau and Kuranze areas. Industrial minerals include sand, building stones (quarry stones) mainly tuff and kaolin (Rop, 2014) while metallic minerals include iron and manganese ores.

3.2.3 Socio-economic characteristics

According to the 2009 census, the population of the County was 284,657 (Ministry of Planning, 2010) with about 145,334 males and 139,323 females representing approximately 51.1% and 49.0%, respectively. Population projections indicated that the County population would be about 301,516 in 2011, 323,867 in 2013 and 347,195 in 2015 (Kenya National Bureau of Statistics, 2012). Table 3.1 below represents population projections of the County.

Table 3.1: Population projections of Taita Taveta County

Census of 2009		**2011 Projection**		**2013 Projection**		**2015 Projection**	
Females	Males	Females	Males	Females	Males	Females	Males
139,323	145,334	147,634	153,882	158,742	165,125	170,410	170,410
284,657		301,516		323,867		347,195	

Source: Modified from Kenya National Bureau of Statistics (2012**)**

Main economic activities in the County include animal husbandry in ranches, ecotourism, small-scale subsistence farming, small and micro enterprises, large-scale mining, small-scale and artisanal mining (Rop, 2014). Also, some of the residents are engaged as employees in various government departments and private sector institutions.

3.3 Materials and Methods

The study employed a mixed methodology whereby both qualitative and quantitative research techniques were utilised to not only help explain and show links between variables but also to make systematic descriptions, deduction and/or inferences based on data acquired (Kothari, 2004).

3.3.1 Target Population

The target population was the artisanal and small-scale miners, key informants from the National government (Ministry of Mining and Petroleum-Mines and Geology office at the county level, the County government, mine owners, Kenya Chamber of Mines, National Environment Management Authority-County office and human rights organisations) and local community members within the gemstone mining areas.

3.3.2 Sampling Design and Sample Size

The non-probability sampling design was used (Kothari, 2004). This is a sampling procedure where the sampling units to be included in the sample are chosen based on subjective. In this study, convenience sampling and purposive sampling were employed in selecting sampling units. The convenience sampling technique was used in the administration of questionnaires to people in the local community and mine workers because of the sparsely populated and quite inaccessible nature of settlements in the area studied, financial and time constraints. Purposive sampling method was used in selecting the key informants from the National government (Ministry of Mining and Petroleum; Mines and Geology office at the County level), the County government, National Environment Management Authority-County office, human rights organisations, Kenya Chamber of Mines and mine owners.

Yamane (1967) provides a sampling table that can be used to determine a sample size depending on the size of the population, population variability, precision level and level of confidence (see Appendix 10). Therefore, the following considerations were taken in choosing the sample size of the mine workers and the locals; a precision level (margin of error) of +/-10%, confidence level of 95% and degree of variability of 50%. According to the table provided by Yamane (1967), for a population size of 5,000 which represented the estimated number of artisanal and small-scale mine workers, the sampling units were 98. The sample size of the surrounding community with a population of 196,445 as estimated in 2015 was 100 for a population size of more than 100,000 as provided by the table. The response rate expected was 95%. Therefore, the sample sizes used in the questionnaire administration to mine workers and the

surrounding community within the study area were 103 and 105, respectively. Table 3.2 below shows the sample size distribution of the surrounding community.

Table 3.2: Sample size distribution of the surrounding community

sub-County	**Projected Population Size in 2015**	**Percentage Sample size (%)**	**Sample size**
Mwatate	87,289	44.43	47
Voi	109,156	55.57	58
Total	**196,445**	**100**	**105**

Source: Modified from Kenya National Bureau of Statistics (2012**)**

3.3.3 Sources of data

Data was gathered from both secondary and primary sources for the achievement of set objectives. The various sources of data utilised in the study are presented herein.

3.3.3.1 Secondary data sources

Secondary data sources included journals, books, internet, geological reports, Kenya law reports and institutional reports. All secondary data obtained were primarily reviewed in a desk study after which contextual analysis and synthesis of findings were done.

3.3.3.2 Primary data sources

Primary data sources included key informant interviews, observations, administration of questionnaires, photography and collection of gemstones-bearing rock samples for their mineral and element contents.

In-person interviews with the key informants were conducted using semi-structured questions as guide. The key informants included ten (10) mine owners, the County Director of Environment (NEMA), the County government Executive Officer for Mining, the County Mines and Geological Officer, Taita Taveta Humans Rights Watch representative and the Kenya Chamber of Mines representative. Data that was sought was related to the nature of the artisanal and small-scale gemstones mining (ASGM), methods and technologies used in mining, benefits and disadvantages of the activity, challenges faced in carrying out the activity, adequacy of the regulatory framework and possible solutions to the challenges identified.

Questionnaires were administered to miners working at mine sites and people in the surrounding community to seek their views on several issues concerning the gemstones mining. The questionnaires comprised both closed and open-ended questions and these provided for multi-responses especially in the open-ended questions.

Direct observations were done using a prepared checklist with defined subjects to be observed. These included the method of mining and level of technology employed, environmental aspects of ASGM and labour issues as well as presence of children or child labour at mine sites.

Photographs were taken during field work to especially illustrate environmental impacts of the gemstones mining in the area.

Samples of gemstones-bearing rocks (one per mine site) were collected at AMEC, Classic EA, Chawia and Fatuma mining sites using Garmin GPSMAP 60CSx Global

Positioning System (GPS) after consent was sought from the mine owners. The Taita Taveta Geological Officer assisted in collecting them. A geological hammer and a cutlass were used to collect them. The rocks were accessed in the tunnels and open pits dug by the miners. Table 3.3 below shows the location of the mining sites sampled in the study area.

Table 3.3: Location of the mining sites sampled

Mining sites	GPS Location in decimal degrees	
	Latitude	**Longitude**
Sites where rock samples were collected		
AMEC	-3.58209	38.27770
Classic EA	-3.64755	38.37009
Chawia	-3.73407	38.37894
Fatuma	-3.75004	38.38983
Other study sites		
Titus	-3.64471	38.37359
Davis Mining	-3.62387	38.29668
Mwangola	-3.65578	38.38263
Hardrock	-3.60245	38.29585
Ikua	-3.77967	38.42505
David Visram	-3.78336	38.44228

3.3.4 Data Analysis

Data from both secondary and primary sources were analysed using appropriate techniques to generate results for the study.

3.3.4.1 Secondary data

Data collected were reviewed and after which content analysis was done and findings were compiled, presented and discussed. The data sought from these sources included the policies, laws and regulations governing the ASGM sector and findings of other studies regarding gemstones mining and its effects.

3.3.4.2 Primary data

It involved data collected through questionnaires administration and key informant interviews and mineral and elemental compositions of gemstones-bearing rock samples using a microscope, scanning electron microscope and x-ray fluorescence spectroscopy.

a) Questionnaire and Key informant interviews analyses

Data from administered questionnaires were analysed by utilising Statistical Package for Social Scientist (SPSS) software version 23 and Ms Excel 2016. Descriptive statistics, analysis of the association between variables using Pearson Chi-square test or Fisher's Exact test where necessary were done and findings obtained were presented and discussed. Data obtained from key informant interviews were transcribed and then content analysis done to obtain findings concerning the ASGM.

b) Mineral and elemental compositions of the rocks

Thin sections of rock samples taken from the study area were prepared at the laboratory at the Department of Earth Science, University of Ghana and examined under the petrographic (polarising) microscope to help identify minerals in the rocks.

For scanning electron microscope (SEM) work, pieces or slabs of the rocks were also prepared at the Department of Earth Science laboratory, University of Ghana and then coated with ultrathin conducting material e.g. aluminium to prevent them from charging. The sections or specimens were mounted on specimen holders, fitted to the specimen chamber and then examined under the SEM to determine textures and

compositions of the rocks using energy dispersive (EDS) mode. This enabled major elements in minerals and their relative proportions to be determined.

X- Ray Fluorescence (XRF) spectroscopy was used to obtain data on the chemical or elemental compositions of the rock samples. The Vanta XRF Analyser was used for the analysis at Ghana Geological Survey Authority (GSSA) laboratory in Accra. The rock samples were first pulverised using a crushing machine and crushed samples sieved through a 212 µm sieve to obtain rock powder. About four (4) grams of the rock powder from each of the samples was weighed, 0.9 grams of wax (binding substance) added and the mixture homogenized before preparation of pellets for elemental analysis using the Vanta XRF machine.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents the results or data acquired from the study from the various methods used (i.e. literature review, key informant interviews, questionnaire administration, observations and collection and analysis of gemstones-bearing rocks for their mineral and element compositions). It begins with presentation of analysis of mineral and element contents in collected gemstones-bearing rocks. It continues with observations made during field work on mining methods utilised in ASGM and environmental impacts, socio-economic data from analyses of questionnaires and information on existing key policies, laws, regulations and institutions relating to ASGM in Kenya.

4.2 Mineral and chemical compositions of gemstones-bearing rocks

4.2.1 Mineral Compositions

Gemstones-bearing rock samples collected from the AMEC and Chawia mines are shown in Figure 4.1 a and b. They are generally light grey in colour, fine to medium grained in texture and jointed with gneissic banding. Under the microscope, the main minerals in the rock from the AMEC mine are plagioclase (20%), quartz (10%), hornblende (45%), muscovite (20%) and opaque minerals (5%). The rock sample from the Chawia mine consist of quartz (40%), plagioclase (30%), muscovite (10%) and opaque minerals (20%). Rocks from both mine sites are therefore essentially gneiss with variable contents of plagioclase, muscovite, quartz and opaque minerals. (Figure 4.1 c & d).

Rock sample taken from the Fatuma mine are light grey in colour, medium grained, massive and often jointed (Figure 4.2a). It is mainly composed of interlocking grains of quartz and is thus quartzite (Figure 4.2b).

The rock sample from the Classic EA mine are generally grey in colour, fine to medium grained and generally massive (Figure 4.3a). In thin section, the rock is composed of plagioclase (10%), quartz (40%), muscovite (30%) and opaque minerals (20%) (Figure 4.3b).

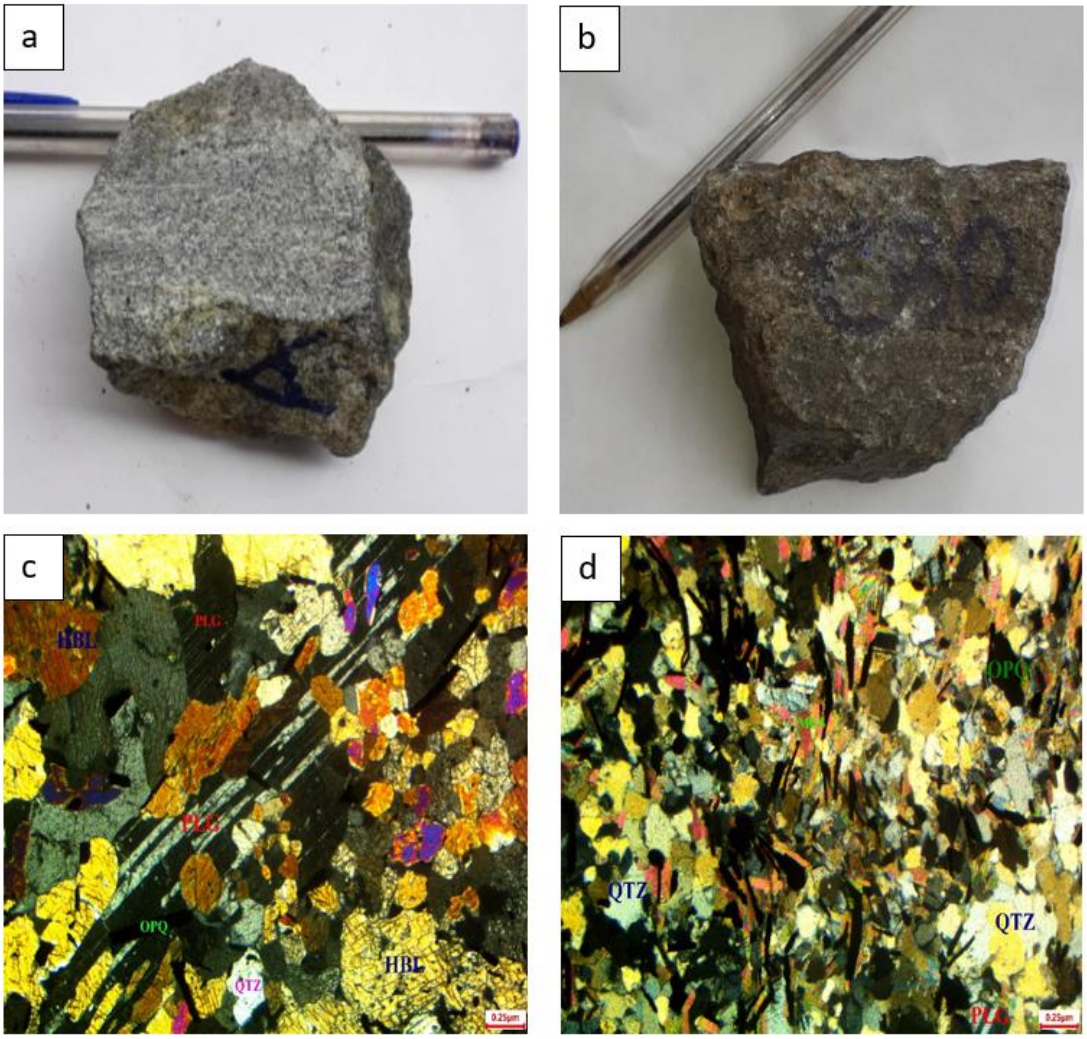


Figure 4.1 (a) and (b) are rock samples taken from AMEC and Chawia mine sites, respectively, (c) and (d) are photomicrographs (crossed nicols) of (a) and (b) showing the fine-grained texture of the rocks and alignment of mineral grains. Quartz (QTZ), Plagioclase (PLG), hornblende (HBL), Opaque minerals (OPAC).

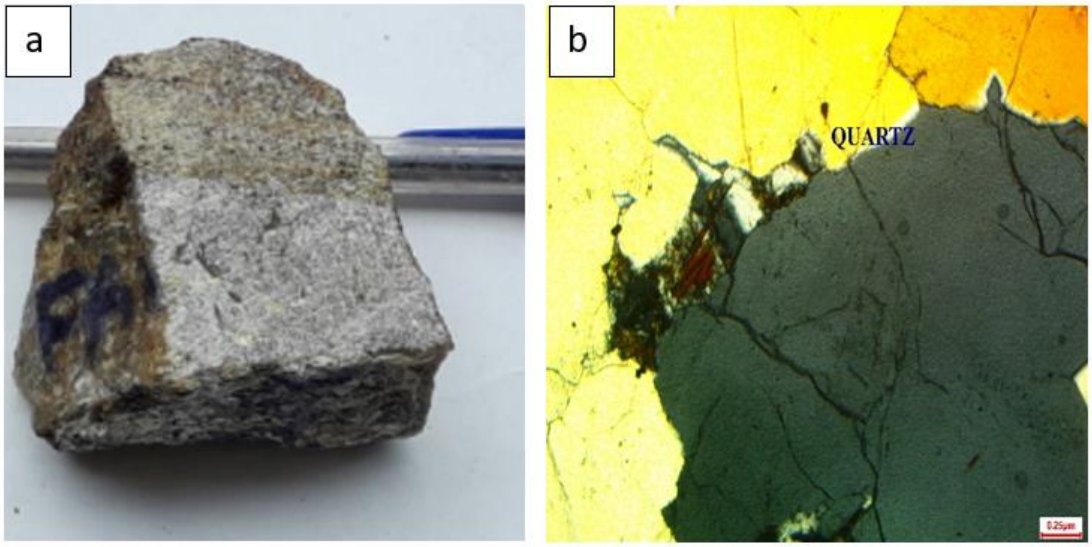


Figure 4.2 (a) Hand specimen and (b) photomicrograph (crossed nicols) showing large quartz grains in quartzite.

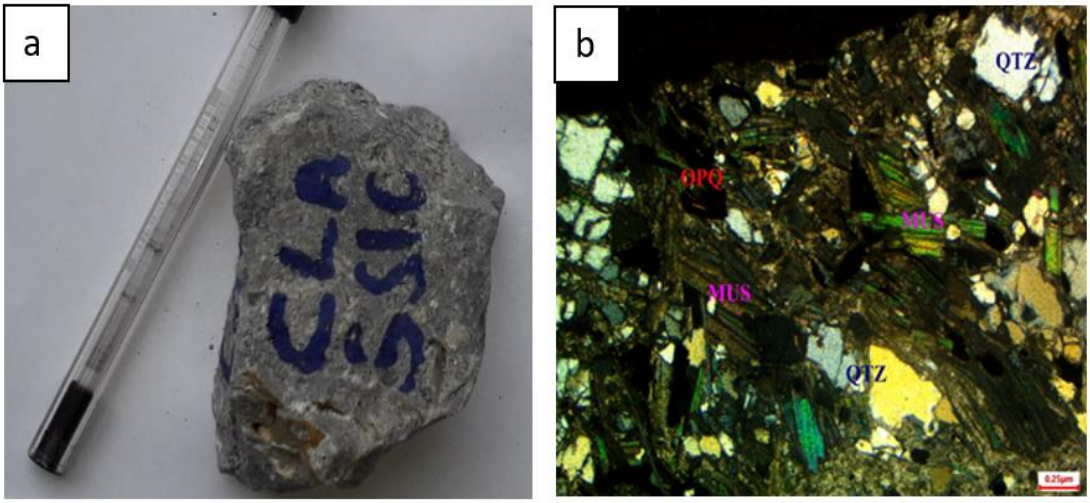


Figure 4.3: (a) Hand specimen and (b) photomicrograph (crossed nicols) showing dark opaque minerals, quartz and muscovite.

Scanning electron microscope (SEM) images of rocks from the four mine sites confirm they are mainly massive gneisses with occasional banding and quartzite (Figure 4.4). Figures 4.5 gives semi-quantitative SEM analyses and accompanying peaks of gneiss and quartzite rock samples. The analytical points exhibit greater variability in Mg, Si, Al and Fe contents.

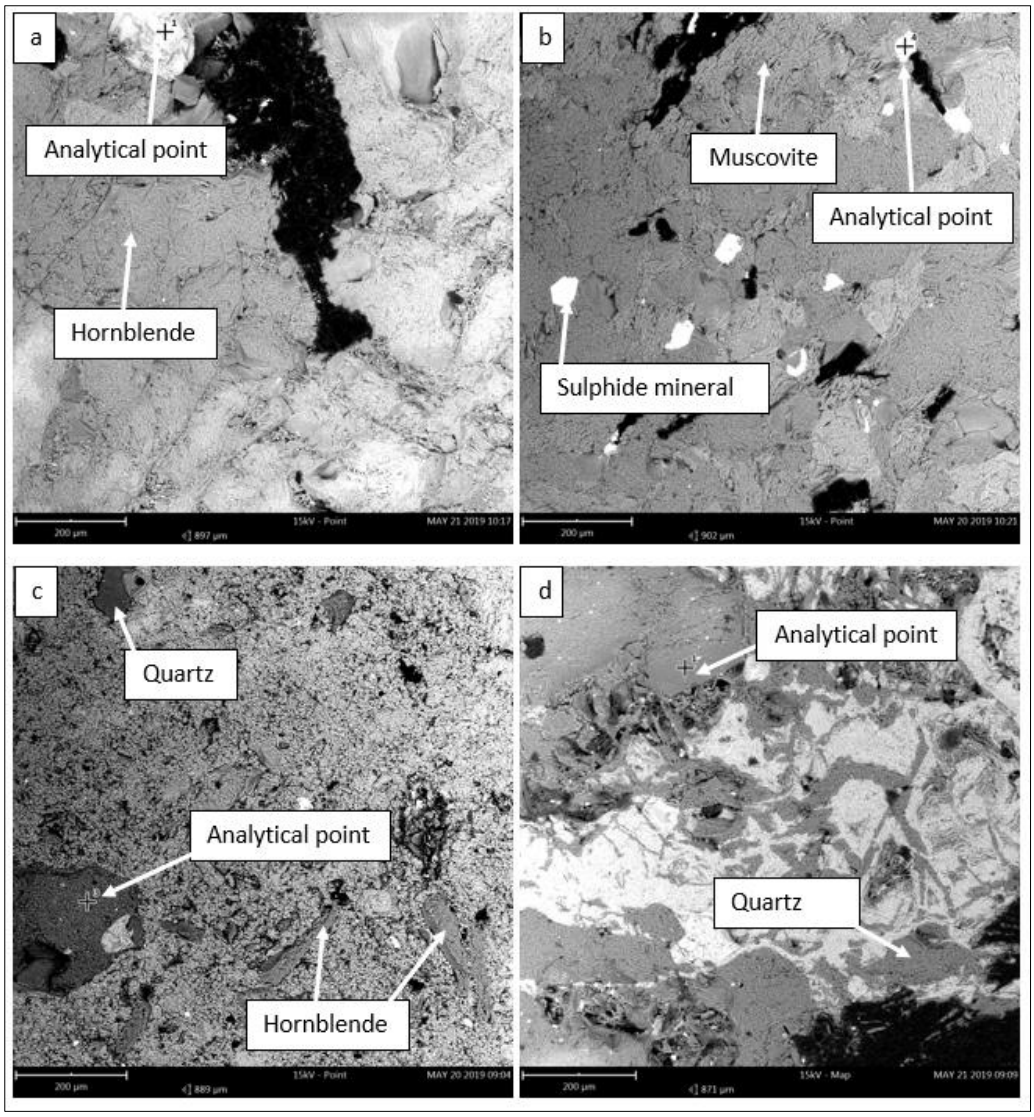
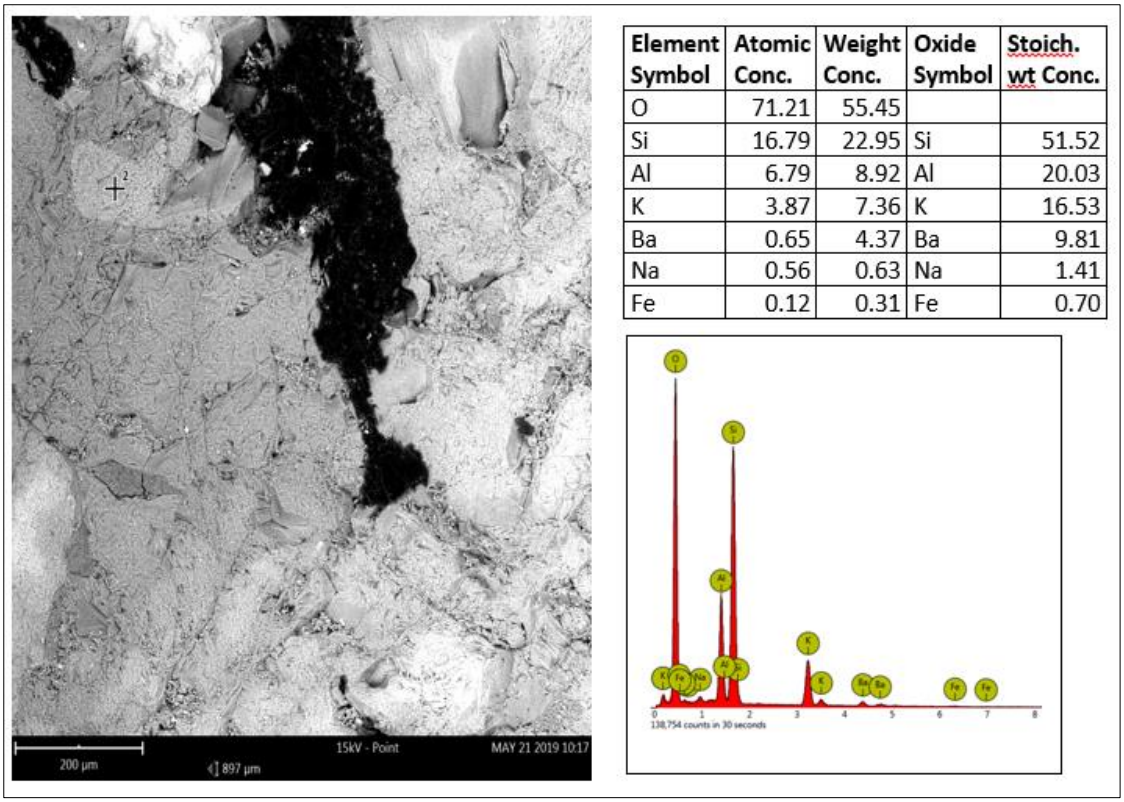


Figure 4.4: SEM images of gneiss (a, b & c) and quartzite (d).



Element Symbol	Atomic Conc.	Weight Conc.	Oxide Symbol	Stoich. wt Conc.
O	71.21	55.45		
Si	16.79	22.95	Si	51.52
Al	6.79	8.92	Al	20.03
K	3.87	7.36	K	16.53
Ba	0.65	4.37	Ba	9.81
Na	0.56	0.63	Na	1.41
Fe	0.12	0.31	Fe	0.70

Figure 4.5: SEM composition and EDS peaks of constituent elements in gneiss.

4.2.2 Major and trace element compositions

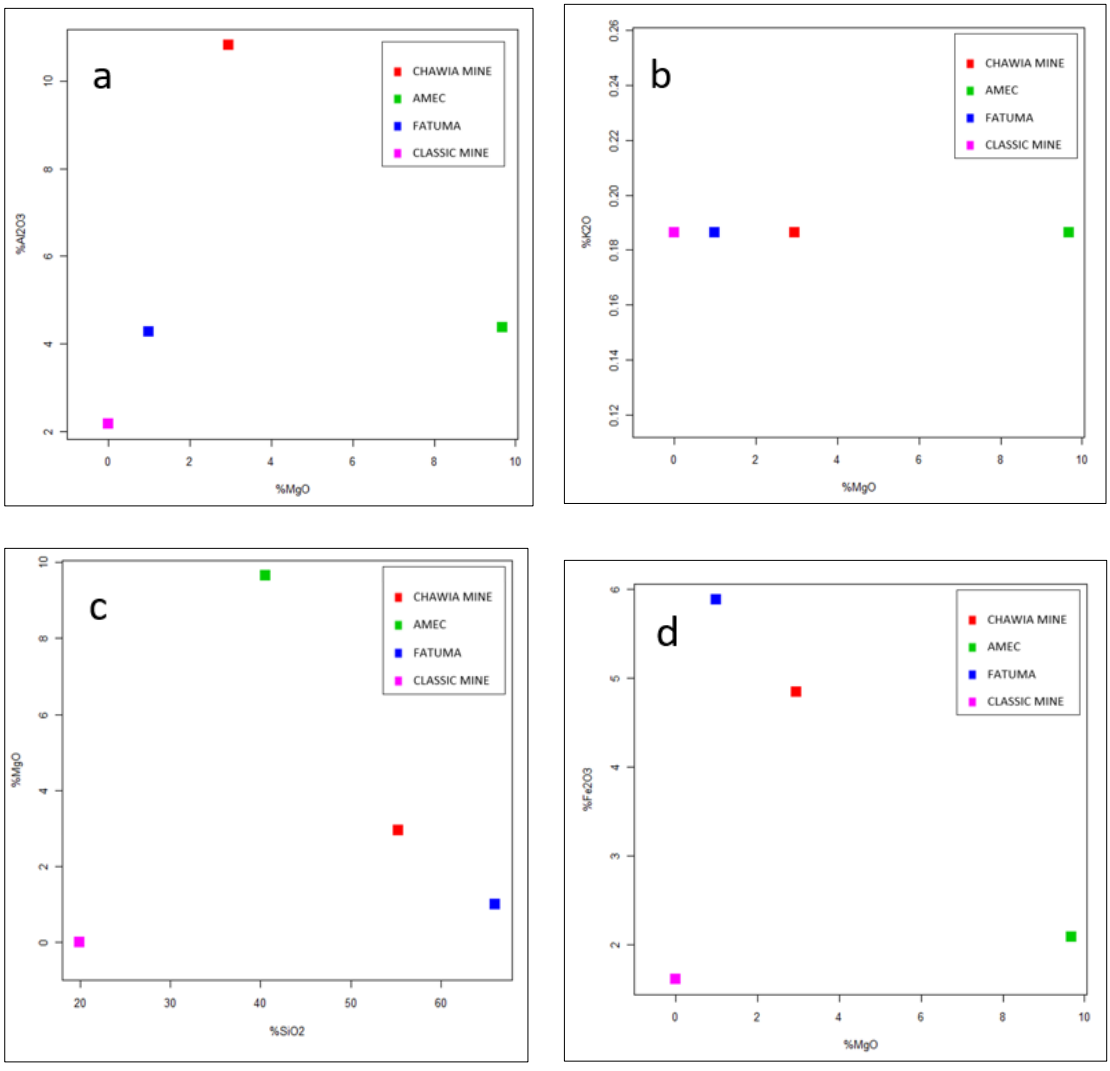
Major and trace element compositions of the gemstones-bearing rocks were analysed using XRF. The analyses indicated variations in both major and trace elements (Table 4.1). Variations in the major elements (as oxides) are as follows; SiO_2 (19.88-66.05%), TiO_2 (0.11-0.74%), Al_2O_3 (2.17-10.83%), Fe_2O_3 (1.61-5.89%), MgO (0-9.66%), CaO (2.34-35.42%), K_2O (0.19%), MnO (0.03-0.12%), P_2O_5 (0-0.38%) and SO_3 (0.5-3.86%).

Table 4.1: XRF analyses of the gemstones-bearing rocks

Sample ID	Chawia Mine	AMEC Mine	Fatuma Mine	Classic Mine	EA
SiO_2%	55.25	40.58	66.05	19.88	
TiO_2	0.74	0.31	0.50	0.11	
Al_2O_3	10.83	4.37	4.28	2.17	
Fe_2O_3	4.85	2.09	5.89	1.61	
MnO	0.08	0.12	0.03	0.12	
MgO	2.95	9.66	0.99	0	
CaO	4.86	17.44	2.34	35.42	
K_2O	0.19	0.19	0.19	0.19	
P_2O_5	0.22	0.38	0.24	0	
SO_3	3.86	1.97	3.36	0.50	
V /ppm	134	162	96	58	
Cr	586	73	34	0	
Co	0	0	0	0	
Ni	47	93	15	12	
Cu	24	16	12	9	
Zn	70	111	13	26	
As	0	9	6	0	
Se	7	8	6	5	
Rb	79	38	20	37	
Sr	272	115	142	70	
Y	25	20	26	14	
Zr	134	86	113	36	
Nb	11	6	5	0	
Mo	13	28	30	0	
Ag	0	0	0	0	
Cd	0	0	0	0	
Sn	0	0	0	0	
Sb	0	0	0	0	
W	0	14	0	0	
Hg	0	0	0	0	
Pb	9	0	8	0	
Bi	0	0	0	0	
Th	0	0	0	0	
U	7	22	8	102	

NB: 0 means < detection limit

Binary graphs for some of the major elements (as oxides) in rocks from the four mine sites are presented in Figures 4.6 (a, b, c, d, e, f, g & h). The binary diagrams display variable characteristics but generally show moderate to high SiO_2 and Al_2O_3 compared to other oxides. A combined plot of major and trace elements in the samples, given in Figure 4.7, reveals the samples are highly enriched in the elements Al, Ca and Fe and moderately to slightly enriched in P, S, K, Ti, V, Cr, Mn, Ni, Cu, Zn, As, Se, Rb, Sr, Y, Zr, Nb, Mo, Pb and U. Fairly high Ca and Fe contents are likely associated with gemstones-rich samples.



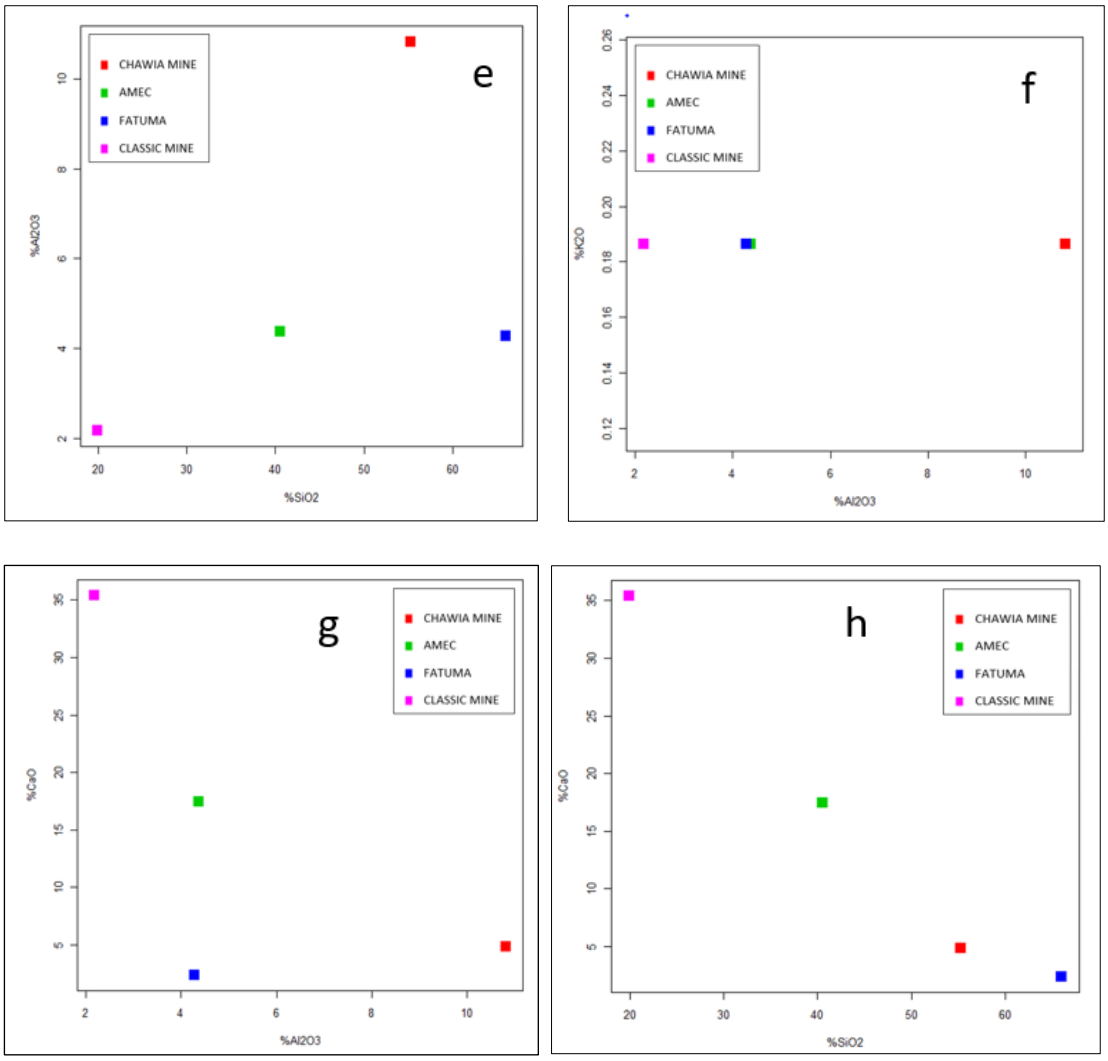


Figure 4.6: Plot of selected major elements as oxides of the gemstones-bearing rocks

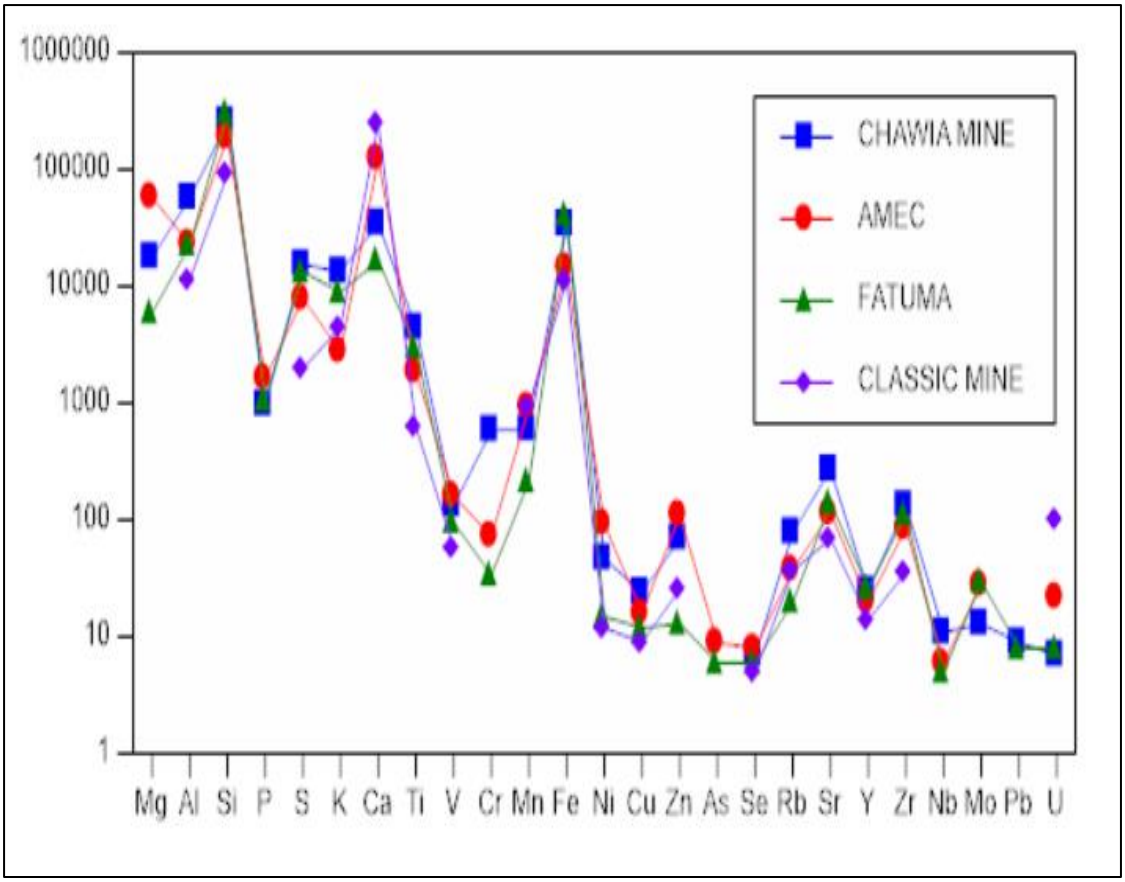


Figure 4.7: Plot of major and trace elements of the gemstones-bearing rocks

4.3 Methods of extraction utilised in ASGM

Direct observations at mine sites and interviews with mine owners and the County Mines and Geological Officer indicated that gemstones miners essentially utilise both open-cast and shallow underground mining. Of the two types, underground mining (or tunnelling) is the most widespread at many mine sites visited. According to miners, the open-cast method is far more expensive since it requires more sophisticated technology and equipment which most of the artisanal miners cannot afford. Miners largely utilise manual labour and equipment such as hammers, hoes, shovels, chisels and sieves. Plate 4.1 shows an entrance into a mine tunnel at one of the mine sites.

Some miners also use explosives to first break down the rock to make separation of the gemstones from the waste rock easier. In a few cases, excavators, compressors, jack hammers, drills and winches are also used by miners who have the financial capacity to buy or hire the equipment. Plates 4.2 and 4.3 show some of the equipment used for gemstones extraction.

Plate 4.1: An entrance to a mine tunnel

Source: Field survey (2018)

Plate 4.2: Shovels used in gemstones extraction

Source: Field survey (2018)

Plate 4.3: Compressor used in gemstones extraction

Source: Field survey (2018)

4.4 Socio-economic data of community members and miners

The socio-economic data of community members and miners were obtained from the administration of questionnaires. One hundred and five (105) questionnaires were administered to community members and 103 were completed and given back giving a response rate of 98.1%. On the other hand, 103 questionnaires were administered to miners and 95 were filled out and handed back giving a response rate of 92.2%.

4.4.1 Demographics of Community Members

The demographics of community members surveyed are presented in Table 4.2. Of the 103 community members surveyed, 70.9% (73) were males and 29.1% (30) were females. Most of them were aged between 25 and 31 years (28.2%) with the least between 46 and 52 years (2.9%). A high percentage of them were Christians (92%) while Muslims formed 7% and people of other affiliations (i.e. those who did not fall in any of the religions provided) accounted for the remaining 1%. In terms of education level, most of the respondents had primary (basic) education (41.7%) while 38.8%, 16.5% and 2.9% had secondary, tertiary and no formal education, respectively. With respect to marital status, 68% were married, 30.1% were single while the remaining were either divorced (1%) or widowed (1%). Also, majority of respondents were natives of the study area (89.3%) while 10.7% were non-natives.

Table 4.2: Demographics of community members

Variables	Frequency (f)	Percentage (%)
Sex		
Male	73	70.9
Female	30	29.1
Age (years)		
18 - 24	21	20.4
25 - 31	29	28.2
32 - 38	20	19.4
39 - 45	15	14.6
46 - 52	3	2.9
Above 52	15	14.6
Religion		
Christianity	95	92.2
Islam	7	6.8
Others	1	1.0
Education level		
None (No formal education)	3	2.9
Primary	43	41.7
Secondary	40	38.8
Tertiary	17	16.5
Marital Status		
Single	31	30.1
Married	70	68.0
Widowed	1	1.0
Divorced	1	1.0
Nativity		
Yes	92	89.3
No	11	10.7

4.4.2 Demographics and Ethnic background of Miners

The demographics of miners surveyed are presented in Table 4.3. All the ninety-five (95) miners surveyed were males. Majority of the miners were aged between 25 and 31 years (26.3%) followed closely by those between 32 and 38 years (25.3%) indicating that these age groups are the most dominant, while the lowest percentage was for those below 18 years (1.1%). With regards to religion, 84.2% of the sampled miners were

Christians whilst 10.5 % and 5.3% were Muslims and others (those that did not fall in any of the religions provided), respectively. Majority of the sampled miners were married (71.6%) with 28.4% being single. Most of the miners had attained primary (basic) education (57.9%) while those that had secondary education, tertiary education and no formal education were 33.7%, 2.1% and 6.3%, respectively. Also, about 68.4% of the sampled miners indicated that they were natives while 31.6% indicated that they were not. Of the thirty (30) non-native miners, twenty-nine (29) of them representing 96% stated that they emigrated into the area in search of employment while only one (1) representing 4% stated that he emigrated into the area when he got gemstones mining job. Most of the miners (about 31.6%) had more than 12 years of mining experience while those with 9-12 years, 5-8 years, 1-4 years and less than a year of mining experience were 14.7%, 26.3%, 14.7% and 12.7%, respectively. Generally, it was observed that most of the miners had been involved in gemstones mining for a period of five or more years.

Table 4.3: Demographics of miners

Variables	Frequency (f)	Percentage (%)
Sex		
Male	95	100
Female	0	0
Age (years)		
< 18	1	1
18 - 24	12	12.6
25 - 31	25	26.3
32 - 38	24	25.3
39 - 45	18	18.9
46 - 52	10	10.5
Above 52	5	5.3
Education level		
None (No formal education)	6	6.3
Primary	55	57.9
Secondary	32	33.7
Tertiary	2	2.1
Religion		
Christianity	80	84.2
Islam	10	10.5
Hindu	1	1.1
Others	4	4.2
Marital status		
Single	27	28.4
Married	68	71.6
Nativity		
Yes	65	68.4
No	30	31.6
Mining experience		
< 1yr	12	12.6
1-4yrs	14	14.7
5-8yrs	25	26.3
9-12yrs	14	14.7
More than 12yrs	30	31.6

It was observed that there are different ethnic groups involved in the ASGM (Table 4.4). The majority were the native Taita (42.6%) followed by Kamba (34.0%) and Mijikenda (11.7%) who are also natives to the area. The other groups represented are non-natives (emigrants) and are nearly from all over Kenya. Some such as Pare (1.1%) and Nyaturo (1.1%) are ethnic groups from Tanzania.

Table 4.4: Ethnicity of miners

Ethnicity	Frequency	Percentage (%)
Borana	1	1.1
Embu	1	1.1
Kamba	32	34.0
Kikuyu	1	1.1
Luo	1	1.1
Maasai	1	1.1
Meru	4	4.3
Mijikenda	11	11.7
Nyaturo	1	1.1
Pare	1	1.1
Taita	40	42.6

4.5 Knowledge and perception of adverse environmental effects of ASGM

4.5.1 Knowledge of adverse environmental effects of ASGM

Seventy-three respondents (73) representing 71% of the community members indicated that they have knowledge of the adverse environmental impacts of ASGM while thirty (30) representing 29% do not have such knowledge. On the other hand, forty-one (41) people representing 43% of the miners indicated that they have knowledge of adverse environmental impacts of ASGM with fifty-four (54) representing 57% of the miners indicating that they lack such knowledge.

A bivariate correlation analysis between knowledge of environmental impacts and demographics (age and education level) of respondents showed no significant correlation. Tables 4.5 and 4.6 show the correlation matrices.

Table 4.5: Spearman's correlation matrix between knowledge of environmental impacts and community members demographics

	Age	Education level	Do you have knowledge of the environmental impacts of ASGM
Age	1.000		-0.079
Education level		1.000	-0.193

Table 4.6: Spearman's correlation matrix between knowledge of environmental impacts and miners' demographics

	Age	Education level	Do you have knowledge of the environmental impacts of ASGM
Age	1.000		-0.172
Education level		1.000	-0.134

4.5.2 Perception of adverse environmental effects of ASGM by community members and miners

Community members and miners perceived adverse environmental effects of ASGM differently. Significant differences were found between their perceptions as regards all the identified adverse environmental effects (vegetation cover loss and disturbance, topsoil removal and disturbance, air pollution, noise and vibrations, aesthetic/visual pollution, water pollution and loss and threat to biodiversity) (Table 4.7). For instance, while majority of the community members considered topsoil removal and disturbance as an adverse environmental effect resulting from ASGM; most miners did not consider it as an adverse environmental effect resulting from the mining activity.

Table 4.7: Differences between community members' and miners' perceptions of adverse environmental effects of ASGM

Environmental effects	Responses in percentage				
	Community members (N=103)		Miners (N=95)		X^2
	Yes	No	Yes	No	
Vegetation cover loss and disturbance	78.6	21.4	54.7	45.3	*
Topsoil removal and disturbance	86.1	13.9	30.5	69.5	*
Air pollution	89.3	10.7	70.5	29.5	*
Noise and vibrations	86.3	13.7	63.2	36.8	*
Aesthetic/Visual pollution	79.2	20.8	51.6	48.4	*
Water pollution	48.0	52.0	22.3	77.7	*
Loss and threat to biodiversity	74.0	26.0	44.7	55.3	*

* Significant at $p < 0.05$

Association between perceived adverse environmental effects of ASGM and demographic factors of community members and miners was determined. The bivariate analysis conducted showed a significant association between some perceived adverse environmental effects of ASGM and some demographic factors. A summary of the association between perceived environmental effects of ASGM and demographic factors of respondents is presented in Appendices 9a, 9b, 9c and 9d.

There was only a significant association between community members' age and noise and vibrations (P-value < 0.05) where all those below the age of 25 years indicated that ASGM causes noise and vibrations. Besides, the majority of community members in

other age groups indicated that the activity causes noise and vibrations. Association between age and other perceived environmental effects did not show significant association. Besides, other demographic factors (sex and education level) of community members did not show any significant association with all the perceived environmental effects of ASGM.

A significant association occurred between miners' education level and air pollution (P-value < 0.05). The results showed that 83.3% of those with no formal education indicated that ASGM does not cause air pollution. However, 74.2% of those with some formal education (primary, secondary or tertiary) indicated that ASGM causes air pollution. No significant association between education level and other perceived environmental effects.

A significant association between activity undertaken by a miner and topsoil removal and disturbance (P-value < 0.05) was also found. However, other perceived environmental effects showed no significant association with the activity that a miner undertakes. The results showed that 73.3% of those involved in gemstones extraction (digging) did not link ASGM to causing topsoil removal and disturbance while those involved in other activities linked it to land degradation. All other factors including age and mining experience did not show any significant association with all the perceived environmental effects of ASGM.

4.6 Socio-economic effects associated with ASGM

Several socio-economic effects both beneficial and adverse as a result of ASGM were revealed by the study. Beneficial effects include employment, revenue generation to the

national government and community projects such as the building of schools and sponsorship to school-going children. Adverse effects include family instability, erosion of social values, human rights violations, occupational hazards, poor housing and land ownership conflicts.

4.6.1 Knowledge of socio-economic effects of mining

Most of the community members had knowledge of socio-economic effects of mining in general where ninety-five (95) people representing 92% indicated to have such knowledge. Only eight (8) representing 8% had no such knowledge. For miners, seventy-four (74) representing 78% were conversant with the socio-economic impacts of mining while twenty-one (21) representing 22% were not aware of such effects.

A bivariate correlation analysis between knowledge of socio-economic impacts and respondents' demographics was done. Tables 4.8 and 4.9 below show the correlation matrices. Results showed a significant positive correlation between the education level of community members and their knowledge of socio-economic impacts though it was weak. The correlation showed that those community members with higher education level were more cognisant with the socio-economic impacts of mining. Besides, a significant negative correlation was found between age of miners and their knowledge of the socio-economic impacts of mining. However, the correlation was weak. The correlation showed that younger miners were more versed with the socio-economic effects of mining than the older miners.

Table 4.8: Spearman's correlation matrix between knowledge of socio-economic impacts of mining and demographics of community members

	Age	Education level	Do you have knowledge of the socio-economic effects of mining?
Age	1.000		0.022
Education level		1.000	0.247*

* Correlation significant at the 0.05 level (2-tailed).

Table 4.9: Spearman's correlation matrix between knowledge of socio-economic impacts of mining and demographics of miners

	Age	Education level	Do you have knowledge of the socio-economic impacts of mining?
Age	1.000		-0.219*
Education level		1.000	-0.071

* Correlation significant at the 0.05 level (2-tailed).

4.6.2 Estimated number of those directly engaged in ASGM and those dependent on it

It is approximated that there are 5,000 miners engaged in ASGM and about 50,000 people are dependent on the activity in Taita Taveta County (Taita Taveta County Mines and Geological Officer, personal communication, November 19, 2018).

4.6.3 Employment and income of community members and miners

Of the one hundred and two (102) community respondents, thirty-six (36) representing 35% indicated that they are directly involved in gemstones mining while sixty-six (66) representing 65% were involved in other economic activities. Of the thirty-six (35%) that are directly involved in gemstones mining, thirty-one (31) representing 86.1% are into mineral (gemstones) extraction, two (2) representing 5.6% are into mineral (gemstones) processing and three (3) representing 8.3% are into buying the gemstones.

The other sixty-six community members (65%) are mainly engaged in retail business (38.5%) and other activities as shown in Table 4.10. Engagement in the retail business was observed to be high as the miners have provided a ready market for products. Therefore, the activity has provided for income generation to those not directly involved in it.

Table 4.10: Occupation of community members not involved in gemstones mining

Occupation	Frequency	Percentage (%)
Transport business	9	13.8
Farming	6	9.2
Hotel business	3	4.6
Masonry	1	1.5
Office cleaning	1	1.5
Retail business	25	38.5
Retired	3	4.6
Security guarding	4	6.2
Student	6	9.2
Teaching	4	6.2
Welding	1	1.5
None	2	3.1

The monthly income of community members participating in other economic activities is shown in Table 4.11. It was observed that the majority of the members earn less than Ksh. 10,000 (USD 98.27) per month (48.2%) with a few earning more than Ksh. 29,999 (USD 294.80) per month (7.1%).

Table 4.11: Distribution of monthly income of community members engaged in other economic activities

Income per month in Ksh	Equivalence of income in USD	Frequency	Percentage (%)
< Ksh. 10,000	< USD 98.27	27	48.2
Ksh. 10,000 - 19,999	USD 98.27 - 196.53	17	30.4
Ksh. 20,000 - 29,999	USD 196.54 - 294.80	8	14.3
> Ksh. 29,999	> USD 294.80	4	7.1
Total		56	100.0

NB: At the time of study, 1 USD averaged approximately Ksh. 101.76

The study revealed that eighty-three (83) representing 87% of the miners depend entirely on gemstones mining as their source of income while eleven (11) representing 13% have other sources of income too. The income earned by miners is shown in Table 4.12. Majority of the miners were found to earn their income through production share (67.4%). Therefore, they could not estimate how much they earn per month as they said they can go several months without production. Majority of those who are paid per month were found to earn less than Ksh. 10,000 (USD 98.27) per month (25.2 %) with few earning more than Ksh. 29,999 (USD 294.80) per month (2.1 %). Farming was the major source of income other than gemstones mining for those miners who had other income sources as shown in Table 4.13 below. Five (5) miners were also engaged too in subsistence farming, four (4) in retail business, one (1) in subsistence farming and retail business and one (1) noted that he also earns rent from tenants.

Table 4.12: Distribution of miners' monthly income

Income per month	Equivalence of income in USD	Frequency	Percentage (%)
< Ksh. 10,000	< USD 98.27	24	25.2
Ksh. 10,000 - 19,999	USD 98.27 - 196.53	5	5.3
> Ksh. 29,999	> USD 294.80	2	2.1
Earn through production share basis		64	67.4

NB: At the time of study, 1 USD averaged approximately Ksh. 101.76

Table 4.13: Sources of income for miners other than gemstones mining

Source	Frequency	Percentage (%)
Retail business	4	36.4
Subsistence farming	5	45.5
Subsistence farming and retail business	1	9.1
Rent from tenants	1	9.1

An independent samples t-test was performed to compare income earned by miners to that earned by community members engaged in other economic activities. The F statistic for the Levene's test for equality of variances (Levene, 1960) was 0.072 with an insignificant p-value of 0.789 (p-value > 0.05). This showed that the variances of the monthly income of both miners and community members are approximately the same. Thus, the assumption of the variables having equal variances was met. The test showed no statistically significant difference between the income earned by miners (M =12,593.75, SD =18,877.977) and that earned by community members not involved in gemstones mining (M =13,579.66, SD =20,023.252); t (89) = 0.229, p = 0.820 (p-value > 0.05). Appendices 8a and 8b show the results of the test.

With regard to activity undertaken by miners, most of them were found to be engaged in mineral extraction activity (94.7%) as shown in Table 4.14 below. Other activities

undertaken by miners include serving as security guards and supervision of other miners. This is represented as 'Others' (Table 4.14). Some of miners undertake more than one activity as was noted by one miner.

Table 4.14: Gemstones mining activity undertaken by miners

Activity	Frequency	Percentage (%)
Mineral extraction (digging)	90	94.7
Others (security guarding and supervision of other miners)	4	4.2
Mineral extraction, Mineral processing	1	1.1
Total	95	100.0

4.6.4 Social benefits of ASGM

Apart from direct economic gains miners derive from the gemstones mining, eighty (80) of the community members representing 77.7% indicated that there are no other social benefits they derive from the industry. This is so because the miners have not formally organised themselves into a recognisable entity in the industry. Nonetheless, twenty-three (23) of the community members representing 22.3% asserted that there are some other benefits they gain from the industry. These included the building of schools, provision of water to schools and sponsorship to school-going children. The community members noted that the projects were being carried out by one mine owner who owns Classic EA mine site. Building of schools was the most mentioned project (Table 4.15).

Table 4.15: Projects mentioned to be carried out in the community

Project	Frequency	Percentage (%)
Building of schools	10	45.5
Provision of water to schools	1	4.5
Sponsorship to school-going children	8	36.4
Sponsorship to school-going children and building of schools	3	13.6

4.6.5 Human rights violations

Key informant interviews revealed that there exist human rights violations in the sector. A representative from the Taita Taveta Humans Rights Watch organisation in an interview, stated that the main problems are the violation of rights to non-discrimination of having equal opportunities, sexual abuse and harassment and labour rights violations. Women were mostly noted to be discriminated against by not being allowed to work in the mines. Some mine owners stated that they do not employ women because of the strenuous nature of the gemstones mining activity. Sexual abuse and harassment were revealed in an interview where some women workers at a mine located in Kasigau area were ordered by the mine owner to undress and searched their private parts for alleged stolen gemstones. Views from miners indicated that over fifty per cent (51%) have observed or experienced the violation of their rights whereas 49% stated that they have not observed or experienced violation of their rights. The discrimination of women by not being allowed to participate in the activity was the human rights violation that was noted by miners.

Labour rights violations were also revealed through interviews which included lower pay, lack of insurance covers and few workers working beyond 8 hours daily. Many mine workers are underpaid as most of their pay was observed to be under the minimum

wage of Ksh.13,572 (USD133.37) set by the Kenyan government in 2018. Some miners' salaries are as low as Ksh.4,000 (USD 39.31) per month. Results from the social survey show that majority of the miners are not provided with insurance cover for injuries and/or illnesses as sixty-six (66), representing 69.5% indicated that no insurance covers are provided by mine owners. Only twenty-nine (29) representing 30.5% of the miners indicated that they are provided with insurance cover. Though most of the mine workers daily working times are within the stipulated period of 8 hours daily, some workers indicated to be working for as long as 16 hours a day (Table 4.16)

Table 4.16: Daily work duration of mine workers

Hours	Frequency	Percentage (%)
6.00	12	12.9
7.00	1	1.1
8.00	72	77.4
9.00	2	2.2
10.00	1	1.1
12.00	2	2.2
15.00	1	1.1
16.00	2	2.2

4.6.6 Effect of ASGM on family stability

According to sixty (60) miners, representing 63.2%, ASGM has an effect on family stability while thirty-five (35) miners, representing 36.8% indicated that the activity does not have any effect on family stability. On the other hand, eighty-six (86) representing 83.5% of the community members were of the opinion that the activity affects family stability while seventeen (17) representing 16.5% of the community members pointed out that family stability is not affected by ASGM.

Key informant interviews revealed that ASGM has obvious effects on family stability in various ways. Most miners engaged in the activity especially the married ones (husbands) leave their families and overstaying at mine site camps. Overstaying at sites is attributed to low income due to long periods spent in extracting the gemstones. In some areas such as Buguta, Sasenyi, Rukanga and Kisemenyi villages, it was reported that some families have broken down and some are headed by children as all the parents are in the mines. The girls are forced to take care of the family as the parents occasionally come home. It was also reported that due to overstay of spouses in the mines, some partners are now into multiple sexual relationships.

The views on ways in which ASGM affects family stability as stated by community members and miners are presented in Tables 4.17 and 4.18. Overstaying at mining sites was noted to be the most significant way in which families are affected. Majority of the miners (82.5%) and 64.7% of the community members indicated overstaying at mining sites as the main way which leads to family stability effects.

Table 4.17: Views of community members on ways in which family stability is affected by ASGM

Ways	Frequency	Percentage (%)
Delayed pay & overstay at sites	1	1.2
Family abandonment	6	7.1
Low production leading to low income	3	3.5
Overstaying at mine sites	55	64.7
Overstaying at mine sites and poor pay	19	22.4
Promiscuity	1	1.2
Total	85	100.0

Table 4.18: Views of miners on ways in which family stability is affected by ASGM

Ways	Frequency	Percentage (%)
Low pay	10	17.5
Overstaying at sites without any production	47	82.5
Total	57	100

4.6.7 Insecurity

Most miners and community members noted that there are security concerns in the mining areas or mine sites. Insecurity issues encountered in the mining sites and within communities were identified to be theft and wildlife attacks. Theft occurs occasionally in some mining sites and trading centres. Wildlife attacks are mainly from elephants which injure or kill miners and even destroy their camps in search of food and water. Other attacks come from snakes. The mining areas are a habitat for some venomous snakes like the Black Mamba. Fifty-eight (58), representing 61.1% of the miners indicated that they face security concerns in the mining sites while thirty-seven (37) representing 38.9% do not face any security issues. From key informant interviews, insecurity was mentioned as an issue due to the absence of police stations at or near mining sites and due to wildlife attacks as a result of interference with wildlife corridors and mining activities taking place near or in the protected area (Tsavo National Park). The insecurity issues mentioned by both miners and the community members indicate theft and wildlife attacks to be the most insecurity issues encountered (Tables 4.19 and 4.20).

Table 4.19: Insecurity issues encountered by miners

Insecurity issue	Frequency	Percentage (%)
Theft	8	13.8
Theft and wildlife attacks	28	48.3
Wildlife attacks	22	37.9

Table 4 20: Insecurity issues faced by the community

Issue	Frequency	Percentage (%)
Theft	11	13.4
Theft and wildlife attacks	49	59.8
Wildlife attacks	22	26.8

4.6.8 Effect of ASGM on socio-cultural values

Key informant interviews revealed that the activity has had an effect on socio-cultural values in the society. Substance abuse in mining sites was noted to be high as miners believe that they have to use certain drugs for them to work in the mines. The most abused drug was noted to be marijuana (composition of leaves and flowers of *Cannabis sativa* plant that are smoked). Another effect was prostitution which was reported in gemstones mining areas such as Kamtonga, Chunga Unga and Rukanga found within the study area. Teenage pregnancies were also mentioned. Eighty-seven (87), representing 84.5% of community members acknowledged that the activity has had an effect on socio-cultural values while sixteen (16), representing 15.5% of them opined that the activity has had no effect on the values. The most mentioned effects were substance abuse, prostitution and teenage pregnancies (Table 4.21).

Table 4.21: Kinds of effects on socio-cultural values as mentioned by community members

Effect	Frequency	Percentage (%)
Substance abuse	9	10.3
Prostitution	3	3.4
Substance abuse and prostitution	10	11.5
Substance abuse, prostitution and teenage pregnancies	65	74.7
Total	87	100.0

On the other hand, miners acknowledged that substance abuse in mining sites was common. Sixty-five (65), representing 69.1% of them stated that substance abuse exists in mining sites while twenty-nine (29), representing 30.9% were of the view that it does not (Figure 4.8). The type of substances abused by miners are shown in Table 4.22. Marijuana was the most cited substance that is abused by miners (38.5%) followed by marijuana and cigarettes (20%) and then marijuana and khat (leaves and young twigs from *Catha edulis* plant that are chewed for stimulation) (10.8%). Thus, the most abused substances were marijuana, cigarettes and khat.

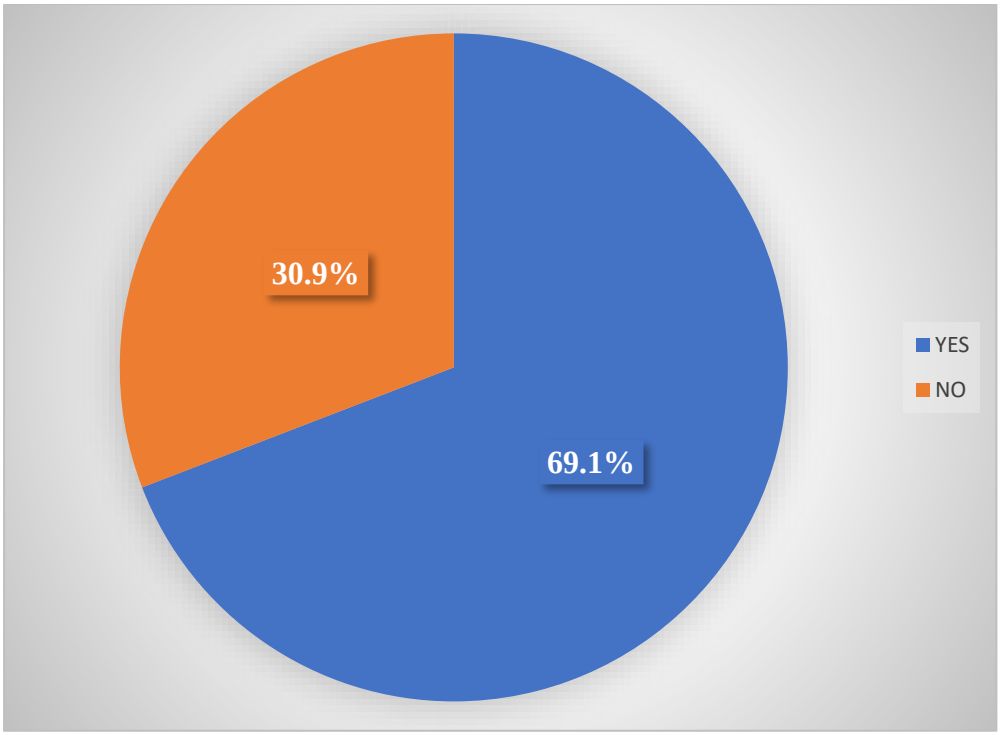


Figure 4.8: Substance abuse in mining areas and at mine sites

Table 4.22: Type of substances abused by miners

Substance	Frequency	Percentage (%)
Alcohol	1	1.5
Alcohol and khat	3	4.6
Cigarettes	5	7.7
Cigarettes, khat and alcohol	1	1.5
Khat	1	1.5
Marijuana	25	38.5
Marijuana and alcohol	3	4.6
Marijuana and cigarettes	13	20.0
Marijuana and khat	7	10.8
Marijuana, alcohol and khat	5	7.7
Marijuana, cigarettes and khat	1	1.5

4.6.9 Child labour

Child labour was observed to be limited. As indicated from the miners' demographics, only 1.1% of the miners were under the age of 18 years showing limited participation of children in the activity. Nevertheless, a key informant reported that in some mining areas such as Kuranze, Kamtonga and Chunga Unga within the study area, it has been observed. Children are engaged in undertakings like sieving, selection and extraction of gemstones.

4.6.10 Occupational safety and health concerns in ASGM

Views on the usage of Personal Protective Equipment (PPE) by miners indicated that sixty-eight (68) representing 71.6% do not use PPE while twenty-seven representing 28.4% do use. Some PPE in use were overalls, helmets, gloves and safety boots. Majority of those that do not use PPE stated that they are not provided with them by their employers while few of them see no need of using them. From direct observations too, most miners were noted not to be using PPE as required.

Views on training on occupational safety and health revealed that most of the miners are not trained. Sixty-six (66) representing 69.5% of the miners stated that they are not trained. Twenty-nine (29), representing 30.5% of the miners have had some training but it was either once-off or after a long time such as after several months or even after a year.

Plate 4.4: Miners working without PPE at Chawia mine on 12th December 2018

Source: Field survey (2018)

Occupational injuries/accidents analysis carried out showed that most of the miners have experienced various injuries/accidents. The inquiry was only partially done where miners were asked to name injuries and/or accidents that they had experienced in the recent past. Most injuries/accidents experienced by miners resulted from being hit by hammers and falling rocks (73.5%) followed by cuts (17.6%), injuries from the collapse of mines (4.4%) and finally falling into pits (1.5%), loss of limbs (one finger) (1.5%) and snake bites (1.5%) (Table 4.23). However, 28.4% of the miners reported no injuries or accidents. The days of work lost were used to show the severity of the injuries or accidents. Most miners, i.e. 43 miners representing 63.2% lost 0-3 days of work, 19.1% lost 4-14 days of work, 8.8% lost 15-30 days and 8.8% lost more than 30 days (Table 4.24).

Table 4.23: Latest self-reported occupational injuries/accidents experienced by miners

Occupational injuries/accidents	Frequency	Percentage (%)	Percentage of injury type (%)
Cuts from hoes, spades and chisels	12	12.6	17.6
Falling into pits	1	1.1	1.5
Hitting by hammers and falling rock	50	52.6	73.5
Injuries from the collapse of mines	3	3.2	4.4
Loss of limbs (finger)	1	1.1	1.5
Snakebite	1	1.1	1.5
Total	68	71.6	100.0
None	27	28.4	
Total	95	100.0	

Table 4.24: Days of work lost by a miner due to the latest injury or accident experienced

Number of days lost	Frequency	Percentage (%)
0-3 days	43	63.2
4-14 days	13	19.1
15-30 days	6	8.8
more than 30 days	6	8.8

The summary of the association between injuries/accidents and the determinant factors (age, activity undertaken by a miner, training of miners on occupational safety and period of engagement in gemstones mining {mining experience}) is presented in Table 4.25. The bivariate analysis conducted to determine the association between injuries/accidents and the determinant factors showed no significant association between the determinant factors and the injuries/accidents (p-value > 0.05).

Table 4.25: Association of injuries/accidents with determinant factors

Determinant factor	Occupational injuries/accidents experienced			
	Yes (%)	No (%)	X^2 value	P-value
Age			1.530	0.463
< 25yrs	76.9	23.1		
25-38yrs	75.5	24.5		
>38yrs	63.6	36.4		
Activity undertaken by a miner			0.561	1.000
Mineral extraction (digging)	71.1	28.9		
Others (security guarding & supervision of other miners)	75.0	25.0		
Mineral extraction & mineral processing	100.0	0.0		
Training on occupational safety and health			1.856	0.173
Yes	62.1	37.9		
No	75.8	24.2		
Mining experience			0.675	0.411
< 5yrs	65.4	34.6		
≥ 5yrs	73.9	26.1		

Cases of fatalities due to the mining activity are not well documented though few miners have been reported to have lost their lives due to suffocation and collapse of mines. The County Mines and Geological Officer in an interview noted that in 2015, a miner died in AMEC and another one in Lilian Gems mines respectively. Furthermore, in 2018 another miner died in Chawia mine.

4.6.11 Water, sanitation and housing

Most of the miners had access to clean water for domestic purposes. Ninety-three (93), representing 97.9% of the miners mentioned that they get clean water for use whilst

two (2), representing 2.1% reported no access to clean water. The major source of water at the mining sites was water from water tankers (96%). This is because the mining sites are in remote areas which are semi-arid with no rivers or streams. Hence, miners are forced to buy water from the tankers. Other water sources noted were piped water (2%) and rainwater (2%) (Figure 4.9).

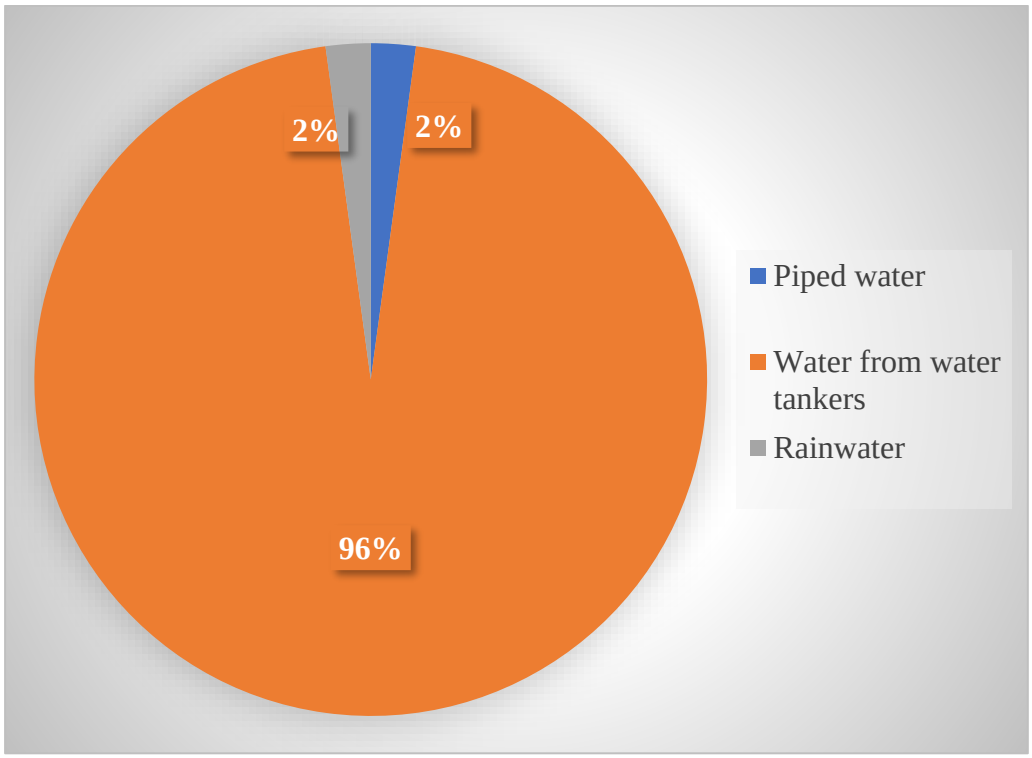


Figure 4.9: Sources of water at mining sites

Majority of the miners (92) representing 96.8% stated that they have access to a toilet facility at the mining site whereas three (3), representing 3.2% indicated to have no access to such a facility. Pit latrines were the common type of toilet facility at the mining sites as indicated by 97% of the miners who indicated to have access to the facility with 3% of them having the VIP latrine (Figure 4.10).

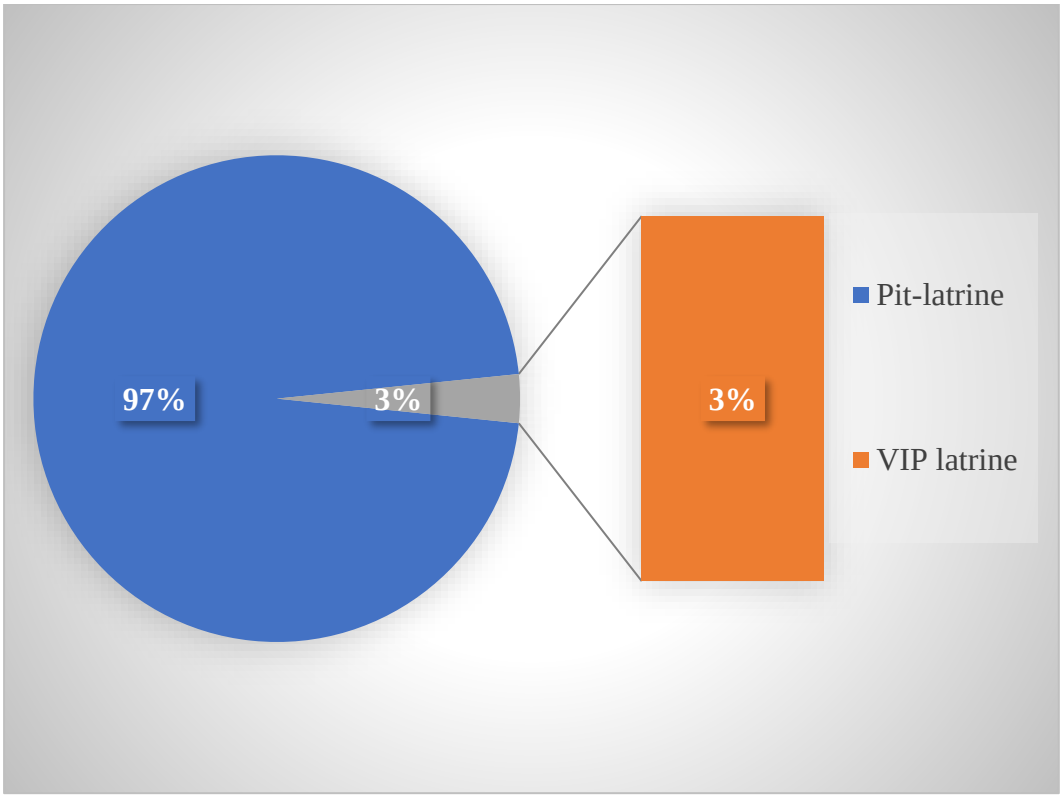


Figure 4.10: Access to toilet facility at mining sites

Plate 4.5: An improvised toilet at a mining camp

Source: Field survey (2018)

Housing was observed to be generally poor in most of the mining sites visited. Many were temporary shelters built of wood and iron sheets and some having polythene as the walling material.

Plate 4.6: Showing shelters at the mining sites

Source: Field survey (2018)

4.6.12 Land ownership conflicts

Land ownership conflicts due to gemstones mining have been reported in some mining areas. During the field work, mine owners indicated that conflicts arise due to old mining claims which have never been exploited. Therefore, those who own them usually have disputes with mainly the illegal miners or 'Zururas' who invade the claims and start prospecting for gemstones. During the data collection exercise in the field in December 2018, the mining officers were forced to intervene to stop a conflict that was brewing between two mine owners who claimed to own a mining location. Prospecting

at the location was put on hold for the dispute to be resolved. This clearly indicated the existence of land use conflicts in the gemstones mining industry.

It has also been reported that some members of the community who own land in mining areas have been dispossessed of their land ownership rights due to occurrence of gemstones in their land. A public inquiry report by Kenya National Commission on Human Rights (KNCHR) on Mining and Impact on Human Rights in Taita Taveta County in 2016 highlighted several cases of land ownership conflicts in the gemstones mining sector. The report indicated that most of the land owners lack land title deeds in the gemstone mining areas. For instance, in 2009, Mr. Luka Kitumbi struck gemstones in his land when he was digging a pit latrine (KNCHR, 2016). As he was preparing to apply for a mining right, he was informed that another person had already applied for the same over the area without seeking a land consent from him as the land owner as required by law (KNCHR, 2016).

4.6.13 Marketing of gemstones

The study sought to find out whether miners have a ready market for gemstones, to whom do they sell, in what state do they sell their gemstones and whether they have knowledge of the gemstones' prices both locally and internationally.

Sixty-four (64) people representing 68.1% of miners noted that there is no a ready market at the local level while thirty (30) representing 31.9% stated that there is ready market.

Regarding gemstones buyers, eighty-two (82) representing 89.1% of the miners indicated that they sell their gemstones to local brokers. Five (5) representing 5.4% sell to mineral dealers, four (4) representing 4.3% sell to international companies while one (1) representing 1.1% sells to both local brokers and mineral dealers.

It was observed that most of the gemstones are sold rough (without being processed) as sixty-three (63) representing 67.7% of the miners indicated that they sell them rough. This means that there is no value addition made by the majority of miners before selling their gemstones. Nineteen (19) representing 20.4% indicated that they sell their gemstones in the cut/polished state while eleven (11) representing 11.8% indicated that they sell their gemstones in both states (sometimes in a rough state and other times in a cut state).

Sixty-one (61) representing 64.9% of the miners had no knowledge of the gemstones' prices at the local and/or international market while thirty-three representing 35.1% of them noted to have such knowledge.

4.7 Gaps in the existing policy, legal and regulatory framework and challenges faced by regulatory institutions

A review of documents revealed certain gaps that could be regarded as useful for monitoring activities in the sector. This section therefore presents some of the gaps identified in the framework and the challenges faced by regulatory institutions in carrying out their mandate of implementing, enforcing, monitoring and ensuring compliance with the set laws and regulations.

4.7.1 Mining Act, 2016 and its adequacy

Some gaps in this new act were identified. In Article 12, the Cabinet Secretary (Minister) in charge of mining has been given sweeping discretionary powers in the administration of the Act with no room for delegation of duties. This could have an effect on the independence of the new institutions. In Articles 32, 40 and 13, the Minister has been given powers to grant, deny, revoke or suspend a mining permit or license, to order compulsory acquisition of land for prospecting and mining and to declare areas to be earmarked for artisanal and small-scale operations respectively. The statute is silent on gender and human rights issues related to the extractive industry and in fact, these words do not appear anywhere in it. Royalty payment procedures are not clearly spelt out in the Act and even in the regulations, the issue is not clear. Partnership issues are mentioned in the Act but the private sector is not included yet it is an important stakeholder in the mining sector. Though the Act recognises artisanal mining, it does not include any mineral right relating to its operations. Though the Act recognises community participation in decision-making process concerning the issuance of land consents, the definition of term "community" is ambiguous. Its definition is given as a group of people residing around the mining operations or those that have been displaced due to the operations. The terms around and group are quite ambiguous. CSR is voluntary as the Act only recommends for miners to do so. Nevertheless, the Local Content Bill of 2018 is geared towards ensuring CSR is carried out by miners. Also, the Act is vague on who is to approve the environmental management plans that miners would be submitting for them to be licensed.

There were varied opinions from the key informants with regards to the adequacy of the new mining law. The County Mines and Geological Officer and the County Director

of Environment-NEMA were satisfied with the provisions of the law. They argued that it was adequate in ensuring sound oversight of the mining sector particularly ASGM. The implementation of the law was cited as the biggest challenge because of political interferences, corruption and insufficient resources to implementing institutions. The Kenya Chamber of Mines representative noted that the law was not fully adequate as there were some inconsistencies in the law and some sections deemed discriminatory. However, it was acknowledged that the law was far better than the old law. For instance, Article 173(1) (d) and (e) which say that the Cabinet Secretary (Minister) in charge can suspend or revoke a licence or permit when the holder dies or becomes of unsound mind respectively. It is noted that most of the ASGM operations are run as family enterprises thus there is a need to provide for a procedure to allow the family or heirs to continue being the license or the permit holders. Inconsistencies in the law include some omissions. For example, in Article 13(1) there is the omission of artisanal mining operations for which designated areas can be reserved for such operations but the same is well captured in Article 13(2).

The mine owners interviewed argued that the new law was inadequate because of various provisions which they felt are an impediment to the growth of ASGM and ASM sector at large. They noted the expensive and complex nature of the law in that the requirements for engaging in the sector are complex and more expensive than in the old law. The fee paid per claim was observed to have increased from Ksh. 1,000 once-off to Ksh. 10,000 requiring renewal annually. The fee for a prospecting license was noted to have increased from Ksh. 2,000 to Ksh. 5,000 requiring renewal annually. For those who want to venture into the sector, other initial expenses would be for preparation of EIA report, geological feasibility study report, restoration plan and land consent. These

were noted to be too enormous and a burden to most miners. Therefore, this was viewed to be an obstacle in ensuring the growth of the sector as many investors may shy away from venturing into it because of the fear of making losses as there is no guarantee of striking the mineral immediately. The mine owners noted that the licensing process is now taking too long as they had not received mining licenses under the new law as it was required since its commencement in May 2016. The process could be taking long as the proponents are required to submit current documents especially the land consents. These were observed to be an obstacle in acquiring the licenses and permits because some of the landowners have family issues concerning the ownership of the land after the death of their parents who gave the initial consent. It was evident that consultation during the preparation of the new law was not well done as indicated by the mine owners. This means that a few participated during the preparation of the law.

4.7.2 The Environmental Management and Co-ordination Act, 1999 (EMCA Cap 387)

It lacks provisions for the application of SEA to policies, plans and programmes however this has been catered for under the Environmental Management and Co-ordination (Amendment) Act, 2015.

4.7.3 The Environmental Management and Co-ordination (Amendment) Act, 2015

In Article 28, the Cabinet Secretary (Minister) has been given many powers in the administration of the Act especially concerning gazettement of new environmental regulations though through recommendations made by the Authority (NEMA).

4.7.4 Challenges facing regulatory institutions

Majority of the institutions face challenges in implementing, enforcing, monitoring and ensuring compliance with the set laws and regulations. They indicated to be faced with limited personnel at the county level, limited finances and political influences which lead to corruption. This hinders effective enforcement and monitoring of compliance to the set laws and regulations. Overlapping mandates and lack of proper coordination of some of the institutions are also a hindrance to ensuring enforcement and compliance with laws and regulations due to conflict of interests.

4.8 Knowledge of and education on the existing policy, legal and regulatory framework

Eighty-eight (88), representing 94.6% of the miners were not aware of any mining laws and regulations that exist in the mining sector whilst five (5) representing 5.4% of the miners were aware of some of the laws and regulations in place. Of the five miners who were aware of some of the mining laws and regulations, two mentioned the EMCA Cap 387 of 1999 and the other three mentioned Mining Act of 2016. On the other hand, six (6) community members representing 5.9% of respondents from the communities were conversant with the mining laws and regulations while ninety-five (95) representing 94.1% were not conversant with any of the laws and regulations. All those community members who were aware of the laws and regulations noted Mining Act of 2016 as the law they are aware of.

Eighty-five (85) miners representing 91.4% indicated that they do not receive any form of education on existing mining laws and regulations while eight (8) representing 8.6% of the miners indicated that they receive some form of education on existing mining

laws and regulations. Out of the eight who indicated that they receive some form of education on the existing laws and regulation, five mentioned that they got the education from the County Mines and Geological officer while the other three mentioned the County government.

The study revealed that few miners (30.5%) and few community members (34%) were able to state some of the institutions responsible for gemstones mining regulation. According to majority of the miners (69.5%) and community members (66%), they do not know any institutions responsible for gemstone mining regulation. Institutions mentioned to be responsible for gemstones mining included Ministry of Mining, NEMA, Ministry of Lands, County Government, KNCHR and Kenya Chamber of Mines as shown in Tables 4.26 and 4.27 below.

Table 4.26: Institutions responsible for gemstones mining regulation according to miners

Institution	Frequency	Percentage
Don't know	66	69.5
Kenya Chamber of Mines	1	1.1
Ministry of Mining	23	24.2
Ministry of Mining & County government	1	1.1
Ministry of Mining and NEMA	3	3.2
NEMA	1	1.1

Table 4.27: Institutions responsible for gemstones mining regulation according to community members

Institution	Frequency	Percentage
Don't know	68	66.0
County government	2	1.9
KNCHR	1	1.0
Ministry of Lands	1	1.0
Ministry of Mining	10	9.7
Ministry of Mining & County government	3	2.9
Ministry of Mining & NEMA	15	14.6
NEMA	3	2.9
Total	103	100.0

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter entails the discussion of the results obtained from the study. It includes discussion on the potential adverse environmental and socio-economic effects of the artisanal and small-scale mining of gemstones in the area studied, extraction methods used in artisanal and small-scale mining of gemstones and the existing policy, legal and regulatory framework of ASM in Kenya; ASGM being part.

5.2 The potential environmental and human health effects posed by the rocks, minerals and elements associated with the gemstones mining

Because gemstones miners generally do not use PPEs, they may be prone to hazards such as physical or bodily injuries due to falling rocks, accidental falls in pits and hitting by work tools such as hammers. Inhalation of minute rock, soil or dust particles could also potentially affect the health of miners in the long term. Minerals in the gemstones-bearing rocks such as quartz and sulphides could also be potentially harmful especially to the health of miners. The presence of quartz (silica) in the rocks could therefore be of critical concern as it is noted that most silica exposures occur in mining and mining related occupations (Rees and Murray, 2007). The exposure to respirable silica dust above recommended exposure limit (REL) recommended by National Institute for Occupational Safety and Health (NIOSH) and WHO has been associated with various diseases. These include silicosis, tuberculosis, chronic obstructive pulmonary disease, lung cancer (silica is carcinogenic), chronic renal disease, emphysema and bronchitis (Calvert et al., 2003; Henry et al., 2017; Rees and Murray, 2007). Exposure to other elements either in oxide form or elemental form such as iron, titanium and sulphur in

form of particulate matter can cause nasal and throat irritations, eye and skin irritations (Henry et al., 2017). A study by Ayaaba et al. (2017) on occupational respiratory diseases of gold miners in two mines in Ghana, showed a significantly high proportion of those that were more exposed to dust to have been affected by some respiratory diseases (asthma, bronchitis and pneumonia) more than those that were less exposed.

Some trace elements such as lead, chromium and arsenic could pose potential adverse environmental effects in the long term even though their concentrations were low. These are heavy metals which bioaccumulate and biomagnify in the environment and along the food chain. They could get released into the environment through leaching and weathering of the excavated waste rocks. Leaching of these trace elements like chromium and arsenic could potentially lead to contamination of groundwater. There is also potential for soil contamination in the long term too. This could occur due to introduction of potentially toxic elements such as chromium, arsenic, lead, nickel and molybdenum as the waste rocks get weathered and eroded. These elements get released and could end up in soils thereby contaminating them.

To emphasise the potential of the aforementioned effects occurring, observations made during field visits suggested clearing of vegetation, haphazard disposal of the waste rock debris and unreclaimed/abandoned open pits and mines. Clearing of some vegetation could facilitate erosion of the haphazardly disposed waste rock debris while during rainy seasons run-off water collects in the abandoned open pits and mines, possibly causing dissolution of potentially toxic elements such as chromium, arsenic and lead that could contaminate the groundwater aquifers.

5.3 Methods of extraction utilised in ASGM

The extraction methods used in ASGM were found to be both underground (tunnelling) and open-cast methods. The most prevalent method used is tunnelling which is less expensive compared to the open-cast method which requires more sophisticated technology. Generally, the methods used are rudimentary which is attributed to the limited finances as reported by mine owners. These methods of extraction are all associated with adverse environmental effects and occupational hazards such as vegetation loss, topsoil removal and destruction of the natural beauty of the land, injuries and fatalities due to collapse of mines, suffocation due to poor ventilation in mine tunnels and occupational diseases due to exposure to dust and other particulate matter (Emmanuel et al., 2018; Mkpuma et al., 2015; Singh et al., 2010).

5.4 Perceptions of adverse environmental effects of ASGM

The study revealed significant differences in the perceptions of all the identified adverse environmental effects resulting from ASGM between miners and the local community. Also, some demographics of community members and miners were found to have an influence on perceptions of adverse environmental effects of ASGM. Age had a significant influence on the perception of noise and vibrations pollution in the case of the community members. In the case of miners, education level was found to have a significant influence on the perception of air pollution while the activity undertaken by a miner was found to have a significant influence on the perception of ASGM causing topsoil removal and disturbance.

5.5 Socio-economic effects of ASGM

Findings on socio-economic effects (beneficial and adverse) resulting from ASGM are talked about herein.

5.5.1 Employment and income opportunities

It was reported that those directly involved in the activity are approximated to be 5,000 people and those indirectly dependent on it to be 50,000 people (Taita Taveta County Mines and Geological Officer, personal communication, November 19, 2018). It was observed that some people have migrated to come and work in the mines from other regions as far as from Tanzania. It was noted that most of the miners depend on the activity solely as their source of livelihood thus acknowledging the significance of ASM activities in providing income to especially the rural inhabitants as showed by several studies. Studies by IGF (2018), the World Bank (2013), Mwakaje (2012) and Kitula (2006) have all noted the significance of ASM in providing a livelihood to people by them getting employed to work in the sector or by providing goods and services to mine workers. For example, Kitula (2006) notes that artisanal gold mining in Geita, Tanzania has offered the locals with employment and income generating activities such as retail businesses, sale of food crops and transport services. Nevertheless, the income earned by most miners was less than Ksh.10,000 (USD 98.27) per month which is way below the minimum wage of Ksh.13,572 (USD133.37) per month set by the government per this study.

An independent samples t-test (Levene, 1960) that was performed to compare the income earned by miners and that earned by community members engaged in other economic activities showed that the income earned by the two groups is approximately

the same. Therefore, the notion that gemstones mining is more lucrative as asserted by some miners could not be ascertained. It was also evident that ASGM is interlinked with other economic activities. Those who also engage in other activities such as retail business, subsistence farming, do so as a way of supplementing their income either from gemstones mining or from the other activities. The activities intertwined with ASGM included subsistence farming and retail business. Some previous studies have noted this interlinkage between ASM activities and other activities too (Hilson, 2016; Kamlongera, 2011; Kitula, 2006; Okoh and Hilson, 2011).

5.5.2 Economic benefits of ASGM

In the year 2018, Kenya earned Ksh. 518.3 million (US$ 5.183 million) from gemstones mainly from exports (Kenya National Bureau Of Statistics, 2019). Therefore, gemstones mining is a significant contributor to revenue earned by the National government from the mining sector. Thus, it promotes the economic development of the country.

5.5.3 Corporate social responsibility (CSR) in the mining community

Reports on corporate social responsibility were poor. Most of the community members (about 78%) indicated that there are no community projects are carried out by some mine owners. However, about 22% of the community members asserted that there are projects carried out by some mine owners in the community including building of schools, provision of water to schools and sponsorship to school-going children. Thus, it is observed that CSR initiatives in the area are very minimal. But this may improve in future because of enactment of the Local Content Bill (2018) which requires companies to carry out CSR by not only offering employment opportunities to locals

but also to provide internships, technology transfer and skills development to local people.

5.5.4 Human rights violations

It was reported that women are usually discriminated in terms of not being allowed to participate in the activity fully (KNCHR, 2016). Only a few are involved in the mining (KNCHR, 2016). They are not allowed to operate in the mines because of the nature of the work which is regarded as cumbersome as revealed by mine owners. Some women workers were also reported to have experienced sexual abuse when the mine owner conducted a body search to them for alleged stolen gemstones (KNCHR, 2016). The owner ordered them to undress and searched their private parts. This was reported at a mine in Kasigau area. Men were not spared as there were reports of sodomy in some of the mining areas such as Kamtonga and Chunga Unga (KNCHR, 2016). Some human rights violations were reported including discrimination against women in terms of not being allowed to work in the mines, sexual abuse, harassment and labour rights violations (KNCHR, 2016). Also, a representative from the Taita Taveta Humans Rights Watch organisation through an interview stated that human rights violations in the ASGM sector exist which include the aforementioned. Kasigau, Kamtonga and Chunga Unga areas within the study area are localities where these violations were reported. Similarly, Kelly et al., (2014) documented sexual abuse of women in ASM in the Eastern part of the Democratic Republic of Congo (DRC) where women were reportedly raped and forced to engage in sex in order to secure employment and continue being employed.

It was observed that some of the labour rights of miners are violated by mine owners. This was mainly through low remuneration to mine workers and lack of provision of insurance cover to workers to ensure them against injuries and accidents which is against the labour laws of the country. Some workers also reported long working hours of over 8 hours per day when the law stipulates clearly that no worker should work beyond 8 hours daily. Similar to this study, violations of labour rights have been reported by de Oliveira and Ali (2011) where workers in small-scale emerald mines in Brazil were found to be working for long hours (8-18 hours) without any health insurance cover.

5.5.5 Effect of ASGM on family stability

The ASGM was noted to cause family instability in a number of ways which included overstaying at mining sites with the hope of getting some production and poor pay. Overstaying at mining sites leads to family abandonment and/or spouses having multiple sexual relations and potentially leading to marriage break-ups. Low pay causes instability to families through spouses not being able to support the needs of their families fully. These findings are similar to those of Mallo (2012) who argues that artisanal mining activities have an impact on family stability as miners stay away from home due to the migration leading to family abandonment and eventually family breakups for those who are married.

5.5.6 Insecurity

Insecurity was noted to be of concern in mining sites and in the surrounding communities. This is due to wildlife attacks as most sites are near or inside protected area. Most attacks were noted to be from elephants which injure and even kill miners

and members of the community. Also, snakes were noted to be a threat to the security of miners as some find their way into camps and mining pits thus biting and injuring or even leading to death of miners. Theft was also highlighted as a problem as criminal gangs sometimes break into shops and steal from the owners and even target miners at mining sites. These findings are in agreement with those of other studies (for instance Bansah et al., 2018; Nyame and Grant, 2014) that observed that mining communities, migratory miners and road users in artisanal mining areas in Ghana were often targeted by armed robbers.

5.5.7 Effects of ASGM on socio-cultural values

The activity was noted to have brought about some social vices both in the mining sites and in the surrounding communities. These include substance abuse, prostitution and teenage pregnancies. Information gathered from both miners and local community members suggest that substance abuse is rampant at mining sites and the most abused drug is marijuana. Many miners claimed that one cannot work in the mines without the drug as it makes them work better, i.e. it acts as a stimulant. Other drugs include cigarettes, khat and alcohol. Therefore, substance abuse is a critical issue in gemstones mining which requires attention. Prostitution was also observed to be practiced in gemstones mining areas like Kamtonga and Chunga Unga and nearby towns like Mwatate town. It is mostly practiced by young women who do it as a way of getting a livelihood. Other studies have also shown that substance abuse, teenage pregnancies and prostitution are social issues that exist in most ASM zones (Bansah et al., 2018; Kelly et al., 2014; Oramah et al., 2015; Yakovleva, 2007).

5.5.8 Child labour

Child labour was observed to be very limited. From field observations, no children were seen in mining sites. Only one respondent out of ninety-five (95) people interviewed was under the age of 18 years suggesting that child labour may not be a serious issue in ASM gemstones mining in the study area. However, there were reports of children involvement in the activity in other mining zones like Kuranze that was not covered in this study. Child labour has been noted to be a critical issue in artisanal mining as noted by some studies. For instance, Barreto et al. (2018a) and Bansah et al. (2018) noted child labour in artisanal gold mining in Kenya and in Ghana, respectively, where children were involved in carrying excavated ore.

5.5.9 Occupational safety and health at the mines

Several occupational safety and health issues were noted at the mining sites. It was evident that most miners do not use PPE and majority claimed that employers did not provide them with PPE. This therefore exposes miners to occupational hazards such as injuries from working tools, machines, collapse of mines and exposure to dust and particulate matter and even death. Training on occupational safety and health measures was reported to be very minimal with few miners indicating to have received some training. Nonetheless, the training was either once-off or only occasionally done. Lack of training on safety measures means exposure to occupational hazards because of deficient knowledge and skills to avoid them. Few fatalities resulting from ASGM have been documented which occur mainly due to collapse of mines and suffocation (Mghanga, 2011; Taita Taveta County Mines and Geological Officer, personal communication, November 19, 2018). A study by Mghanga (2011) has documented some fatalities in the industry. The study reported that in 2008 two miners died due to

suffocation in AMEC mine, while in 2009 one miner from Wanjiru mine and another from Classic EA mine died as they got buried due to the collapse of the mines.

An inquiry on the injuries and/or accidents experienced by miners showed that most of them have had some injuries and/or accidents. Miners were asked to mention the injuries/accidents that one had undergone in the recent past. The most reported injuries were as a result of being hit by hammers and falling rocks and cuts from spades, hoes and chisels. This clearly indicates that the mechanism of injury is mostly handling of tools. This finding is alike to that reported by other studies where the major mechanism of injury was handling of tools (Elenge et al., 2013; Michelo et al., 2009).

The number of work days lost by miners was used to show the severity of the injuries/accidents experienced by miners. Approximately two-thirds of miners (43 out of 68 respondents) who had experienced injuries/accidents lost 0-3 days of work. This suggests that most of the injuries were mild. Nevertheless, there were those that lost 4-14 days (13 out of 68 respondents who had experienced injuries), 15-30 days (6 out of 68 respondents who had experienced injuries) and more than 30 days (6 out of 68 respondents who had experienced injuries) suggesting moderate, severe and very severe injuries.

A bivariate analysis that was done to determine the association between injuries/accidents and age, activity undertaken by a miner, training of miners on occupational safety and mining experience (period of engagement in gemstones mining) showed no significant association between the variables (P-value > 0.05). The findings of this study that showed no significant association between injuries and

activity undertaken by the miner and mining experience differ from those of Calys-Tagoe et al. (2015) which found a significant association between injuries experienced and activity undertaken by the miner and miner's mining experience. However, the findings of this study where no significant association between injuries and age of miners and training on occupational safety occurred concur with those of the aforementioned study. The findings of this study also concord with those of Elenge et al. (2013) that age and mining experience do not have no a significant effect on injuries that miners experience.

5.5.10 Water, sanitation and housing

Most miners apparently had access to clean water which was mostly purchased from water tankers. In spite of this, water supply was observed to be a critical challenge at most mine sites. This is due to the exorbitant prices of water as the tankers had to bring in water from several kilometres away. Hence, majority of the miners only had access to or could afford water for drinking and cooking. Sanitation was generally observed to be good though few of the miners indicated that they do not have a toilet facility. This means that there is open defaecation which can lead to outbreak of diseases such as cholera. Housing was generally poor as most miners live in temporary shelters which are "crudely" built with wood and sheets. This exposes them to cold temperatures at night and even to attacks by wild animals especially snakes that sneak into the shanties. These findings concur with those of Basu et al. (2015) and Cook and Healy (2012) which indicated poor housing, inadequate sanitation facilities and poor hygiene due to lack of clean water.

5.5.11 Land ownership issues in ASGM

Land ownership was found to be a critical issue in gemstones mining areas. Cases of land ownership conflicts have been reported where some have resulted in the loss of lives (KNCHR, 2016). Most of the land owners in the mining zones were found to be without land title deeds and were thus vulnerable to exploitation and loss of land to outsiders or strangers who apply for mining rights over their lands without seeking the consent of land owners. These conflicts mainly result from old mining claims that are not utilised and illegal dispossession of land due to occurrence of gemstones in one's land.

The new Mining Act of 2016 has now provided provisions that ensure that mine owners provide a genuine land consent as a requirement for licensing and public participation in the licensing process. The public are now allowed to provide their views on issues concerning land ownership of areas being applied for to ensure all those concerned with the land are involved so as to avoid conflicts after a license is issued. These findings are consistent with the findings of Nyame and Grant (2014), Hilson and Yakovleva (2007) and Mghanga (2011) that observed that land conflicts are usually experienced in ASM areas due to deficiency of land ownership rights, multi-level land rights systems and undertaking of the activities without seeking consents from land owners.

5.5.12 Gemstones marketing issues

Access to ready market by mostly artisanal miners was reported to be a challenge as majority of miners (68.1%) indicated that they have no ready access to gemstones market. This revelation is emphasised by the fact that most miners (89.1%) sell their gemstones to local brokers who dictate the purchase price gemstones regardless of

prevailing market prices. Most miners (about 65%) also indicated that they have no knowledge of the market prices of gemstones. Therefore, most miners just sell their gemstones without a clear understanding of the market dynamics. Furthermore, it was found out that majority of miners (67.7%) do sell their gemstones as rough gemstones as they lack the knowledge and equipment for value-addition. Similarly, Rop (2014) and Barreto et al. (2018a) noted that most gemstones are sold to local brokers as rough gemstones. This means that miners do not realise the maximum profits from their production. The government eagerly wants to solve this marketing problem and has built a gemstone centre in one of the nearest towns, i.e. Voi where miners could take their products for sale and for value-addition. The centre though is yet to become fully operational to offer these services. Marketing of gemstones is hence a critical issue in the industry which needs to be streamlined for full realisation of the potential of the industry in providing income and employment to the locals and the nation at large.

5.7 Existing Policy, Legal and Regulatory framework governing ASM in Kenya

Provisions of the existing framework regulating ASM in Kenya; ASGM being part, its gaps and challenges facing the regulatory institutions established under it are discussed herein. Also, miners' and community members' awareness of the framework is discussed.

5.7.1 Provisions of Key policies, laws and regulations and regulatory institutions

The various policies, laws and regulations such as the Constitution of Kenya (2010), the Mining Act (2016), the Environmental Management and Co-ordination Act (1999), the Mining (Licensing and Permit) Regulations (2017) and the Environmental (Impact Assessment and Audit) Regulations (2003) have provisions that are primarily geared

towards sustainable management and conservation of natural resources in Kenya. Various institutions have been established to ensure the implementation of the provisions in them including Ministry of Mining and Petroleum, National Environment Management Authority, County government and Kenya Chamber of Mines. These institutions are supposed to coordinate in ensuring that the legislation is implemented and adhered to by all actors in the mining sector.

5.7.2 The Adequacy of the new mining law (The Mining Act, 2016)

The new law incorporates various provisions geared towards sustainable mining and protection of the environment. These include provisions mining companies and mine owners adhere to or comply with EIA and EA regulations concerning occupational safety and health as provided by EMCA Cap 387 (1999) and Occupational Safety and Health Act (OSHA) (2007), respectively. Besides, miners are expected to adhere to provisions of the Water Act (2002) concerning water rights. The law also now recognises the artisanal operations thus enabling legalisation and formalisation of artisanal mining activities including gemstones mining. Varied opinions from key stakeholders were noted concerning the adequacy of the new mining law. Some people (mining regulatory institutions such as NEMA and the Ministry of Mining and Petroleum) noted that the law was very adequate. The Kenya Chamber of Mines and the mine owners stated that it was not fully adequate.

The new mining law appears promising in that it is aimed at ensuring sustainable mining and environmental conservation through its provisions. Nevertheless, the issues brought out by different stakeholders such as the Kenya Chamber of Mines and the mine owners need to be considered especially those concerning mining license fees and

land consents as they are critical in ensuring sustainable mining through promotion of formalisation of especially artisanal mining activities.

5.7.3 Analysis of the gaps and challenges in the existing framework governing ASM

Gaps identified in the framework governing ASM and the whole mining industry are seen as hindrance to achieving sustainability in the industry. For instance, the sweeping powers given to the Ministers in charge of Mining and Environment, respectively, mean that they could abuse them in carrying out their duties. The Minister in charge of Mining has powers to grant, deny, revoke or suspend a mining permit or license, to order compulsory acquisition of land for prospecting and mining and to declare areas to be earmarked for artisanal and small-scale operations. The Minister in charge of Environment too has all powers concerning gazettement of new environmental regulations. This would affect the sector negatively as final decisions are solely made by the Ministers in charge concerning management and regulation of natural resources and the environment. In addition, lack of consideration of human rights and gender issues in the Mining Act (2016) could enable mine owners to deliberately violate rights of workers. Also, ambiguous definitions such as the term “community” as defined in Article 4 in the Act concerning those that would be affected by mining activities may cause persistence of land conflicts.

Challenges faced by regulatory institutions including lack of personnel and resources to carry out inspections and monitoring of mining activities, political interference, corruption, overlapping mandates and lack of coordination of some institutions would continue to hinder achievement of sustainability in the sector if no remedial measures

are put in place. Sustainable mining would therefore be an elusive dream if some of these issues are not effectively tackled or resolved.

5.7.4 Knowledge of the existing policy, legal and regulatory framework by miners and community members

Findings from this study reveal that the majority of the miners and the community members were not aware of the existing laws and regulations and the regulatory institutions mandated to regulate the mining sector which ASGM is part. This could be as a result of ignorance, lack of awareness creation and/or public education to miners and local community by the government or regulatory bodies and infrequent or occasional inspection and monitoring by institutions responsible for regulating gemstones mining activities. Therefore, this means that majority of the miners and community members may not be aware of their rights and obligations as stakeholders in the mining sector.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Artisanal gemstones mining in the Taita Taveta area in Kenya is an important activity that provides direct employment and income to both locals and non-locals who work at the mines, generate revenue to the government and, in addition, indirectly creates knock-on opportunities for local community members and small business enterprises. The miners utilise both underground and open-cast methods to extract gemstones with the underground method being the prevalent or preferred one. The technology utilised is generally rudimentary. Negative impacts associated with the artisanal gemstones mining include loss of vegetative cover, soil degradation and erosion, un-reclaimed pits, poor occupational and health practices, poor housing, prevalence of social vices, human rights violations and land ownership disputes.

Microscopic work done indicates the gemstones-bearing rocks contain minerals such as quartz, plagioclase, hornblende, muscovite and minor sulphides. Chemical compositions of analysed rocks, especially the trace elements Ni, Cu, Zn, As, Pb, Cr, V, U, Rb, Sr, Se, Y, Zr, Mo and Nb, are low to negligible, suggesting minimal contamination of the surrounding environment from chemical decomposition of the gemstones bearing rocks as a result of the mining activity.

Review of the existing policy, legal and regulatory framework governing the gemstones mining revealed sweeping powers bestowed on the Ministers responsible for mining and environment, lack of consideration of human rights and gender issues and lack of

clear procedures for royalty payment which could impede effective management of gemstones mining activities in the country.

6.2 Recommendations

Based on the study, the following recommendations are made:

1. Strict enforcement of environmental and mining laws and regulations such as rehabilitation of abandoned mines and observance of occupational safety and health regulations by the Ministry of Mining and Petroleum, National Environment Management Authority (NEMA) and the County government through the Mining unit in order to ensure sustainability is achieved in the ASGM sector.
2. The Ministry of Mining and Petroleum to institute a policy to encourage value addition of gemstones through cutting and polishing by providing training on value addition process and equipment to miners.
3. Both the County and National governments through the Mining Unit and the Ministry of Mining and Petroleum, respectively, must fully support the ASGM sector by providing direct financial assistance and/or avenues for accessing credit facilities. This would enable miners acquire appropriate and environmentally friendly extraction and value addition equipment.
4. The National and County governments through the Ministry of Mining and Petroleum and the Mining Unit respectively, to train gemstones miners on marketing skills to equip them with knowledge on access to and conditions within the gemstones market.
5. Considerations for amendment of the existing policy, legal and regulatory framework by the Ministry of Mining and Petroleum through the National

Assembly in order to eliminate the gaps such as the sweeping or extensive powers given to the Minister (powers to permit, deny, revoke or suspend a mining permit/license) which might be susceptible to abuse, inconsistencies and lack of inclusion of human rights and gender issues which might hinder effectiveness of the framework.

6. The National government through the Ministry of Finance might have to strengthen the capacity of the regulatory institutions by providing them with adequate finances/resources for inspection and monitoring of the mining activity to help ensure that miners comply with the set regulations.
7. Need to increase community-level public awareness and education through the Ministry of Mining and Petroleum, National Environment Management Authority (NEMA) and the County government Mining Unit on the existing policies, laws and regulations governing the ASGM sector.

6.4 Areas for Further Studies

Areas for further studies include:

- Assessment of the concentration of the particulate matter (PM_{10} and $PM_{2.5}$) at gemstones mine sites and associated human health implications.
- Extent of miners' exposure to respirable silica and associated human health implications.
- In-depth investigation of occupational hazards (accidents and diseases) in the ASGM sector.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE FOR THE MINERS

I am **Njumwa John Zollo**, a student at the **University of Ghana** studying towards a **Master of Philosophy Degree in Environmental Science**. I am currently undertaking a thesis research on **"Environmental and Socio-economic impacts of Artisanal and Small-scale mining: The Case of Gemstone mining in Taita Taveta County, Kenya"**. I am therefore kindly soliciting for your knowledge and views about the above-mentioned. Please be assured that any information given would be handled as private and utilised for academic reasons only.

Thank you.

Questionnaire ID: ……

INSTRUCTIONS: Please mark or write where appropriate as indicated.

SECTION A: GENERAL INFORMATION OF THE RESPONDENT

1. Sex: Male [ ] Female [ ] Other [ ]

2. Age:

< 18yrs [ ] 18- 24yrs [ ] 25- 31yrs [ ] 32- 38yrs [ ] 39- 45yrs [ ] 46- 52yrs [ ] Above 52yrs [ ]

3. Place of birth: ……

4. Home town: …….

5. Ethnicity: ……

6. Religion: a. Christianity b. Islam c. Hindu d. Others, specify …….

7. Educational level: None [ ] Primary [ ] Secondary [ ] Tertiary [ ]

8. Marital Status: a. Single [ ] b. Married [ ] c. Widowed [ ] d. Other, specify …….

SECTION B: MIGRATION, EMPLOYMENT AND INCOME

9. Are you a native of this County? Yes [ ] No [ ]

10. If No, where do you come from? County…… Country……

11. When did you migrate to this area?.....

12. Reason(s) for emigration

……

……

13. Have you ever been involved in any type of mining activity before?

Yes [ ] No [ ]

14. Is gemstone mining your only source of income? Yes [ ] No [ ] If No, state the other source(s) ……

15. How many hours do you work per day? ……

16. How much do you earn per month from gemstone mining? ……

17. For how long have you been engaged in gemstone mining activity?

a.<1year [ ] b. 1-4yrs [ ] c. 5-8yrs [ ] d. 9-12yrs [ ]

e. More than 12yrs [ ]

18. Which activity do you undertake at this mining site?

a. Mineral extraction (digging) [ ] b. Mineral processing (separation, sorting and washing) [ ] c. Providing goods and services [ ] d. Buying gemstones [ ]

e. Others (specify)…….

SECTION D: ENVIRONMENTAL IMPACTS

19. Do you have knowledge of the environmental impacts of mining? Yes [ ] No [ ]

20. How is the gemstone mining done? Underground/Tunnelling [ ] Open-cast [ ]

21. Name types of the equipment used in your work including protective gear

……

……

22. Is gemstone mining associated with the following;

a. Vegetation cover loss Yes [ ] No [ ] If Yes, how?

……

……

b. Land degradation Yes [ ] No [ ] If Yes, how?

……

……

c. Air pollution Yes [ ] No [ ] If Yes, how?

……

……

d. Noise and vibrations Yes [ ] No [ ] If Yes, how?

……

……

e. Aesthetic pollution Yes [ ] No [ ] If Yes, how?

……

……

f. Impact on water resources Yes [ ] No [ ] If Yes, how?

……

……

g. Loss and threat to biodiversity Yes [ ] No [ ] If Yes, how?

……

……

Others, specify…….

SECTION E: SOCIO-ECONOMIC IMPACTS OF GEMSTONE MINING

23. Do you have knowledge of the socio-economic impacts of mining?

Yes [ ] No [ ]

24. What are your reasons for engaging in gemstone mining?

……

……

25. Is the mining activity associated with occupational health and safety hazards/accidents and injuries? Yes [ ] No [ ]

26. Name the accidents and/or injuries that you have experienced so far

……

……

27. How many work days did you lose due to the latest accident(s)/injury mentioned above?

a. 0 – 3 days b. 4-14 days c. 14 - 30days d. More than 30days

28. Are you trained on occupational health and safety measures on mining?

Yes [ ] No [ ]

29.If yes, how often …….

30. Are you provided with insurance cover/scheme for some of these hazards?

Yes [ ] No [ ]

31. Do you have access to toilet facility at your work place? Yes [ ] No [ ]

32. If Yes, what type do you have?

Pit-latrine [ ] VIP latrine [ ] WC [ ] Others [ ]

33. Do you have access to clean water for drinking and other purposes?

Yes [ ] No [ ]

34. If yes, state the source of the water a. Piped water b. Water from tankers c. Rain water

35. Do you use Personal Protective Equipment (PPE) while working? Yes [ ] No [ ]

36. If Yes, state some of the PPE in use

……

……

37. If No, why? ……..

38. Does the activity have any effect on family stability? Yes [ ] No [ ]

39. If yes, in what way(s)?

……

……

40. Have you experienced or heard of someone who has faced human rights violations? Yes [ ] No [ ]

41. If Yes, what kind of violations and by whom, the locality/place where they took place, when and how many times the violations have been experienced?

……

……

42. Is substance abuse prevalent at mining sites? Yes [ ] No [ ]

43. Which substances are used at the sites?

……

……

44. Do you face any security issues while at the mining sites? Yes [ ] No [ ]

45. If yes, state the issues encountered

……

……

SECTION F: MARKETING

46. Do you have ready access to gemstone market? Yes [ ] No [ ]

47. How do you market your product? a. In sizes b. Grades c. Colour d. Texture Others specify ……..

48. To whom do you sell your gemstones? a. Local brokers b. Local cooperatives c. Mineral dealers d. International companies e. Government agencies

49. Do you sell the gemstones as rough gemstones or as cut/polished gemstones? …….....

50. Do you have any knowledge on pricing at local or international market? Yes [ ] No [ ]

SECTION G: MINING LAWS, REGULATIONS AND INSTITUTIONS

51. Are you aware of any laws or regulations on mining? Yes [ ] No [ ]

52. If Yes, state some of them

……

……

53. Do you get any form of education on the existing mining laws and regulations?

Yes [ ] No [ ]

54. Which institution(s) is/are responsible for gemstone mining regulation?

……

……

55. How often do they monitor the mining activities/mine sites?

……

……

56. Were you consulted when the new mining law was being prepared?

Yes [ ] No [

APPENDIX 2: QUESTIONNAIRE FOR SURROUNDING COMMUNITY

I am **Njumwa John Zollo**, a student at the **University of Ghana** studying towards a **Master of Philosophy Degree in Environmental Science**. I am currently undertaking a thesis research on **"Environmental and Socio-economic impacts of Artisanal and Small-scale mining: The Case of Gemstone mining in Taita Taveta County, Kenya"**. I am therefore kindly soliciting for your knowledge and views about the above-mentioned. Please be assured that any information given would be handled as private and utilised for academic reasons only.

Thank you.

Questionnaire ID: ……

INSTRUCTIONS: Please tick or write where appropriate as indicated.

SECTION A: GENERAL INFORMATION OF THE RESPONDENT

1. Sex: Male [ ] Female [ ] Other [ ]

2. Age:

< 18yrs [ ] 18- 24yrs [ ] 25- 31yrs [ ] 32- 38yrs [ ] 39- 45yrs [ ] 46-52yrs [ ] Above 52yrs [ ]

3. Place of birth: ……

4. Home town: …….

5. Ethnicity: ……

6. Religion: a. Christianity b. Islam c. Hindu d. Others, specify…….

7. Educational level: None [ ] Primary [ ] Secondary [ ] Tertiary [ ]

8. Marital Status: a. Single [ ] b. Married [ ] c. Widowed [ ] d. Other (specify)…….

SECTION B: MIGRATION, EMPLOYMENT AND INCOME

9. Are you a native of this County? Yes [ ] No [ ]

10. If No, where do you come from? County…… Country…….

11.When did you migrate to this area? .....

12. Reason(s) for emigration……

……..

13. Are you involved in any related gemstone mining activities? Yes [ ] No [ ]

(If Yes, proceed to question 14 and if No, proceed to question 15 & 16 in this section)

14. If Yes, which activities are those?

a. Mineral extraction [ ] b. Mineral processing [ ] c. Providing services [ ]

d. Buying gemstones [ ] e. Others (specify) …….

15. What is your economic activity? ……

16. How much do you earn from it per month?……

SECTION C: ENVIRONMENTAL IMPACTS

17. Do you have knowledge of the environmental impacts of gemstone mining?

Yes [ ] No [ ]

18. Is gemstone mining associated with the following;

a. Vegetation cover loss Yes [ ] No [ ] If Yes, how?

……

……

b. Land degradation Yes [ ] No [ ] If Yes, how?

……

……

c. Air pollution Yes [ ] No [ ] If Yes, how?

……

……

d. Noise and vibrations Yes [ ] No [ ] If Yes, how?

……

……

e. Aesthetic pollution Yes [ ] No [ ] If Yes, how?

……

……

f. Impact on water resources Yes [ ] No [ ] If Yes, how?

……

……

g. Loss and threat to biodiversity Yes [ ] No [ ] If Yes, how?

……

……

Others, specify …….

SECTION D: SOCIO-ECONOMIC IMPACTS OF GEMSTONE MINING

19. Do you have knowledge about the socio-economic impacts of mining?

Yes [ ] No [ ]

20. Does the activity have an effect on family stability?

Yes [ ] No [ ]

21. If yes, in what way(s)?

……

……

22. Are there any security issues faced by surrounding communities like you due the activity? Yes [ ] No [ ]

23. If Yes, state them

……

……

24. Are there any mining companies or individuals involved in corporate social responsibility? Yes [ ] No [ ]

25. If yes, name some of the projects they have or are carrying out in the community?

……

……

26. Does the activity have an effect on socio-cultural values? Yes [ ] No [ ]

27. If Yes, state the effects. a. Substance abuse [ ] b. Prostitution [ ] c. Teenage pregnancies [ ] Others, specify ……...

28. Are children involved in gemstone mining? Yes [ ] No [ ]

29. If yes, which activities are they involved in?

……

……

SECTION D: MINING LAWS, REGULATIONS AND INSTITUTIONS

30. Are you aware of any laws or regulations on mining? Yes [ ] No [ ]

31. If Yes, state some of them

……

……

32. Who is/are the regulator(s) of the gemstone mining industry and mining at large? Name any institutions …….

……..

33. Were you consulted when the new mining law was being prepared?

Yes [ ] No [ ]

APPENDIX 3: INTERVIEW SCHEDULE FOR COUNTY EXECUTIVE OFFICER FOR MINING -TAITA TAVETA COUNTY

1. What is role of County government in the mining sector especially the small-scale and artisanal sector in terms of regulation and monitoring and restoration of mine fields?
2. Role of traditional authorities and land owners
3. What are the environmental and socio-economic impacts of the gemstone mining?
4. What are the challenges faced by the sector and their possible solutions?
5. What initiatives are or have being put in place to improve the sector?
6. What is the number of miners in the county and people dependent on the sector?
7. Are there any conflicts facing the sector in terms of land ownership?
8. Are there any regulations made by the county to ensure sustainability of the sector?
9. Is the current mining policy and legal framework adequate? If not, what changes should be made?

APPENDIX 4: INTERVIEW SCHEDULE FOR COUNTY DIRECTOR OF ENVIRONMENT - NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY

1. Role of NEMA in the mining sector.
2. Relationship of NEMA with other lead agencies involved in the sector, local leaders and County government.
3. From your view point is the sector environmentally sustainable
4. Environmental laws and regulations concerned with gemstone mining.
5. Environmental and socio-economic impacts of the mining activity both direct and indirect/secondary impacts.
6. Challenges faced in implementing the regulations and possible solutions.

APPENDIX 5: INTERVIEW SCHEDULE FOR COUNTY MINES AND GEOLOGY OFFICER – TAITA TAVETA COUNTY

1. What is role of the geological office especially in artisanal and small-scale mining operations?
2. What is the history of gemstone mining in the County?
3. Is there a database showing the registered and active mining sites including companies, individuals, groups and associations?
4. What methods are used in extraction of the gemstones?
5. Is the mining policy and legal framework of the sector adequate?
6. What are the procedures involved in the issuance of permits to ASGM?
7. How is the relationship between the office and the County government and miners?
8. Is there adequate geological information on gemstones and what are the gaps?
9. What are the environmental and socio-economic aspects of the gemstone mining?
10. Recent and current trends in the sector.
11. What are the challenges facing the sector and their possible solutions?

APPENDIX 6: KEY INFORMANT INTERVIEW SCHEDULE FOR MINE OWNERS

1. For how long have you been in the industry?

2. Describe the governance framework of the sector.

3. Describe the process and requirements of acquiring a mining permit under the new mining law. Is the process simple or complex and affordable?

4. Where is the mining license given?

5. What is the approximate average cost to acquire a mining license?

6. Was consultation done during the preparation of the new mining law?

7. Satisfaction on the provisions of the new law and regulations and any suggestions to improve the current framework.

8. Conflicts encountered especially concerning land ownership and relationship between artisanal and small-scale miners.

9. What challenges do you encounter as a mine owner?

10. What methods and level of technology do you employ?

11. What benefits/ incomes do you gain from this activity?

12. What are the environmental and socio-economic impacts of gemstone mining? What are possible solutions to the curb the negative ones and improve the positive ones?

13. Actions/views in regard to restoration of mine sites or abandoned sites

14. Is there any political influence in the sector? How does it affect the sector and what are the possible solutions?

15. Are there any security issues faced?

16. Relationship with the county government, local leaders and land owners.

17. Are there any legal aspects that promote and hinder the growth of the sector?

APPENDIX 7: INTERVIEW SCHEDULE FOR KENYA CHAMBER OF MINES OFFICER

1. What is the role of KCM in the ASGM sector especially in restoration of mine fields?

……

……

2. How is the relationship between KCM, county government and other lead agencies in the gemstone mining sector in the county?

……

……

3. List of registered members with KCM undertaking gemstone mining in Taita Taveta county

……

……

4. What are the challenges facing the sector with regard to the current regulatory framework and what are some of the possible solutions?

……

……

5. What are some of the environmental and socio-economic aspects of the sector?

……

……

6. Is the current mining policy and legal framework adequate?

Are there any areas requiring improvements?

……

……

APPENDIX 8a: Group Statistics

	Main source of Income (Miners & community members)	N	Mean	Std. Deviation	Std. Error Mean
Monthly income earned	Community members	59	13,579.66	20,023.252	2,606.805
	Miners	32	12,593.75	18,877.977	3,337.186

APPENDIX 8b: Independent Samples t-Test for monthly income earned by miners and community members

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Amount earned monthly	Equal variances assumed	0.072	0.789	0.229	89	0.820	985.911	4,310.052	-7,578.070	9,549.892
	Equal variances not assumed			0.233	67.033	0.817	985.911	4,234.648	-7,466.405	9,438.227

APPENDIX 9a: Showing association between community members demographics and perceived environmental effects of ASGM

Perceived environmental effects	Vegetation cover loss and disturbance			Topsoil removal and disturbance			Air pollution			Noise and vibrations		
Variables	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value
Sex			0.829			0.218			0.291			1.000
Male	78.1	21.9		88.9	11.1		91.8	8.2		86.3	13.7	
Female	80.0	20.0		79.3	20.7		83.3	16.7		86.2	13.8	
Age			0.904			0.602			0.196			0.002*
< 25yrs	81.0	9.0		90.5	9.5		100.0	0.0		100.0	0.0	
25-38yrs	79.6	20.4		87.8	12.2		85.7	14.3		91.7	8.3	
>38yrs	75.8	24.2		80.6	19.4		87.9	12.1		69.7	30.3	
Education level			1.000			1.000			1.000			0.364
No formal education	100.0	0.0		100.0	0.0		100.0	0.0		66.7	33.3	
				86.6	13.4		88.9	11.1		86.7	13.3	
Some formal education	78.8	21.2										

* shows significance at $p < 0.05$

APPENDIX 9b: Showing association between community members demographics and perceived environmental effects of ASGM

Perceived environmental effects	Aesthetic/Visual pollution			Water pollution			Loss and threat to biodiversity		
Variables	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value
Sex			0.053			0.798			0.715
Male	74.3	25.7		47.2	52.8		75.0	25.0	
Female	92.3	7.7		50.0	50.0		71.4	28.6	
Age			0.320			0.590			0.639
< 25yrs	88.9	11.1		57.1	42.9		81.0	19.0	
25-38yrs	80.9	19.1		43.8	56.3		70.2	29.8	
>38yrs	71.0	29.0		48.5	51.5		75.0	25.0	
Education level			0.512			1.000			1.000
No formal education	66.7	33.3		33.3	66.7		66.7	33.3	
Some formal education	79.3	20.7		49.0	51.0		74.0	26.0	

APPENDIX 9c: Showing association between miners' demographics and perceived environmental effects of ASGM

Perceived environmental effects	Vegetation cover loss and disturbance			Topsoil removal and disturbance			Air pollution			Noise and vibrations		
Variables	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value
Age			0.503			0.908			0.523			1.000
< 25yrs	69.2	30.8		30.8	69.2		84.6	15.4		61.5	29.5	
25-38yrs	51.0	49.0		32.7	67.3		69.4	30.6		63.3	36.7	
>38yrs	54.5	45.5		27.3	72.7		66.7	33.3		63.6	36.4	
Education level			0.405			0.663			0.008*			1.000
No formal education	33.3	66.7		16.7	83.3		16.7	83.3		66.7	33.3	
Some formal education	56.2	43.8		31.5	68.5		74.2	25.8		62.9	37.1	
Mining experience			0.569			0.975			0.738			0.841
< 5yrs	50.0	50.0		30.8	69.2		73.1	26.9		61.5	38.5	
≥ 5yrs	56.5	43.5		30.4	69.6		69.6	30.4		63.8	36.2	
Activity undertaken by a miner			0.124			0.002*			0.516			0.293
Mineral extraction (digging)	52.2	47.8		26.7	73.3		68.9	31.1		61.1	38.9	

Others (security guarding & supervision of other miners)	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
Mineral extraction & mineral processing	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0

* shows significance at $p < 0.05$

APPENDIX 9d: Showing association between miners' demographics and perceived environmental effects of ASGM

Perceived environmental effects	Aesthetic/Visual pollution			Water pollution			Loss and threat to biodiversity		
Variables	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value	Yes (%)	No (%)	P-value
Age			0.250			1.000			0.211
< 25yrs	69.2	30.8		23.1	76.9		61.5	38.5	
25-38yrs	53.1	46.9		22.4	77.6		36.7	63.3	
>38yrs	42.4	57.6		21.9	78.1		50.0	50.0	
Education level			0.426			1.000			0.688
No formal education	33.3	66.7		16.7	83.3		33.3	66.7	
Some formal education	52.8	47.2		22.7	77.3		45.5	54.5	
Mining experience			0.464			0.510			0.859
< 5yrs	57.7	42.3		26.9	73.1		46.2	53.8	
≥ 5yrs	49.3	50.7		20.6	79.4		44.1	55.9	
Activity undertaken by a miner			0.618			0.072			0.210
Mineral extraction (digging)	50.0	50.0		20.2	79.8		42.7	57.3	
Others (security guarding &	75.0	25.0		50.0	50.0		75.0	25.0	

supervision of other miners)						
Mineral extraction & mineral processing	100.0	0.0	100.0	0.0	100.0	0.0

APPENDIX 10: Sampling table for sample size determination

Table 1. Sample size for ±3%, ±5%, ±7% and ±10% Precision Levels Where Confidence Level is 95% and P=.5.

Size of Population	Sample Size (n) for Precision (e) of:			
	±3%	±5%	±7%	±10%
500	a	222	145	83
600	a	240	152	86
700	a	255	158	88
800	a	267	163	89
900	a	277	166	90
1,000	a	286	169	91
2,000	714	333	185	95
3,000	811	353	191	97
4,000	870	364	194	98
5,000	909	370	196	98
6,000	938	375	197	98
7,000	959	378	198	99
8,000	976	381	199	99
9,000	989	383	200	99
10,000	1,000	385	200	99
15,000	1,034	390	201	99
20,000	1,053	392	204	100
25,000	1,064	394	204	100
50,000	1,087	397	204	100
100,000	1,099	398	204	100
>100,000	1,111	400	204	100

a = Assumption of normal population is poor (Yamane, 1967). The entire population should be sampled.

Source: Yamane (1967)